Developing Virginia's Offshore Wind Resource

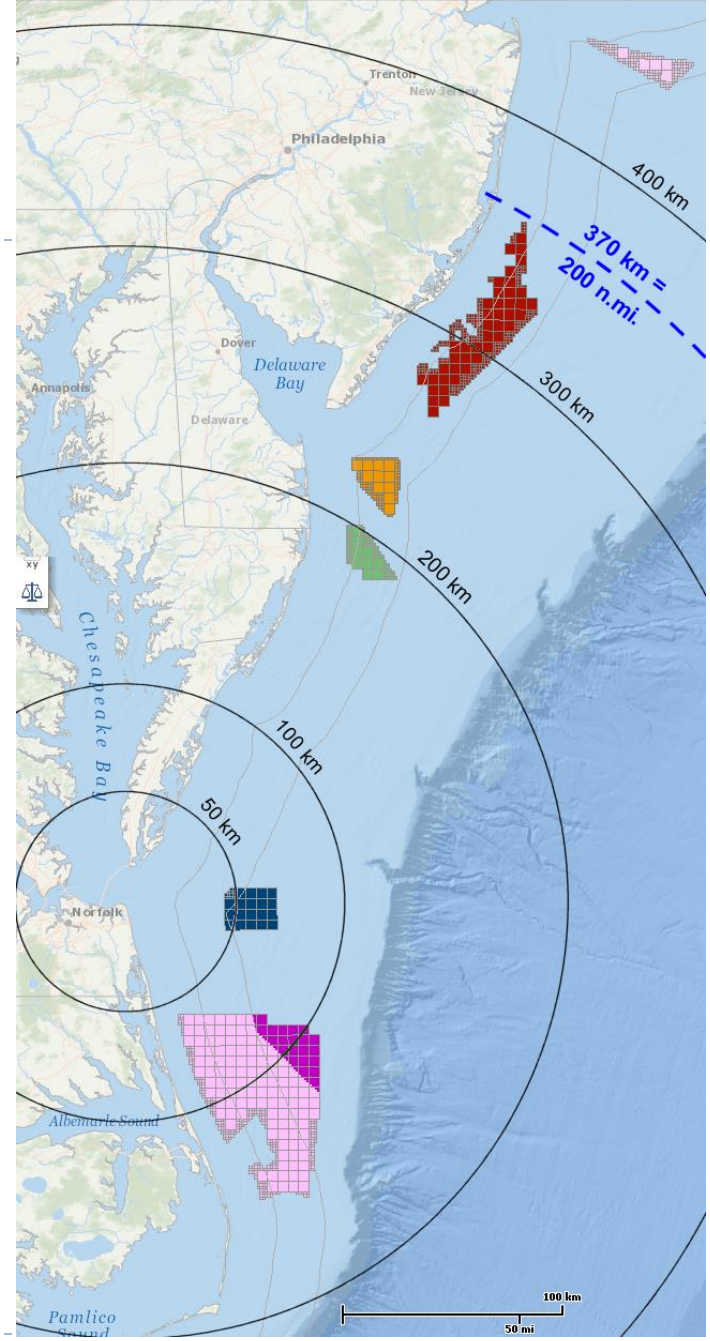
Supply Chain Economic Initiatives

- Offshore Wind Development Authority
- Robert Matthias

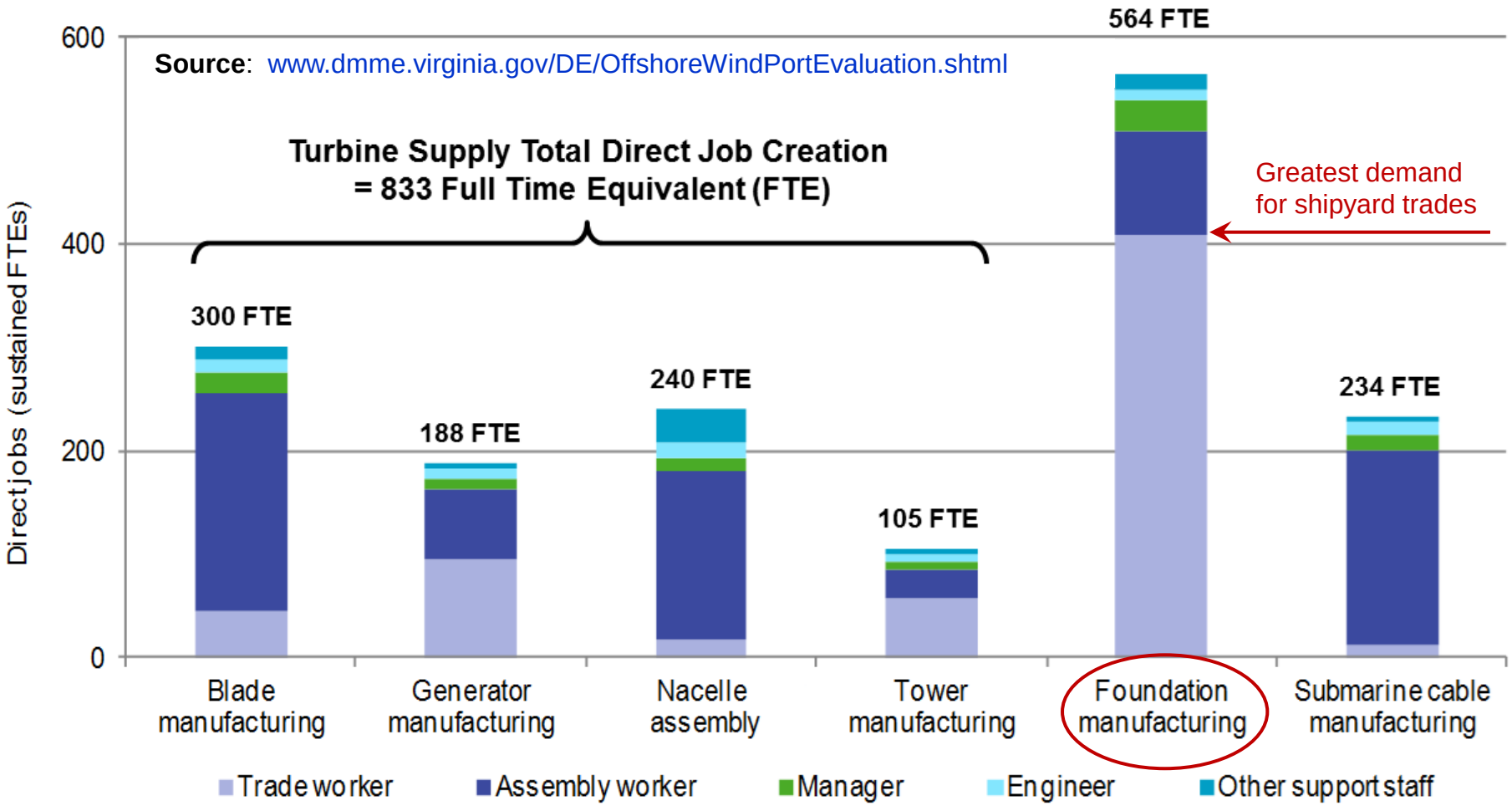
BOEM Intergovernmental RE Task Force 07 Dec 2017

Supply Chain Initiatives

- Recognition that Hampton Roads is well positioned to localize foundation fabrication for a substantial portion of the Mid-Atlantic commercial offshore wind market region
- Commercial leases off NJ, DE, MD, VA, and Kitty Hawk, NC can be reached in less than 24 hours by installation vessels traveling at 10 knots
- In the past three months, the Port of Virginia has hosted site tours by globally recognized offshore wind developers, procurement & logistics specialists, a European foundation fabricator and a US tower manufacturer



Foundation Fabrication would Diversify Shipbuilding and Ship Repair Industry



Virginia offshore wind port study (in 2015) estimated numbers of direct jobs created at six different purpose-built facilities to produce 100 turbines annually (i.e., 0.6 to 0.8 GW per year)

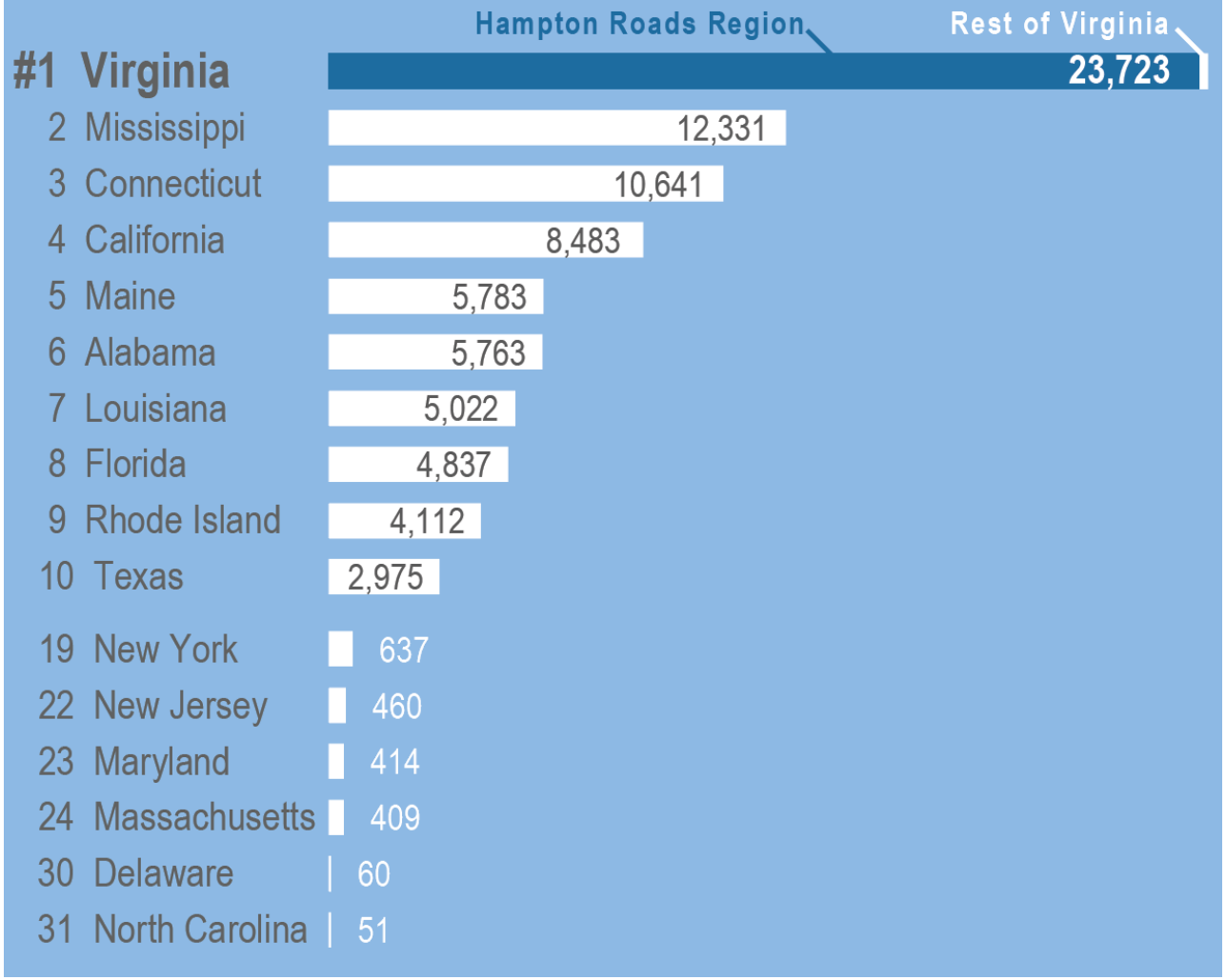
Virginia's Shipbuilding and Ship Repair Industry has Unparalleled Advantages

Average Direct Wages per Job ($/Year) by State in Shipbuilding and Ship Repair, 2013

Massachusetts	$100,290
Rhode Island	$103,100
Connecticut	$107,960
New York	$126,230
New Jersey	$76,230
Delaware	$70,000
Maryland	$71,590
Virginia	**$81,900**
North Carolina	$71,430

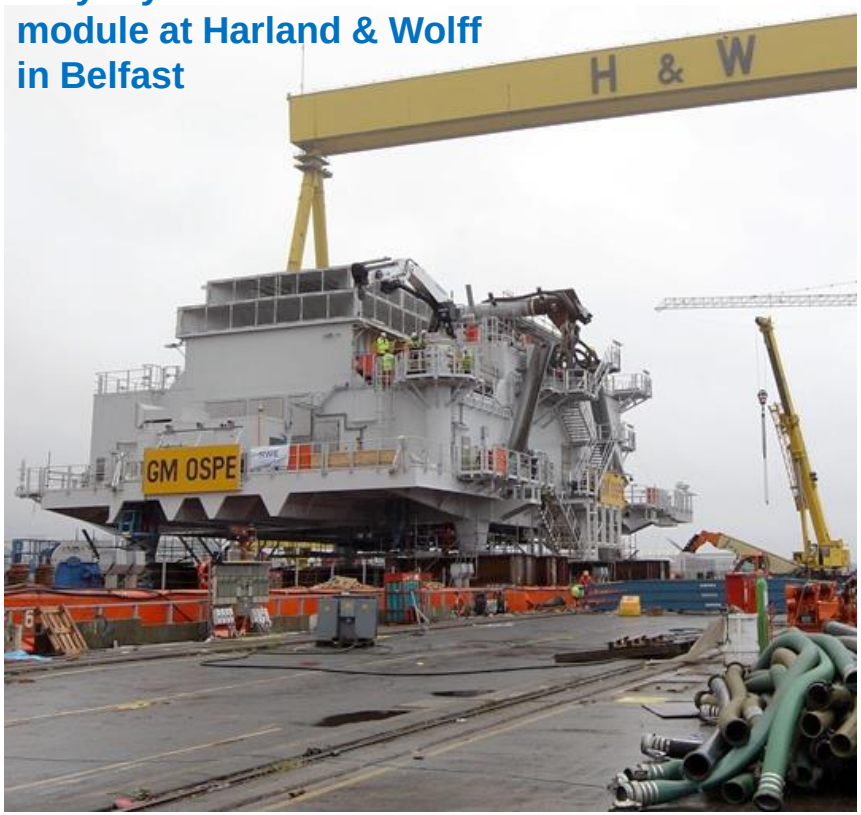
Virginia has more than 500,000 military veterans in the age range from 17 to 64, representing a work-ready pool of potential employees for offshore wind supply chain businesses

Number of Direct Jobs by State in Shipbuilding and Ship Repair, 2017



Virginia's Shipyard Supply Chains are Well-Suited to Offshore Substation Manufacturing

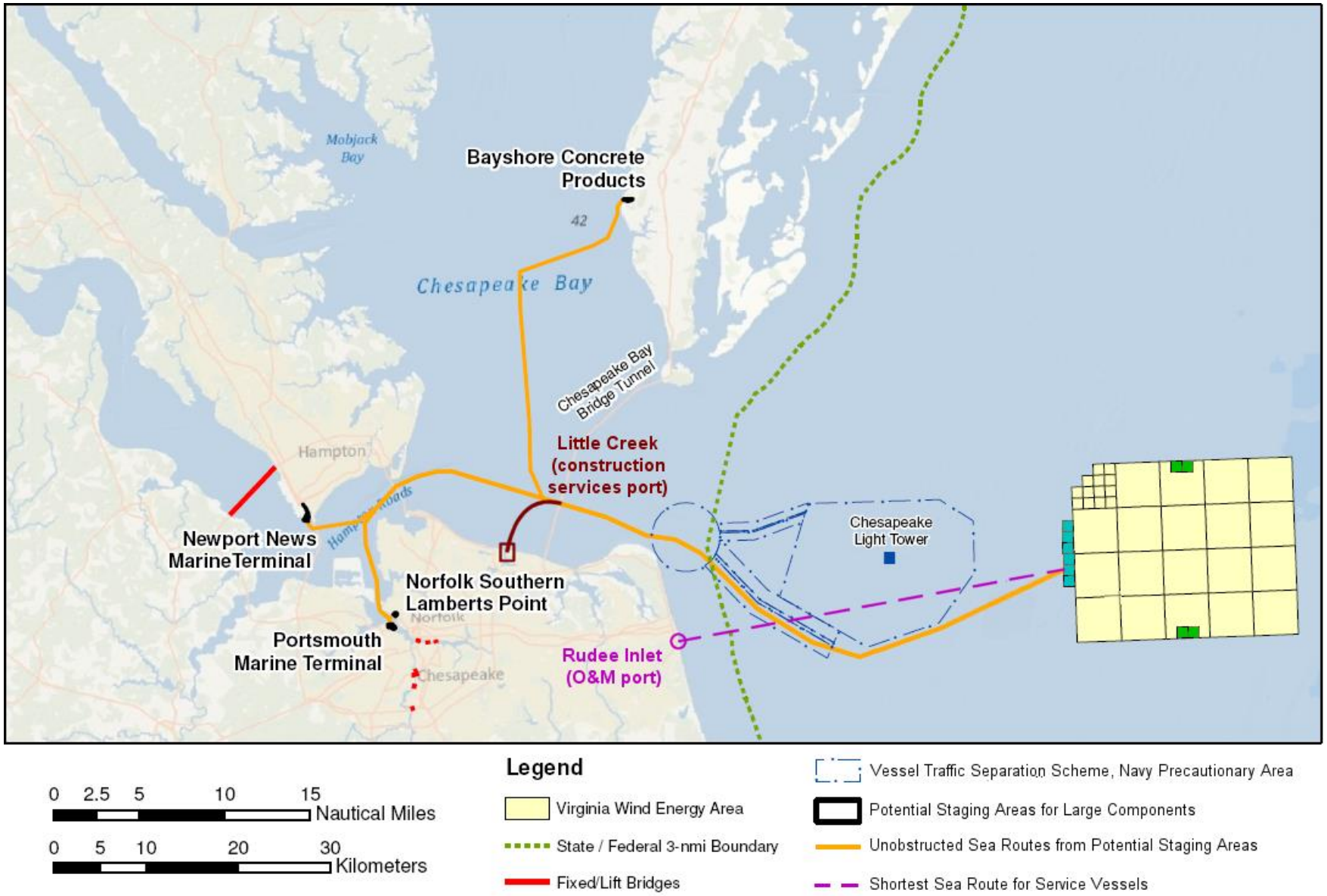
Gwynt y Mor substation module at Harland & Wolff in Belfast



***USS Abraham Lincoln* island module at Newport News**

Offshore wind substation manufacturing is similar to shipbuilding in that large steel modules are fabricated with full integration of complex systems such as electrical equipment and wiring, piping, climate control, fire suppression, personnel safety, and personnel overnight accommodation.

City of Virginia Beach Support Harbors are Closest to Research and Commercial Leases



Developing Virginia's Offshore Wind Resource

Research Activities – Past, Present, and Future

- Department of Mines, Minerals and Energy
- Ken Jurman, Division of Energy, DMME
  George Hagerman, Virginia Tech

BOEM Intergovernmental RE Task Force 07 Dec 2017

Virginia Department of Mines Minerals and Energy

Offshore Wind Development Objectives

- Purpose and mission is not distillable to a single goal, but the overarching theme and role of the Commonwealth is to accelerate and support private development of the Virginia Wind Energy Area and the industry supply chain
- **Why?** Development supports Virginia's energy policy goals:
  - renewable generation
  - energy security
  - economic development
  - environmental stewardship
- **How?** Make and encourage investments and activities that will reduce energy and developer costs and lower investment risks …
  - … which has motivated more than a dozen state-funded and collaboratively funded (with BOEM and with private industry) research and development projects since 2010

State-Funded and Collaboratively Funded Research Addresses Four Key Questions

1) What is the size of the Mid-Atlantic offshore wind market, and is it sufficient to attract a domestic supply chain in which Virginia can participate?
2) What is Virginia's potential offshore wind generation capacity and associated annual energy production that can contribute to the Commonwealth's energy supply portfolio?
3) What innovative products and services can be demonstrated on Virginia's research leases to address either or both of the above wind-resource-related questions?
4) What innovative products and services can be demonstrated on Virginia's research leases that will reduce energy and developer costs and lower investment risks

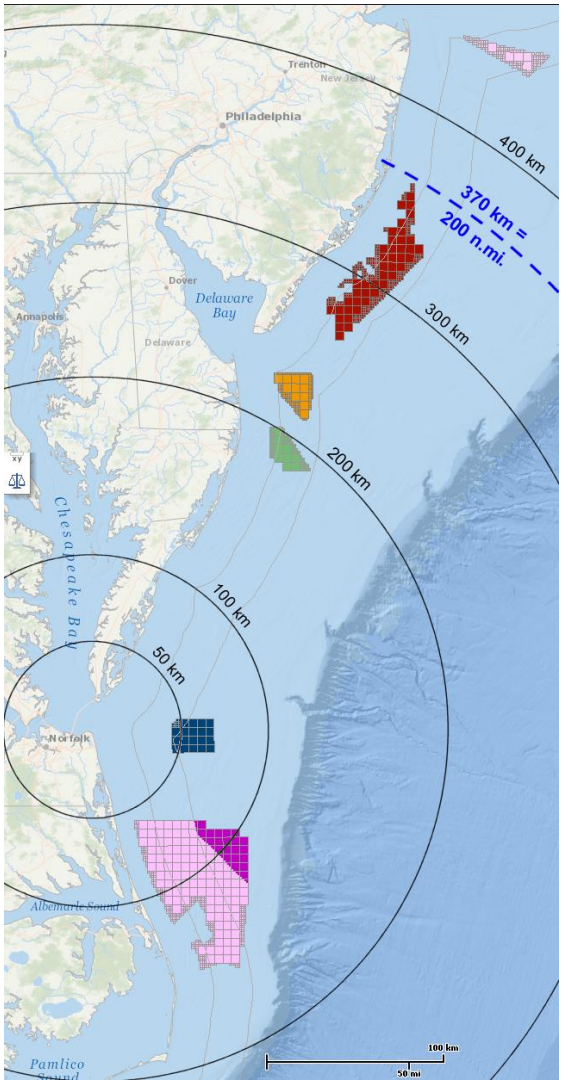
Recent Dramatic Energy Cost Reductions in Europe when Pipeline >20 GW (see backup slides)

Research Key Question 1)

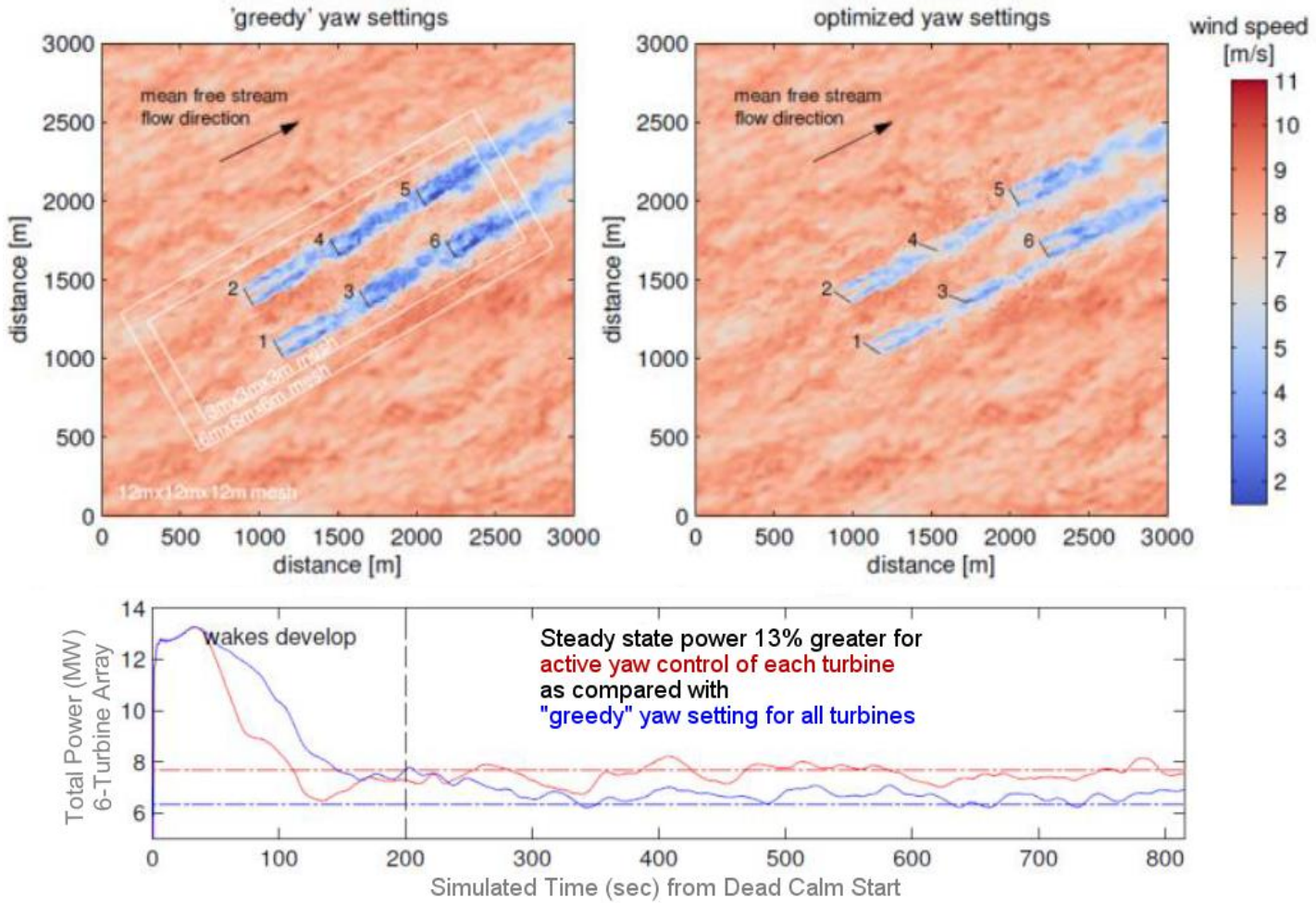
What is the southern Mid-Atlantic leased OSW pipeline within a day's sail from Hampton Roads?

Answer depends on assumed turbine density:

- Commercial leases off NJ, DE, MD, VA, and Kitty Hawk, NC have a total combined area of 3,056 square kilometers
- U.S. National Offshore Wind Strategy assumes a potential installed turbine density of 3 megawatts per square kilometer, or 3.0 MW/km², yielding a 9.17 GW pipeline
- Most recent European resource study (BVGA, June 2017) assumes 5.4 MW/km², yielding a 16.5 GW pipeline
- National Renewable Energy Laboratory studies show that when optimal turbine positioning is combined with wake steering by active yaw control, baseline of 5.4 MW/km² can be increased to 8.8 MW/km², yielding a 26.9 GW pipeline



Natl. Renewable Energy Laboratory (NREL) Simulation of Wind Plant Layout & Control

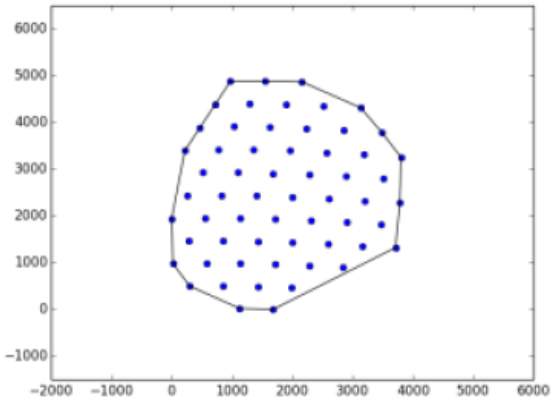


Source: Katherine Dykes, National Renewable Energy Laboratory, 11 Oct 2017

NREL Simulation Results for Hypothetical Project Derived from European Example

	Baseline	YawOpt	PosOpt	Combined
Mean power (MW)	78.86	84.91	78.86	78.84
Area (km^2)	14.53	14.53	12.45	8.96
Power density ($W/m^{2)}$	5.43	5.84	6.33	8.80
AEP(GWh)	1040.3	1094 (+5.2%)	1055.8 (+1.5%)	1095 (+5.3%)

Baseline Layout



Baseline: fixed (original) positions, turbines all yawed in mean wind direction

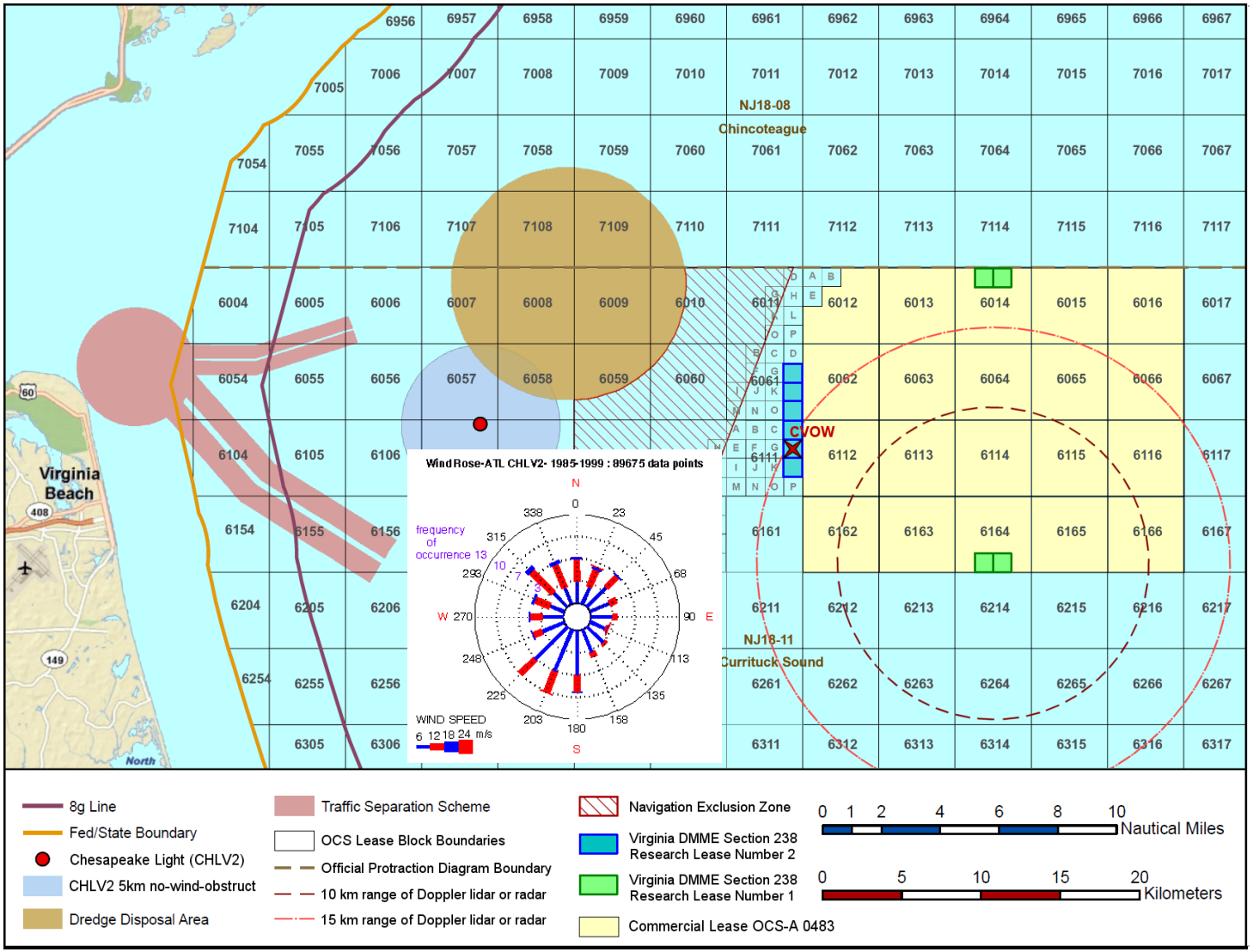
YawOpt: fixed (original) positions, turbines actively yawed for each wind direction

PosOpt: positions optimized, turbines all yawed in mean wind direction

Combined: positions optimized AND turbines actively yawed for each wind direction

Source: Katherine Dykes, National Renewable Energy Laboratory, 11 Oct 2017
See http://onlinelibrary.wiley.com/doi/10.1002/we.1993/abstract for peer-reviewed paper.

Virginia's Research Leases are Well-Positioned to Validate Wind Plant Layout and Control

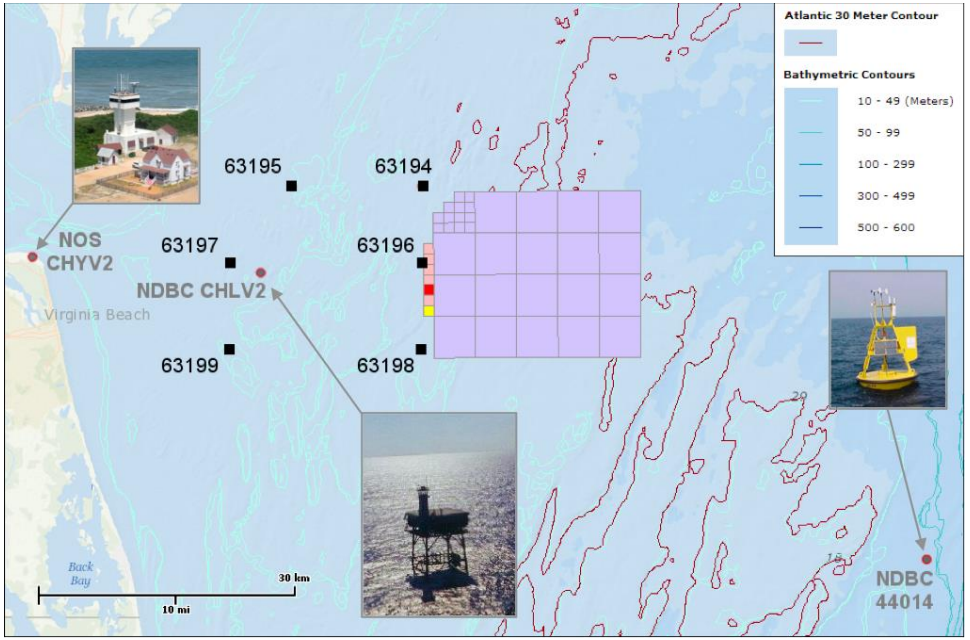


New Reference Met Mast Needed to Replace Chesapeake Light Tower (see backup slides)

Research Key Question 2)

What is Virginia's potential offshore wind generation capacity and associated annual energy production?

Answer depends on assumed turbine density AND correlation between short-term lidar buoy measurements and long-term reference record

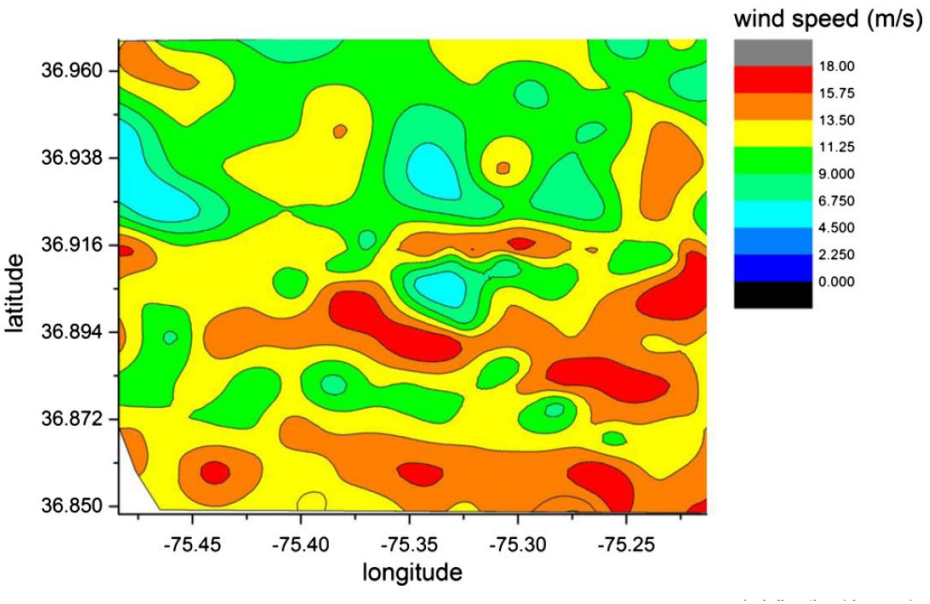


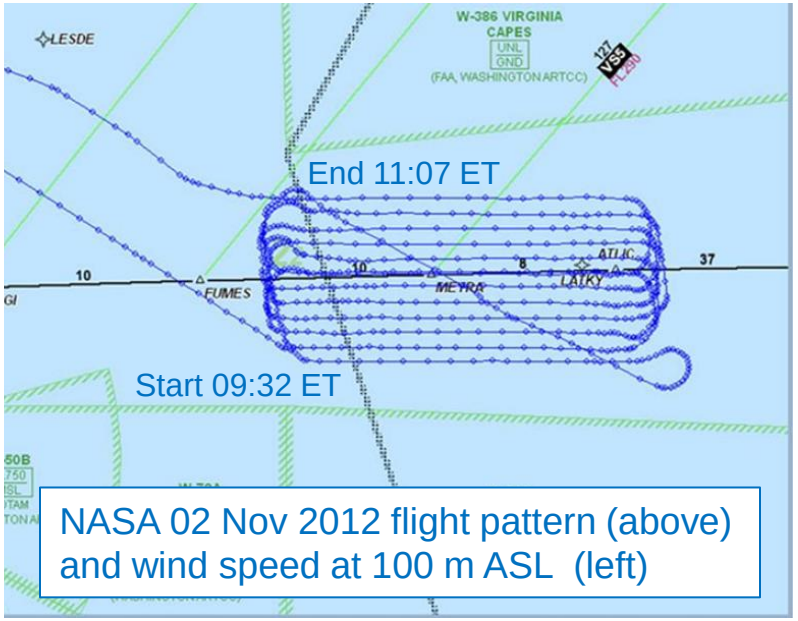
Doppler Lidar or Radar on Fixed Platforms in RL1 Aliquots also can Fully Map Resource

Research Key Question 3)

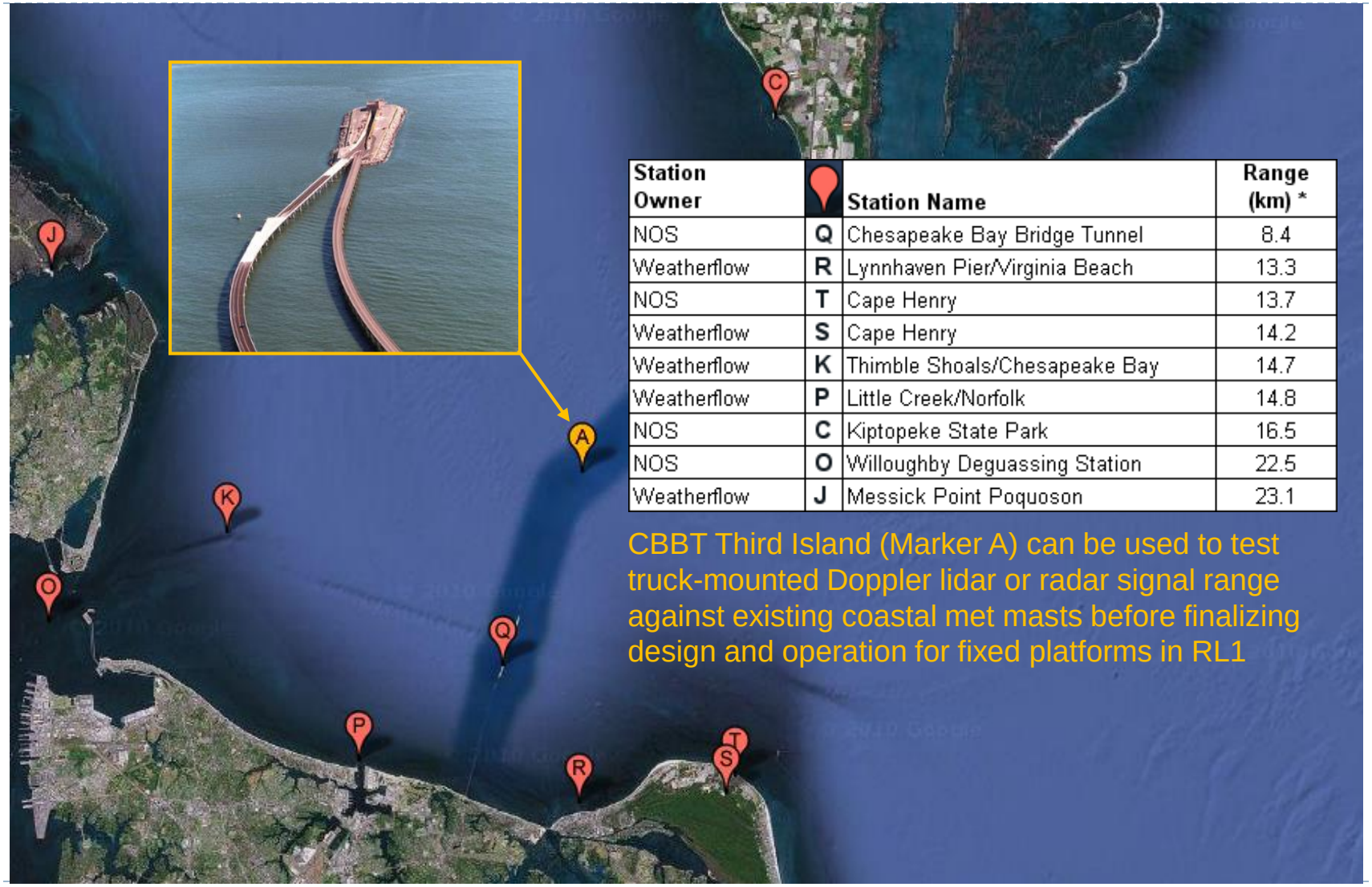
What innovative products and services can be demonstrated on Virginia's research leases to address wind-resource-related questions?

NASA Langley Research Center airborne Lidar measurements suggest large spatial variability in offshore wind resource across commercial lease area.





Doppler Lidar or Radar on Fixed Platforms in RL1 Aliquots also can Fully Map Resource



Station Owner		Station Name	Range (km) *
NOS	Q	Chesapeake Bay Bridge Tunnel	8.4
Weatherflow	R	Lynnhaven Pier/Virginia Beach	13.3
NOS	T	Cape Henry	13.7
Weatherflow	S	Cape Henry	14.2
Weatherflow	K	Thimble Shoals/Chesapeake Bay	14.7
Weatherflow	P	Little Creek/Norfolk	14.8
NOS	C	Kiptopeke State Park	16.5
NOS	O	Willoughby Deguassing Station	22.5
Weatherflow	J	Messick Point Poquoson	23.1

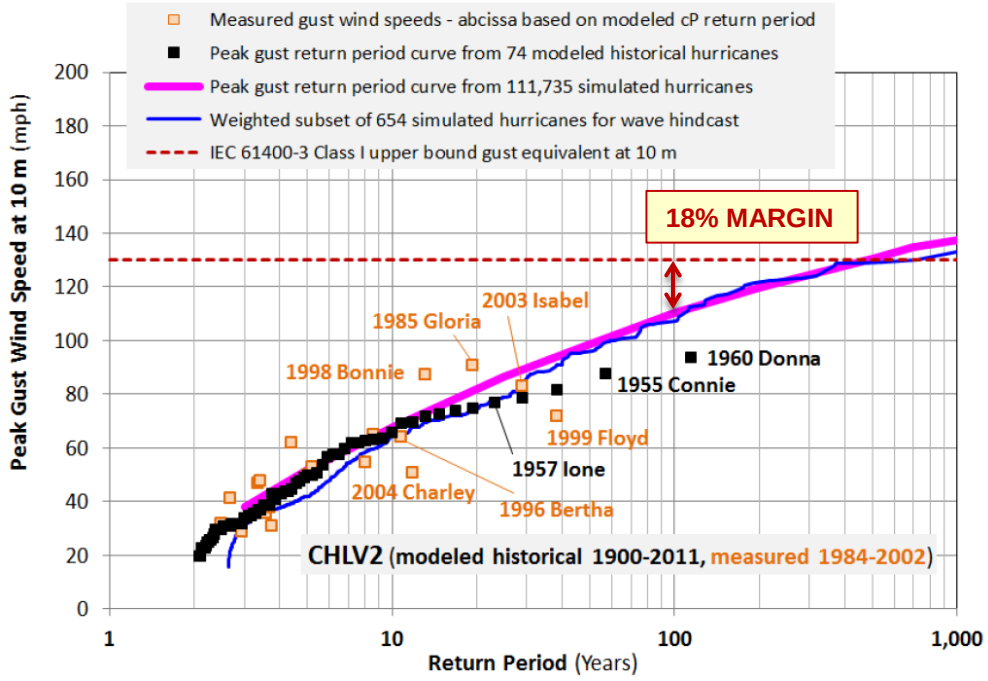
CBBT Third Island (Marker A) can be used to test truck-mounted Doppler lidar or radar signal range against existing coastal met masts before finalizing design and operation for fixed platforms in RL1

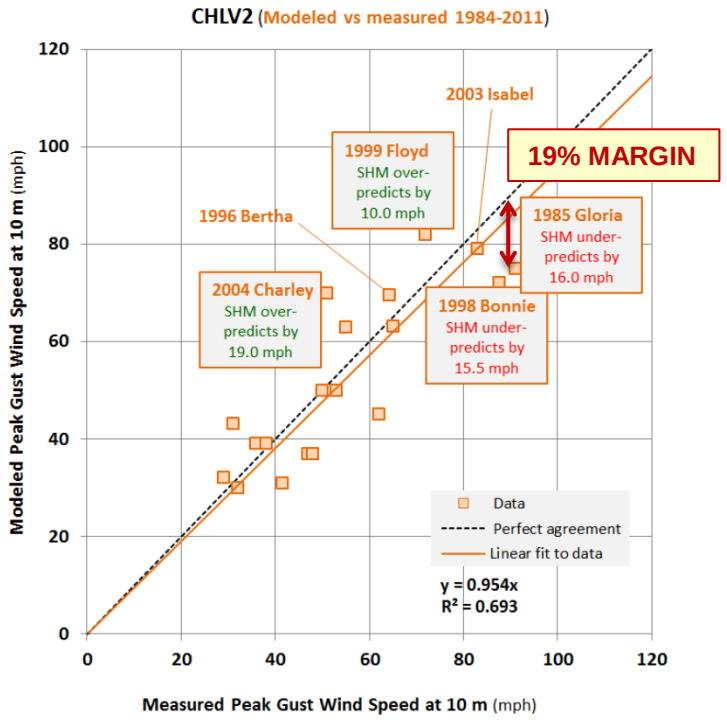
Fixed Met Mast Needed to Reliably Measure Hurricane Winds for Design Validation

Research Key Question 4)

What innovative products and services can be demonstrated on Virginia's research leases that will reduce developer costs and lower investment risks?

Hurricane rain bands attenuate lidar wind measurements at rotor heights



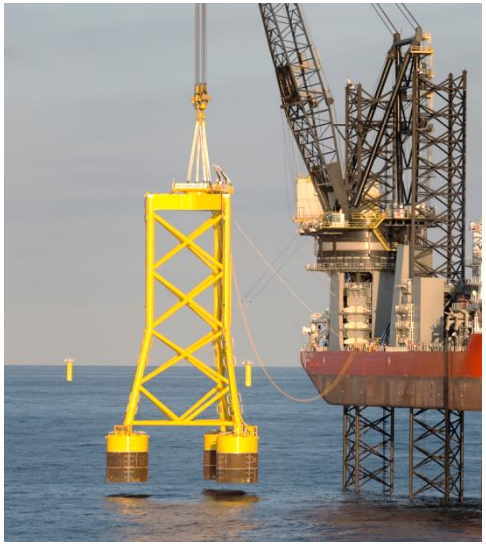


Fixed Metocean Platforms can Demonstrate Suction-Bucket Jacket Foundations

Research Key Question 4)

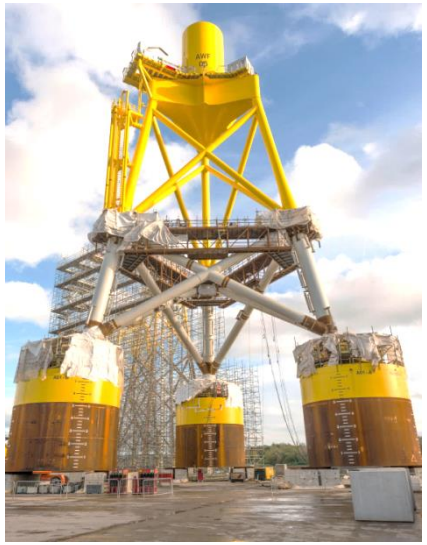
What innovative products and services can be demonstrated on Virginia's research leases that will reduce developer costs and lower investment risks?

Validate jacket transparency to impact of breaking storm waves



First prototype suction-bucket jacket at Borkum Riffgrund I, pioneered by DONG Energy

Breaking wave at FINO-1 platform in 28 m water depth when significant wave height is only 6 m



Suction-bucket jacket for European Offshore Wind Deployment Center

Past State Collaboration with Federal Research and Possible Future Opportunities

- As described in backup slides, DMME has collaborated with the US Dept. of Energy (DOE) and the Pacific Northwest National Laboratory to test a WindSentinel floating lidar buoy and determine correlation of short-term data with data at long-term reference stations. DMME also has collaborated with BOEM to develop a Mid-Atlantic geological model based on reconnaissance level geological and geophysical surveys of Virginia's commercial lease area.
- The four key research questions addressed in this presentation have wider implications beyond Virginia, potentially reducing costs and lowering risks for commercial offshore wind development throughout the Mid-Atlantic.
- In September, BOEM solicited white papers for possible funding through the BSEE Technology Assessment Program (TAP), which included topics on suction-bucket cyclic loading in sand and on wind area power density.
- Virginia's research leases are well poised to provide ocean validation of results from any TAP-funded studies that emerge from submitted white papers.
- In December, DOE will issue a Funding Opportunity Announcement (FOA) for a single $18.5M four-year award to implement a U.S. Offshore Wind Research and Development Consortium. Virginia's research leases can well serve as a national ocean test bed within this FOA framework.

Developing Virginia's Offshore Wind Resource

Backup Slides

DMME
Virginia Department of
Mines Minerals and Energy

VOWDA Purpose and Mission

- The Virginia Offshore Wind Development Authority (VOWDA) was legislatively created in 2010 for the purposes of facilitating, coordinating and supporting the development of the offshore wind energy industry, offshore wind energy projects, and associated supply chain vendors in the Commonwealth.

- The Authority oversees data gathering, research and planning to support offshore wind development off Virginia's coast, tracks issues as they arise, and makes recommendations for promoting Virginia offshore wind development and associated economic development opportunities for supply chain businesses and Virginia's ports.

VOWDA Recommendations for 2018

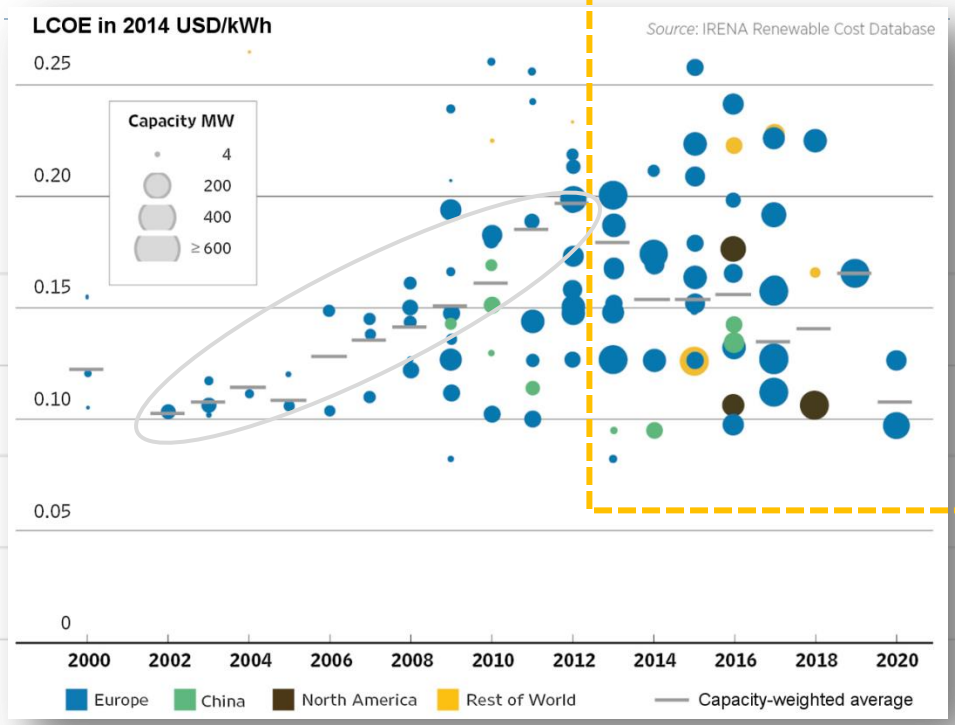
- **RECOMMENDATION 1**: Encourage and advocate for supportive state and federal regulatory changes, as well as legislative proposals, such as the establishment of a mandatory renewable energy standard with a specific goal for offshore wind and for extension of the federal tax credits.
- **RECOMMENDATION 2**: Collaborate with stakeholders, including Dominion Energy, Ørsted, Virginia Economic Development Partnership, the Port of Virginia, Virginia and European manufacturers, and others to promote Virginia companies as part of the supply chain for offshore wind.
- **RECOMMENDATION 3:** Work with the Governor's Office, DMME, and interested stakeholders to build support for State Corporation Commission approval of the Coastal Virginia Offshore Wind (CVOW) demonstration project.
- **RECOMMENDATION 4:** Work with CVOW partners to identify possible power offtakers in the Commonwealth and elsewhere, such as large data companies with clean energy commitments, for offshore wind energy from CVOW and the commercial Wind Energy Area.
- **RECOMMENDATION 5:** Actively solicit third party participants to undertake offshore wind project development activities in the DMME Research Lease in conformance with existing agreements.

DMME Purpose and Mission

- DMME by statute provides staff support to VOWDA
- … is lead executive branch agency for energy, reporting to the Secretary of Commerce and Trade and supporting energy policy initiatives of the Governor
- … by statute produces and helps to implement the recommendations of the Virginia Energy Plan, which embodies the energy policy strategy of the Commonwealth. The Energy Plan is published in the 1st year and updated in the 3rd year of each Governor's term
- The Energy Plan also reflects the Commonwealth's Energy Policy and Objectives, which periodically are updated and amended by Act of Assembly

European Experience 2000 to 2012: Emerging Supply Chain

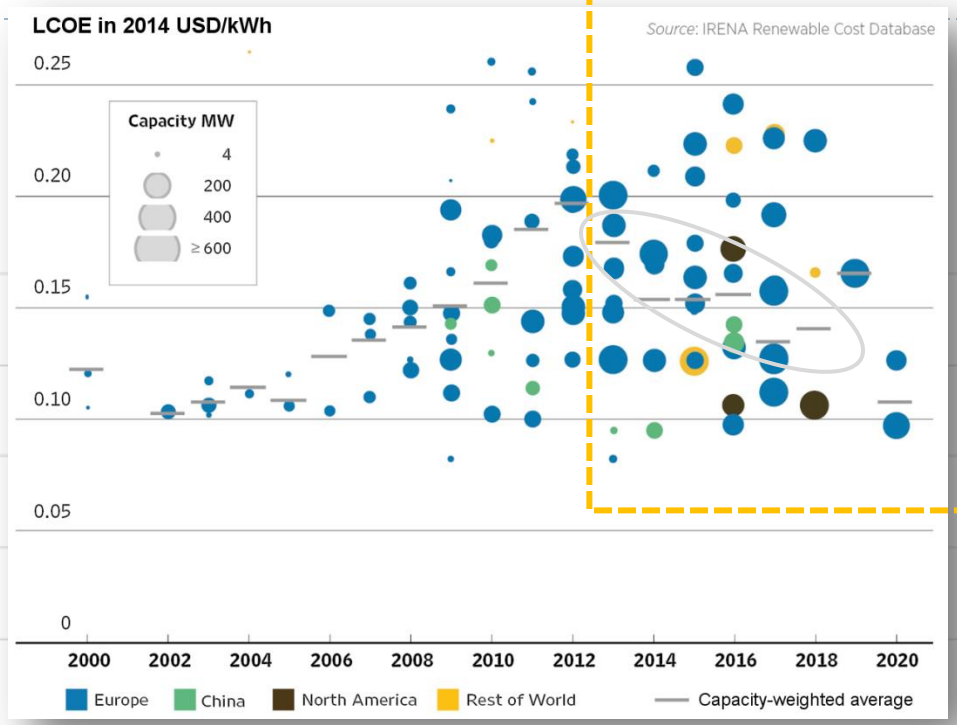
For in-service dates between 2000 and 2012, the levelized cost of energy (LCOE) rose as supply chain monetized risks



Sources: www.irena.org/publications/2015/Jan/Renewable-Power-Generation-Costs-in-2014
https://windeurope.org/policy/topics/offshore-wind-energy

Source: WindEurope

European Experience 2012 to 2016: Consolidating Supply Chain

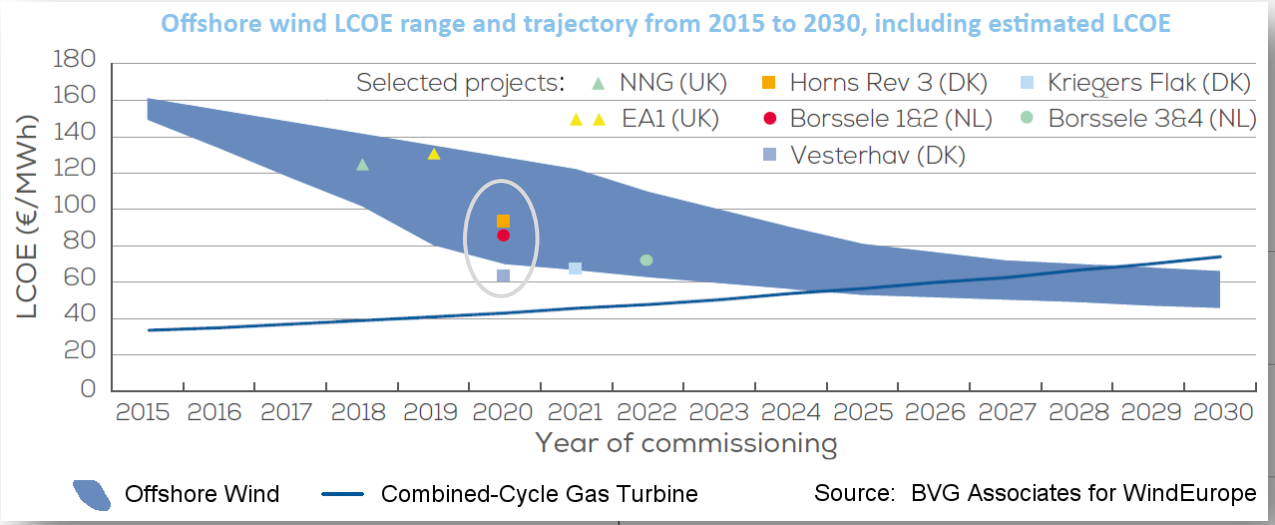


LCOE declining for in-service dates between 2012 and 2019 as supply chain consolidated

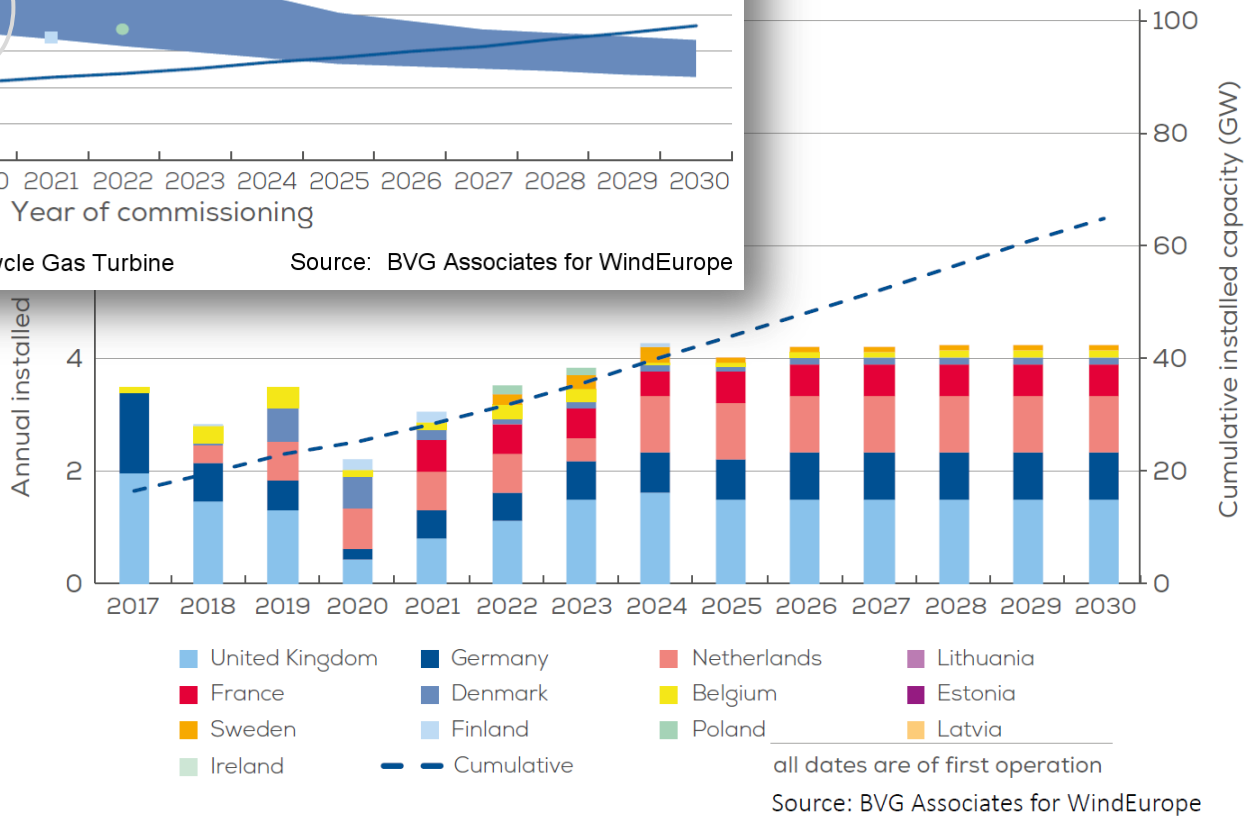
Sources: www.irena.org/publications/2015/Jan/Renewable-Power-Generation-Costs-in-2014
https://windeurope.org/policy/topics/offshore-wind-energy

Source: WindEurope

European Forecast to 2030:
Mature Supply Chain



For in-service dates in 2020 and beyond, LCOE pushed lower by reverse auctions



Source: https://windeurope.org/wp-content/uploads/files/about-wind/reports/Unleashing-Europes-offshore-wind-potential.pdf

Mid-Atlantic Offshore Wind Lease Pipeline at Turbine Density of 3.0 MW per km^2

					Assumed turbine capacity density	
	US Mid-Atlantic Offshore Wind Lease Areas				3.0	MW per sq.km
	(Cape Cod, MA to Cape Hatteras, NC)					
			Area		Date of	Lease Effective
State	**Lease No.**	**Lease Holder / Developer**	**(acres)**	**(sq.km)**	**Lease Sale**	**Start Date**
MA	OCS-A 0500	Ørsted (Bay State Wind)	187,523	759	29-Jan-2015	01-Apr-2015
MA	OCS-A 0501	50:50 CIP:Avangrid (Vineyard Wind)	166,886	675	29-Jan-2015	01-Apr-2015
MA	OCS-A 0502	offered, but no bids (farther offshore) *	248,015	1,004	29-Jan-2015	
MA	OCS-A 0503	offered, but no bids (farthest offshore) *	140,554	569	29-Jan-2015	
RI	OCS-A 0486	Deepwater Wind New England (RI north)	97,500	395	31-Jul-2013	01-Oct-2013
RI	OCS-A 0487	Deepwater Wind New England (RI south)	67,250	272	31-Jul-2013	01-Oct-2013
NY	OCS-A 0512	Statoil Wind US LLC	79,350	321	16-Dec-2016	15-Mar-2017
		Northern sub-total:		3,995	sq.km	
		active leases:		61%		7,266.50 MW
NJ	OCS-A 0499	US Wind Inc.	160,480	649	09-Nov-2015	01-Mar-2016
NJ	OCS-A 0498	Ørsted **	183,353	742	09-Nov-2015	01-Mar-2016
DE	OCS-A 0482	Deepwater Wind (representing GSOE) ***	96,430	390	n/a	16-Nov-2012
MD	OCS-A 0489	US Wind Inc.	32,737	132	19-Aug-2014	01-Dec-2014
MD	OCS-A 0490	US Wind Inc.	46,970	190	19-Aug-2014	01-Dec-2014
VA	OCS-A 0483	Dominion Virginia Power	112,799	456	04-Sep-2013	01-Nov-2013
NC	OCS-A 0508	Avangrid Renewables LLC	122,405	495	16-Mar-2017	01-Nov-2017
		Southern sub-total:		3,056	sq.km	
		active leases:		100%		9,168.57 MW
		unleased:	510,974	2,068	29%	
		active leases:	1,231,278	4,983	71%	
		TOTAL:	1,742,252	7,051		21,152.68 MW

Mid-Atlantic Offshore Wind Lease Pipeline at Turbine Density of 5.4 MW per km^2

					Assumed turbine capacity density	
	US Mid-Atlantic Offshore Wind Lease Areas			5.4	MW per sq.km	
	(Cape Cod, MA to Cape Hatteras, NC)					
			Area		Date of	Lease Effective
State	**Lease No.**	**Lease Holder / Developer**	**(acres)**	**(sq.km)**	**Lease Sale**	**Start Date**
MA	OCS-A 0500	Ørsted (Bay State Wind)	187,523	759	29-Jan-2015	01-Apr-2015
MA	OCS-A 0501	50:50 CIP:Avangrid (Vineyard Wind)	166,886	675	29-Jan-2015	01-Apr-2015
MA	OCS-A 0502	offered, but no bids (farther offshore) *	248,015	1,004	29-Jan-2015	
MA	OCS-A 0503	offered, but no bids (farthest offshore) *	140,554	569	29-Jan-2015	
RI	OCS-A 0486	Deepwater Wind New England (RI north)	97,500	395	31-Jul-2013	01-Oct-2013
RI	OCS-A 0487	Deepwater Wind New England (RI south)	67,250	272	31-Jul-2013	01-Oct-2013
NY	OCS-A 0512	Statoil Wind US LLC	79,350	321	16-Dec-2016	15-Mar-2017
		Northern sub-total:		3,995	sq.km	
		active leases:		61%		13,079.70 MW
NJ	OCS-A 0499	US Wind Inc.	160,480	649	09-Nov-2015	01-Mar-2016
NJ	OCS-A 0498	Ørsted **	183,353	742	09-Nov-2015	01-Mar-2016
DE	OCS-A 0482	Deepwater Wind (representing GSOE) ***	96,430	390	n/a	16-Nov-2012
MD	OCS-A 0489	US Wind Inc.	32,737	132	19-Aug-2014	01-Dec-2014
MD	OCS-A 0490	US Wind Inc.	46,970	190	19-Aug-2014	01-Dec-2014
VA	OCS-A 0483	Dominion Virginia Power	112,799	456	04-Sep-2013	01-Nov-2013
NC	OCS-A 0508	Avangrid Renewables LLC	122,405	495	16-Mar-2017	01-Nov-2017
		Southern sub-total:		3,056	sq.km	
		active leases:		100%		16,503.42 MW
		unleased:	510,974	2,068	29%	
		active leases:	1,231,278	4,983	71%	
		TOTAL:	1,742,252	7,051		38,074.83 MW

Mid-Atlantic Offshore Wind Lease Pipeline at Turbine Density of 8.8 MW per km^2

					Assumed turbine capacity density		
	US Mid-Atlantic Offshore Wind Lease Areas				8.8	MW per sq.km	
	(Cape Cod, MA to Cape Hatteras, NC)						
			Area		Date of	Lease Effective	
State	**Lease No.**	**Lease Holder / Developer**	**(acres)**	**(sq.km)**	**Lease Sale**	**Start Date**	
MA	OCS-A 0500	Ørsted (Bay State Wind)	187,523	759	29-Jan-2015	01-Apr-2015	
MA	OCS-A 0501	50:50 CIP:Avangrid (Vineyard Wind)	166,886	675	29-Jan-2015	01-Apr-2015	
MA	OCS-A 0502	offered, but no bids (farther offshore) *	248,015	1,004	29-Jan-2015		
MA	OCS-A 0503	offered, but no bids (farthest offshore) *	140,554	569	29-Jan-2015		
RI	OCS-A 0486	Deepwater Wind New England (RI north)	97,500	395	31-Jul-2013	01-Oct-2013	
RI	OCS-A 0487	Deepwater Wind New England (RI south)	67,250	272	31-Jul-2013	01-Oct-2013	
NY	OCS-A 0512	Statoil Wind US LLC	79,350	321	16-Dec-2016	15-Mar-2017	
		Northern sub-total:		3,995	sq.km		
		active leases:		61%		21,315.06	MW
NJ	OCS-A 0499	US Wind Inc.	160,480	649	09-Nov-2015	01-Mar-2016	
NJ	OCS-A 0498	Ørsted **	183,353	742	09-Nov-2015	01-Mar-2016	
DE	OCS-A 0482	Deepwater Wind (representing GSOE) ***	96,430	390	n/a	16-Nov-2012	
MD	OCS-A 0489	US Wind Inc.	32,737	132	19-Aug-2014	01-Dec-2014	
MD	OCS-A 0490	US Wind Inc.	46,970	190	19-Aug-2014	01-Dec-2014	
VA	OCS-A 0483	Dominion Virginia Power	112,799	456	04-Sep-2013	01-Nov-2013	
NC	OCS-A 0508	Avangrid Renewables LLC	122,405	495	16-Mar-2017	01-Nov-2017	
		Southern sub-total:		3,056	sq.km		
		active leases:		100%		26,894.46	MW
		unleased:	510,974	2,068	29%		
		active leases:	1,231,278	4,983	71%		
		TOTAL:	1,742,252	7,051		62,047.87	MW

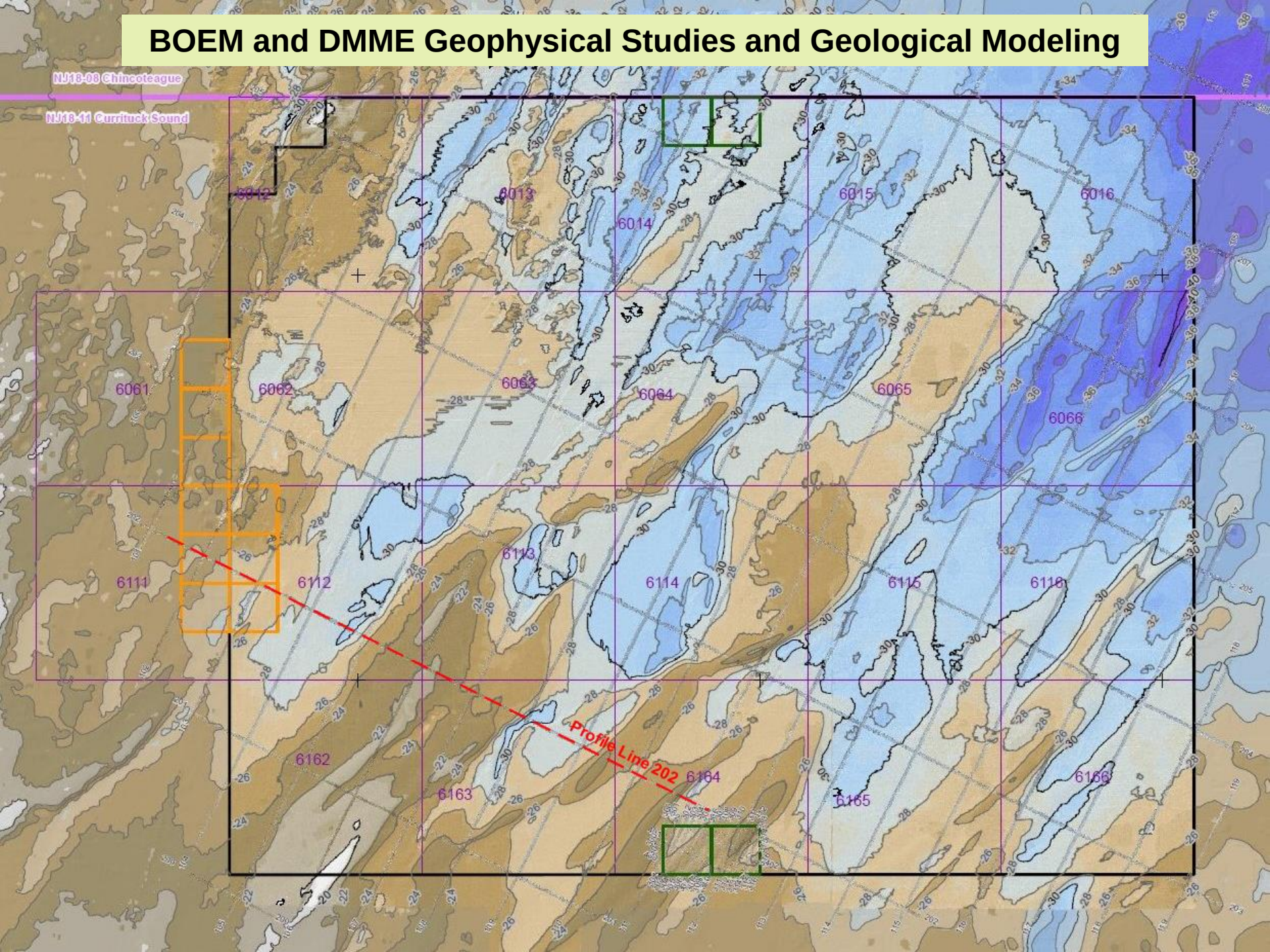
DOE and DMME Metocean Measurements in 6111-P

Mid-Atlantic Final
cant Impact for
sment activities

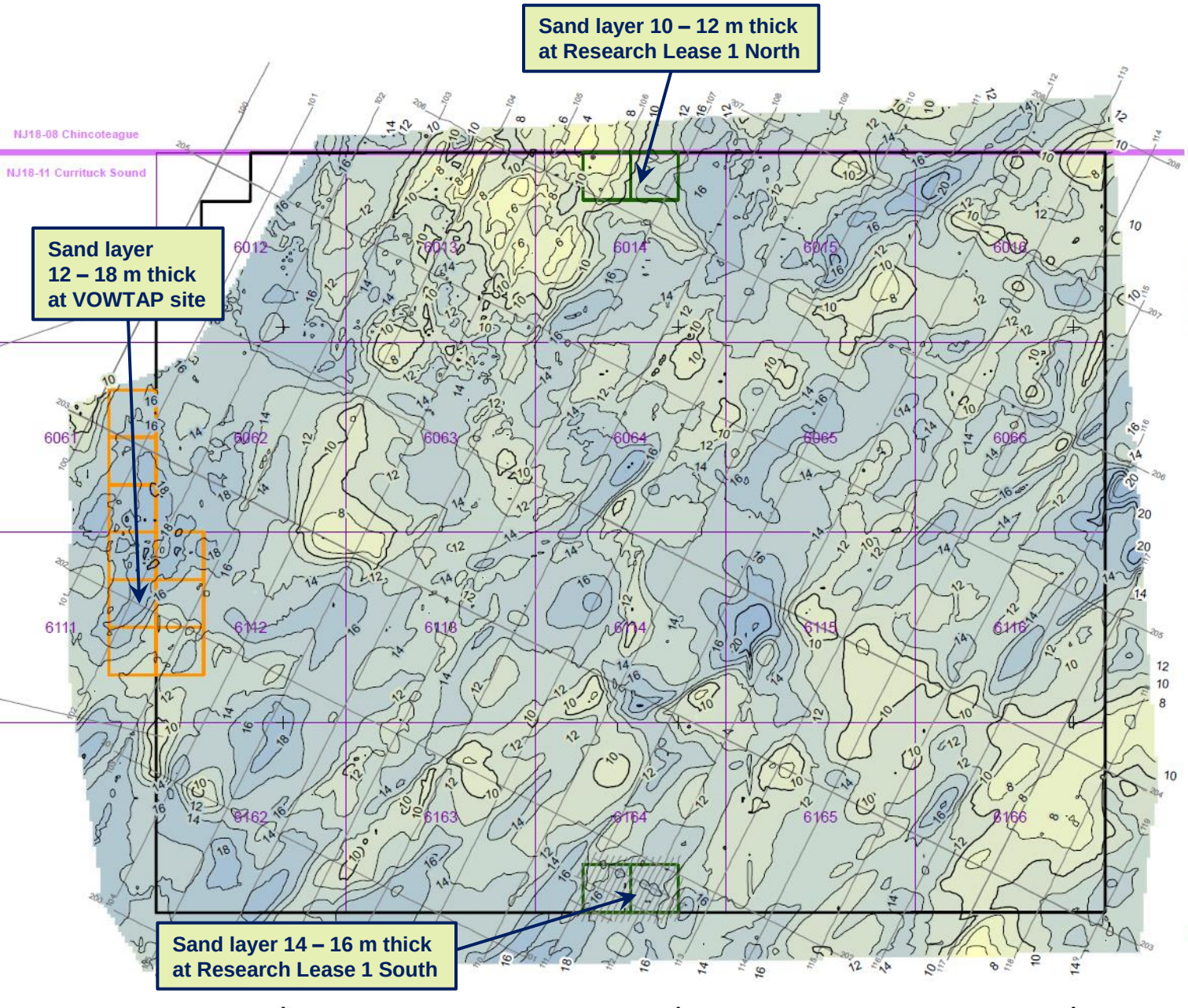
0 2 4 6 8 10 12 Nautical Miles

0 5 10 15 20 25 30 Kilometers

BOEM and DMME Geophysical Studies and Geological Modeling



BOEM and DMME Geophysical Studies and Geological Modeling



LEGEND

- Survey Vessel Navigation Trackline
- Virginia Wind Energy Area
- 6016 — Wind Energy Area OCS Lease Block
- Demonstration Project Lease Aliquot
- Meteorological Tower Aliquot
- Coordinate Grid is UTM Zone 18N, NAD 1983, Meters

Approximate Isopach (Thickness) of Deposits Above Horizon 30, Meters

Deposits above Horizon 30 are inferred to be Quaternary deposits. Time-to-depth conversions based on V_p = 1,500 m/s; thus thickness should be considered approximate.

- Major contour interval is 10 meters.
- Minor contour interval is 2 meters
- 2.4 - 4
- 4.1 - 6
- 6.1 - 8
- 8.1 - 10
- 10.1 - 12
- 12.1 - 14
- 14.1 - 16
- 16.1 - 18
- 18.1 - 20
- 20.1 - 22

N, W, E, S

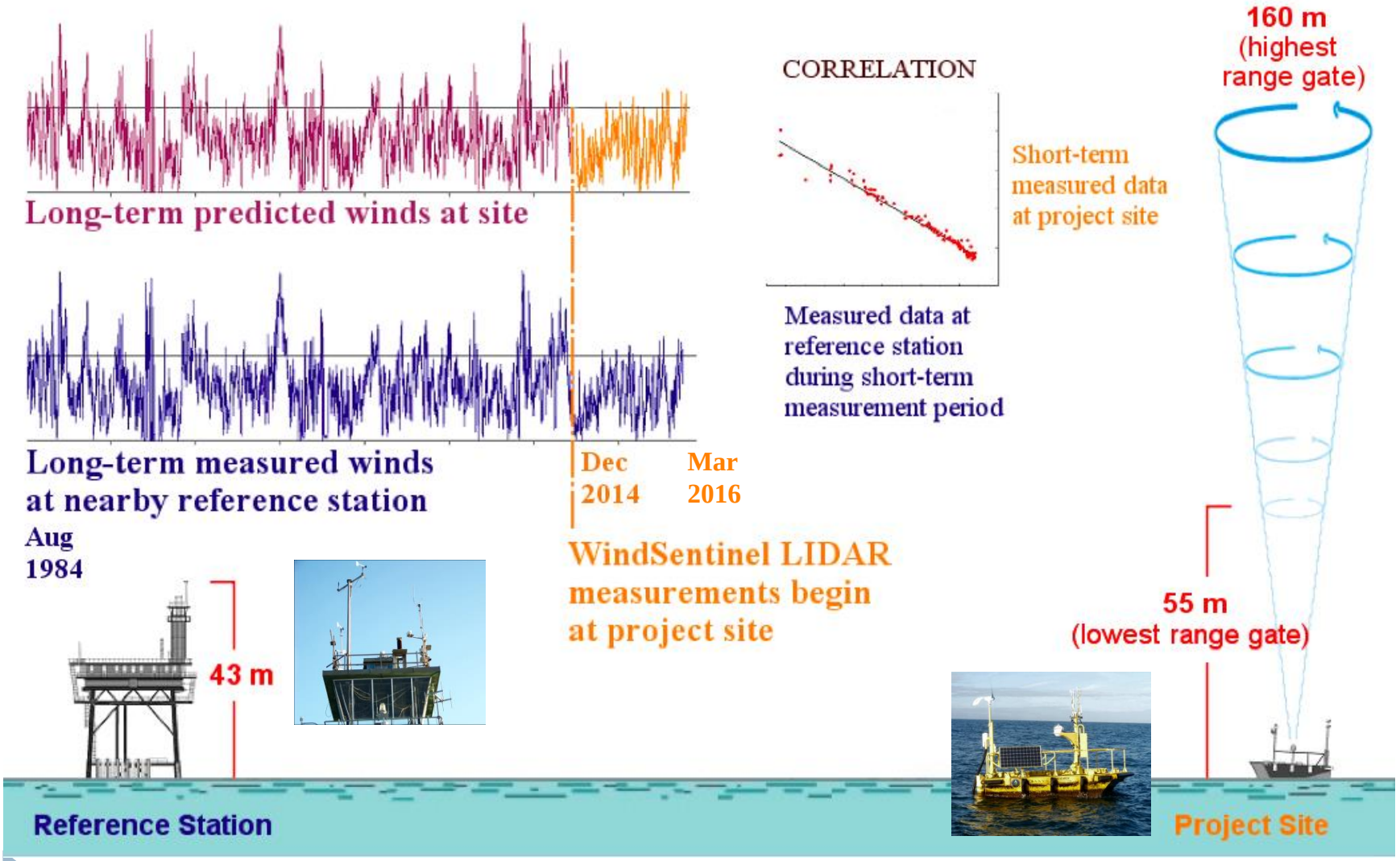
0 2 Nautical Miles

0 3 6 Kilometers

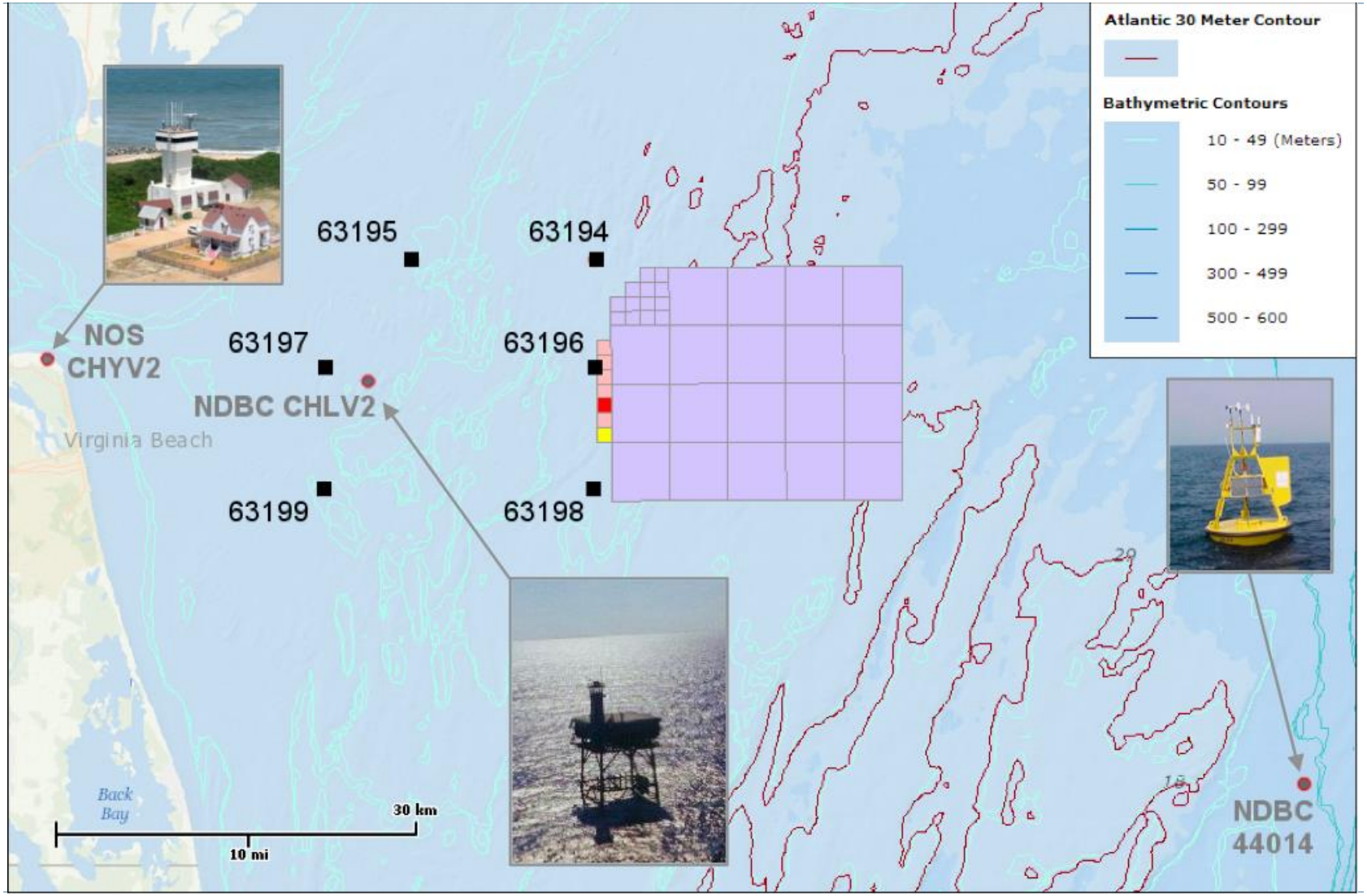
ISOPACH (THICKNESS) OF DEPOSITS ABOVE HORIZON 30

Virginia Wind Energy Area
Geophysical Survey
Virginia Outer Continental Shelf

DMME-Funded Measure-Correlate-Predict Analysis of DOE WindSentinel Data

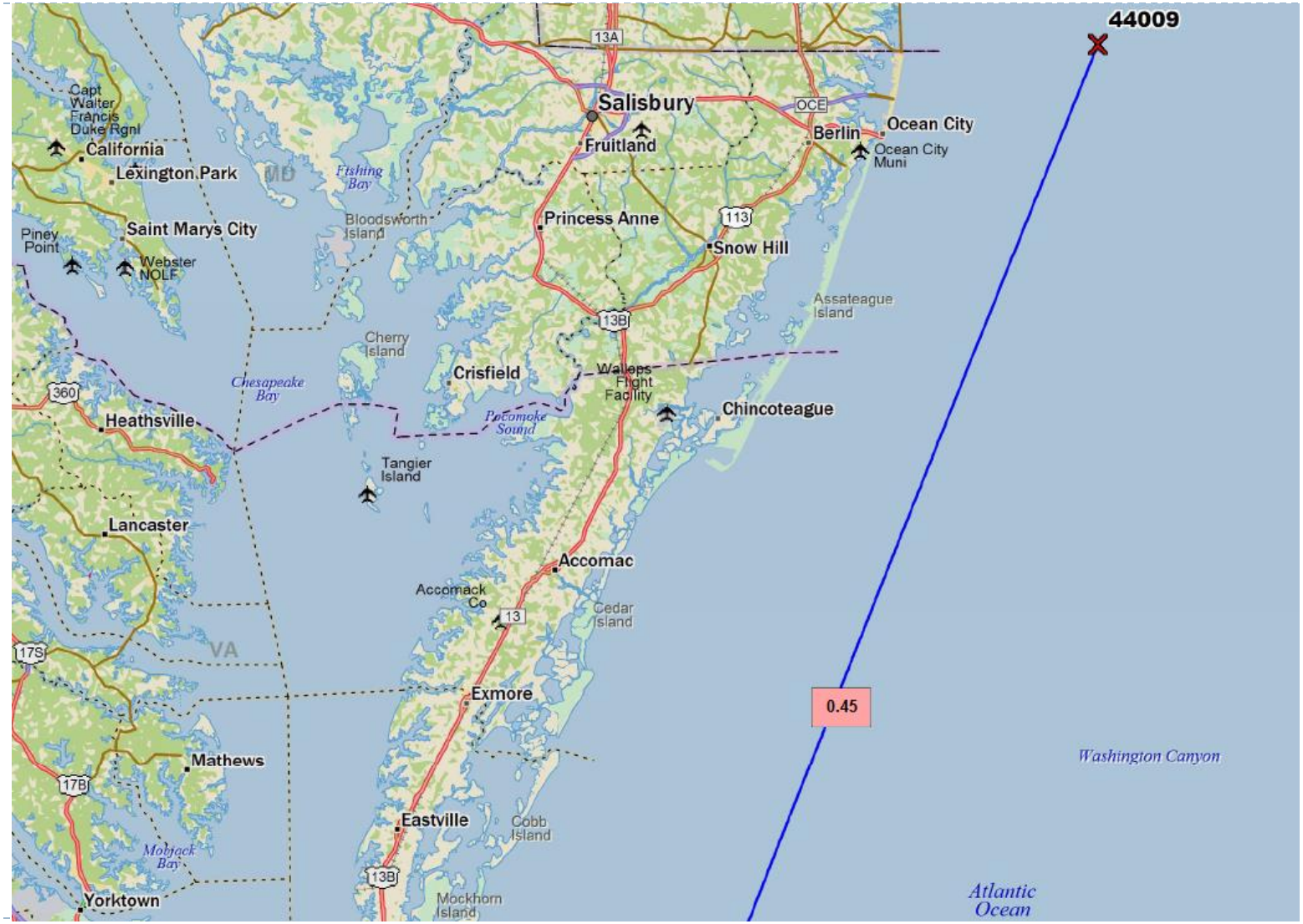


DMME-Funded Measure-Correlate-Predict Analysis of DOE WindSentinel Data



DMME-Funded Measure-Correlate-Predict Analysis of DOE WindSentinel Data

DMME-Funded Measure-Correlate-Predict Analysis of DOE WindSentinel Data



DMME-Funded Measure-Correlate-Predict Analysis of DOE WindSentinel Data

Short-term (ST = 15 months) correlation with 90m level of Lidar Buoy during 15-month overlap period

Long-term (LT = 20 years) 90m P50 wind speed estimates based on various reference stations (m/s)

Reference Station	Measured ST mean (m/s)	LT data year start	ST correlation hourly r^2	regression eqn slope	regression eqn intercept	P50 MCP LT mean at 90 m ASL (m/s)
CHLV2 (CLT)	7.68	1994	0.81	0.998	0.619	8.28
44014 buoy	6.35	2003	0.53	0.929	2.242	8.14
DUKN7 Duck, NC	6.01	2008	0.52	1.042	2.184	8.45
44009 buoy	6.34	2006	0.45	0.765	2.657	7.50
CHYV2 Cape Henry	5.45	2006	0.41	0.851	3.814	8.46

Long-term 90m wind speed estimates at five Pxx levels using different Reference Stations

Reference Station	P50	P75	P90	P95	P99
CHLV2 (CLT)	8.28	8.17	8.07	8.01	7.89
44014 buoy	8.14	7.89	7.64	7.50	7.23
DUKN7 Duck, NC	8.45	8.17	7.90	7.75	7.45
44009 buoy	7.50	7.22	6.94	6.79	6.49
CHYV2 Cape Henry	8.46	8.13	7.80	7.62	7.26

Best Correlated Reference Station will be Lost when CHLV2 becomes Unsafe to Access

Station CHLV2 - Chesapeake Light, VA

Owned and maintained by National Data Buoy Center
C-MAN Station
DACT payload
36.905 N 75.713 W (36°54'17" N 75°42'46" W)

Site elevation: 0 m above mean sea level
Air temp height: 22.3 m above site elevation
Anemometer height: 43.3 m above site elevation
Barometer elevation: 23.4 m above mean sea level

On 8/26/16, the Chesapeake Light Tower was disestablished due to deteriorating structural conditions. See the notice for more details.

http://www.nws.noaa.gov/os/notification/scn16-30chesapeake_light_va.htm

Right whales are active off VA from November to April. Speed restrictions of 10 knots apply to vessels 65 feet or greater in specific areas along the mid-Atlantic coast. To learn more about right whales and rules protecting them, go to:
http://www.nmfs.noaa.gov/pr/shipstrike

Latest NWS Marine Forecast

Important Notice to Mariners

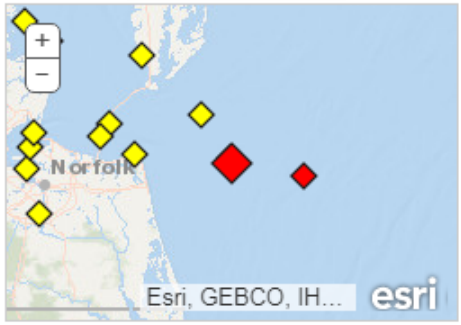
Meteorological Observations from Nearby Stations and Ships

Regional HF Radar Surface Current Observations

Sector pictures are available for this station at 0, 45, 90, 135, 180, 225, 270, 315 degrees.

(SECTOR PHOTOS ARE NOT IN REAL-TIME AND ARE NOT UPDATED!)

Oceans



Large icon indicates selected station. Disclaimer
Stations with recent data
Stations with no data in last 8 hours
(24 hours for tsunami stations)

No Recent Reports

Private WeatherFlow Station Installed 15 Dec 2014 is now Bridging the Gap