Northeast Wind Resource Center Webinar

The Case for Building a U.S. Offshore Wind Vessel + Other Opportunities for the U.S. O&G Sector in Offshore Wind

Hosted by
Val Stori, Clean Energy Group
June 6, 2017
Housekeeping

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The Northeast Wind Resource Center

The Northeast Wind Resource Center (NWRC) is the regional epicenter for salient, unbiased information on land-based and offshore wind energy in the Northeastern United States. Published research, studies, and analyses associated with the issues impacting public acceptance of wind deployment are available in the NWRC Resource Library.

The NWRC is supported in part by a grant from the U.S. Department of Energy's WINDExchange program, and is managed by Clean Energy Group, with participation from Sustainable Energy Advantage and the Maine Ocean & Wind Industry Initiative.

www.northeastwindcenter.org
About WINDEXchange

WINDEXchange is the U.S. Department of Energy (DOE) Wind Program's platform for disseminating credible information about wind energy. The purpose of WINDEXchange is to help communities weigh the benefits and costs of wind energy, understand the deployment process, and make wind development decisions supported by the best available information.

On March 11, 2014, the U.S. Department of Energy (DOE) announced six Wind Energy Regional Resource Centers that were selected through a competitive process administered by the National Renewable Energy Laboratory (NREL).
Panelists

• **Jennifer Runyon**, Chief Editor, Renewable Energy World

• **Brian Cheater**, Technical Director - Naval Architecture, GustoMSC US, Inc.

• **Val Stori**, Project Director, Clean Energy Group
Renewable Energy World is the authoritative source for information on markets, policy and finance covering all renewable technologies – solar, wind, energy storage, geothermal, bioenergy, ocean, river, tidal and hydropower. With 700,000 average monthly page views and more than 300,000 unique visitors. Our digital magazine boast more than 52,000 subscribers; more than 200,000 registered e-newsletter subscribers and a global readership in 174 countries.

Jennifer Runyon
Background: Writing/editing/teaching (Began career as an English teacher). Switched to editing in 2000
Managing editor at Renewable Energy World, 2007
Chief Editor, 2012

In sum: have been covering renewable energy generation since 2007 and have witnessed its growth.
Diversification Avenues for Oil and Gas to support Offshore Wind
1. Project Management

- **Survey**
  - Ornithological and mammal surveying craft
  - Geophysical survey vessel
  - Met station surveys

- **Install Foundations**
  - Construction port
  - Foundation installation vessel
  - Array cable-laying vessel
  - Work class ROV
  - Cable plough

- **Install Turbines and Substations**
  - Substation installation vessel
  - Turbine installation vessel
  - Offshore substation

- **Perform Operations and Maintenance**
  - Technician and equipment transfer
2. Cables

**JDR CHOSEN BY US WIND INC. AS CABLE PARTNER**

February 20th, 2017: JDR, a leading supplier of subsea power cables and umbilicals to the global offshore energy industry, has been selected by US Wind Inc., as the preferred cable partner for its first offshore wind project.
3. Substations

An Offshore Substation

Credit: The Crown Estate / Siemens plc and McNulty Offshore
4. Foundations
More on foundation types

Gravity Base (O&G and WIND)
Monopile (O&G and WIND)
Suction Pile (O&G and WIND)
Post-piled Jacket (O&G and WIND)
Pre-piled Jacket (WIND)
Tripod (O&G and WIND)
Suction Bucket Jacket (O&G and WIND)
Twisted Jacket (O&G and WIND)
Traditional Jacket (O&G and WIND)
5. Secondary Steelwork
6. Installation equipment, Installation support service and Maintenance and Inspection services
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OFFSHORE WIND EXECUTIVE SUMMIT
THE PARALLELS OF WIND, OIL & GAS

NORRIS CONFERENCE CENTERS HOUSTON/
CITYCENTRE
HOUSTON, TEXAS

AUGUST 9
10 2017

TWO MARKETS | TWO DAYS

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Presented By: RENEWABLE ENERGY WORLD Offshore

#OWES17
AGENDA

- COMPANY BACKGROUND
- TRACK RECORD
- VESSEL STUDY
- THE PHYSICAL ENVIRONMENT
- ASSUMED WIND FARM
- TRANSPORTATION AND INSTALLATION
- OUR SOLUTION
- FINANCES
COMPANY BACKGROUND
1862
Start of Gusto Shipyard (The Netherlands)

1977
Start of Marine Structure Consultants B.V. (Sliedrecht)

1978
Start of Gusto Engineering (Schiedam)

1988
IHC Caland completes the repurchase of all Gusto Engineering and MSC shares

2003
Start of GustoMSC alliance

2011
Start of GustoMSC B.V.

2012
GustoMSC acquired by Parcom Capital, management & staff (as of November 2012)
OFFICES

Houston

Schiedam
Headquarters in Schiedam, GustoMSC employs over 140 highly skilled and talented staff.

November 2012 Parcom Capital and the GustoMSC management acquired GustoMSC. As an independent design office we continue to work with our clients and other business partners.
GustoMSC understands how to protect reputations against risks
Collaboration with Energy Companies / Developers, High-End Contractors, Universities, Shipyards, Government Organizations
Safety and Efficiency are key words
GUSTOMSC DESIGN SERIES

CJ Series
Drilling & Production

AJ Series
Accommodation

Sea Series
Construction

NG Series
Construction

Drillships

DSS & Ocean Series

NG Series - Wind

TriFloater
VESSELS
HEAVY LIFT VESSEL “OLEG STRASHNOV” WITH 5,000 TON OFFSHORE CRANE

Design
Engineering & consultancy
Equipment design & supply
After sales services

Photo courtesy Seaway Heavy Lifting
TRI-FLOATER
SEMI-SUBMERSIBLE FLOATING WIND TURBINE FOUNDATION

Design
Engineering & consultancy
Equipment design & supply
After sales services
• **UPGRADES AND MODIFICATIONS:**
  • LEG EXTENSIONS
  • MOORING UPGRADES
  • HULLFORM MODIFICATION – SIZING, MOTIONS AND STABILITY
  • STRUCTURAL MODIFICATIONS

• **CONSULTANCY:**
  • DEADWEIGHT SURVEYS AND INCLINES
  • FEASIBILITY STUDIES
  • HYDRODYNAMICS AND MODEL TESTING
  • CFD STUDIES

• **EQUIPMENT:**
  • CRANES DESIGNS AND UPGRADES
  • JACKING SYSTEMS
  • FIXATION SYSTEMS
  • XY CANTILEVER SKIDDING SYSTEM
HYDRAULIC CYLINDRICAL LEGS
CONTINUOUS HYDRAULIC CYLINDRICAL LEGS
RACK AND PINION TRUSS LEGS
**Heavy Lift Crane**
- Heavy lift, fully revolving offshore derrick cranes. Ideally suited for construction work in the oil and gas sector and for installation of foundations for wind turbines. It can be mounted on either a ship or a semi-submersible.

**Column Crane**
- A range of cranes that can be positioned on a pedestal onboard any type of vessel.

**“Around the Leg” Crane**
- Situated around the leg of a jack-up unit and supported on the jack-house. Enhances operations and increases net deck area, used typically for wind turbine installation.
SPECIALTY CRANES

Main features – leg cranes:

- Bogie wheel system i.s.o. classic slewing bearing
- Electric driven
- Fully (unrestricted) revolving with slip ring for electrical power and instrumentation

Bogie wheel system (typical)
MARKET SHARE OF TURBINE AND FOUNDATION INSTALLATION FROM 2010 TO 2016

**Number of installed Turbines**
- By GustoMSC Jack-ups: 2,024 pcs. (77%)
- Total installed: 2,614 pcs.

**Number of installed foundations**
- By GustoMSC designs: 1,274 pcs. (64%)
- Total installed: 2,000 pcs.

Proven by experience:
- A2SEA, Sea Installer
- Ballast Nedam, Svanen
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<th>Owner</th>
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SEA-SERIES

SEA-3250 “JB-117”
NON-PROPELLED JACK-UP
WITH 800T PEDESTAL CRANE

Other SEA-series
• SEA-600
• SEA-900
• SEA-1250
• SEA-1600
• SEA-1800X
• SEA-2000
• SEA-2500X
• SEA-2750
• SEA-3750C
• SEA-5500C
• SEA-5500X

Design
Engineering & consultancy
Equipment design & supply
After sales services
NG-SERIES
NG-9000C “BRAVE TERN” SELF-PROPELLED JACK-UP WITH 800T LEG CRANE

Other NG-series
• NG-1250
• NG-1800X
• NG-2000
• NG-2500X
• NG-2750C
• NG-3500X
• NG-3750C
• NG-5500C
• NG-5500X
• NG-9800C
• NG-10000X
• NG-14000X
• NG-14000XL

Design
Engineering & consultancy
Equipment design & supply
After sales services
Shallow water range

Characteristics:
• Towed or self propelled and DP
• Crane capacity between 300 – 800 ton
• Load capacity between 1,000 – 2,200 ton
• Water depth range up to 35 - 40 m
Medium water range

Characteristics:
• Self propelled and DP
• Crane capacity between 800 – 1,000 ton
• Load capacity between 2,500 – 6,500 ton
• Water depth range up to 45-55 m
Deep water range

Characteristics:
- Self propelled and DP
- Crane capacity between 1,200 – 2,500 ton
- Load capacity between 6,500 – 8,500 ton
- Water depth range up to 65 m
• NYSERDA ("New York State Energy Research and Development Authority")

• New York, Rhode Island, Massachusetts and Maine part of DOE funded project.

• Growing Realization that Commercial Wind Farm Development will need cross state cooperation.

• Road Map for Multi-State Cooperation on Offshore Wind Development.
  • A Strategy to Achieve a Regional Market of Scale
    • Project 3: US Vessel Study
PROJECT GOAL

• Create a Framework to understand what is required of a wind turbine installation vessel from technical and financial perspectives
  • Design a WTIV
  • Cost it
  • Define the business case required to support it
Questions to frame-up technical requirements:

• What do we need to install and where does it need to go?
• How big is it and how do we need to lift and how do we hold it for installation?
• What do the water depth and metocean conditions look like at the sites we need to work? 
• How far do we need to travel and what are the limitations on draft, beam and height?
Questions to frame-up financial requirements:

- What is the CAPEX of a Jones Act vessel?
- What would the operating expenses (OPEX) be?
- How many turbine installations might be required and how many years of work does this correspond to?
- What kind of pipeline is required?
- What combination of day-rates and pipeline generate acceptable returns on investment?
1. Assume a hypothetical but realistic set of wind farm developments in the Region
2. Assume construction and installation methodologies
3. Develop functional requirements to satisfy those methodologies
4. Develop the concept designs for a WTIV or feeder jack-up satisfying the technical requirements
5. Submit the estimating packages to selected US shipyards to obtain build prices for Jones Act compliant vessels
6. Create a crewing model for a US flagged installation vessel
7. Create a vessel-specific financial model tracking capital (CAPEX) and operational (OPEX) expenses to generate Net Present Value (NPV), and Internal Rate of Return (IRR)
THE PHYSICAL ENVIRONMENT
WIND FARMS

1. Massachusetts - Deepwater ONE (1200 MW)  
   Deepwater wind  
   31.3 - 49.3m WD
2. Massachusetts - Bay State Wind (1000 MW)  
   DONG Energy  
   33.1 - 56.6m WD
3. Massachusetts - Vineyard Wind  
   CIP / Avangrid  
   36.5 - 58.5m WD
4. Rhode Island - Block Island Wind Farm (30 MW)  
   Deepwater wind  
   23 m WD
5. New York - Wind Energy Area  
   Statoil  
   18.5 - 42m WD
6. New Jersey - US Wind Inc (2230 MW)  
   US Wind / Renexia  
   14.0 - 32.9m WD
   DONG Energy  
   13.4 - 40.5m WD
8. Maryland - Skipjack & Garden state  
   Deepwater wind  
   18 - 27 m WD
9. Maryland - US Wind Inc (750 MW)  
   US Wind / Renexia  
   11.8 - 46.5m WD
10. Virginia - Dominion - Phase 1+2 (2000 MW)  
    Dominion  
    18 - 33m WD
11. North Carolina - Kitty Hawk  
    Avangrid  
    31 - 43m WD
- 81% of sites < 55m of water
- Average Water Depth 48.71m
Let’s put this in perspective – this is deep compared to Europe
CHALLENGES - SITE CONDITIONS

• Offshore Environmental Conditions
  • Wave Conditions – height and period
  • Tides and Storm Surges
  • Wind Speed
  • Current
• **Design Environmental Conditions (50-yr storm)**

  • Significant Wave Height (Hs): 10m
  • Maximum Wave Height (Hmax): 19.5m at 14 sec
  • Highest Astronomical Tide (HAT): 0.79m
  • Associated Storm Surge: 1.59m
  • 1-minute mean wind at 10m (Vw): 38 m/s [74 knots]
  • Surface Current (Vc): 1.2 m/s [2.3 knots]
• **SOIL CONDITIONS**

  • No site specific data available. Following assumed based on public reports.
  
  • High Sand Content (80-100%) in the Northern 2/3\(^{rd}\) of the region
  
  • Predominantly silt and clay in the southeastern section
  
  • Southern extent of glaciation -> Risk of large boulders.
CHALLENGES - WEATHER AND WATER DEPTH

• Increasing Water Depth
  • Europe: 15-30m
  • North East US: 15-65m
• 18m (59ft) winter waves
ASSUMED WIND FARM
REQUIREMENTS

- Install 100 x 8MW wind turbines:
  - Foundations – piles and jackets (optional)
  - Towers
  - Nacelle
  - Blades

- Safe and Secure Year-round operation.
- Maximum water depth 55m (summer) and 50m (winter)
- Deck area and load capacity to carry four turbines
- Crane capacity and reach to lift, position, and hold in precise alignment 8MW turbine
REQUIREMENTS - 8MW TURBINE

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<td>BLADE CHORD(m)</td>
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<td>NACELLE WEIGHT(te)</td>
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<td>LIFTING FRAME (te)</td>
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<td>NACELLE WIDTH(m)</td>
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<td>SECTION WEIGHT(te)</td>
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REQUIREMENTS - 8MW TURBINE

• Towers may be up to 500MT
• Lengths of up to 94m
• Diameters of up to 6.75m
• Large Deck Capacities
REQUIREMENTS - 8MW TURBINE

• Nacelles at great height and reach:
  • Nacelles may be 21mL x 9.6mW x 9.6mH
  • They weigh up to 450MT with 50MT lifting frame
  • They need to be lifted to at least 117m above the sea and held in place while they are bolted
LIFTING REQUIREMENTS

- 450 te nacelle +
- 50 te frame/rigging
- 500 te SWL

Height = 123m above still water line
CHALLENGES - CRANE CAPACITY

- Not just lifting weight
- Reach and Hook Height requirements drives selection of crane
- Need to refer to the Crane Load Chart
REQUIREMENTS - 8MW TURBINE

- Turbine Blades at great height and reach:
  - Blades are 85m long with a 6m chord
  - They weigh up to 40MT
  - They need to be lifted to at least 117m above the sea and held in place while they are bolted
CHALLENGES - PRECISION

- Held precisely for extended periods of time for assembly and securing
- Safety is paramount!
DESIGN CONSIDERATIONS - FOUNDATIONS

8 MW

8

WATER DEPTH >20m Y/N?

N

MONO-PILES Y/N?

WEIGH 1050MT FLOAT OUT

UPEND AND INSTALL WITH 2500MT CLASS FLOATING CRANE

Y

GOTO "A" JACKET

JACKETS

PIN PILES Y/N?

SITE PREP: ROCK DUMP JETTING LEVELING

N

Y

JACKET > 1300t Y/N?

INSTALL WITH HEAVY LIFT 2500MT CLASS FLOATING CRANE

N

GOTO "A" JACKET

A

INSTALL JACKETS with WTIV

N

500MT SWL @ 120m above sea

800 MT CLASS CRANE

Y

1000MT SWL @ 21m out reach

1500MT CLASS CRANE

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• 8 MW turbines in 55m of water exceed the current range for monopiles.

• Risk of monopile refusal if boulder hit.

• Jackets may be more complex to manufacture but are proven technology.

• Pin-Pile Jackets were adopted as the most weight efficient and also with these installation of the piles can be done separately providing more schedule flexibility.
REQUIREMENTS - 8MW TURBINE

- FOUNDATION supporting an 8MW turbine in 55m of water:
  - Water Depth - 55m
  - Airgap - 15m
  - Jacket Height - 70m
  - Jacket Base - 30m x 30m
  - Jacket Weight - 1000te (approx)
- Transportation
  - Barge - 3 or 4 per trip.
  - Deck of Self Propelled WTIV or Feeder Barge - 1 per trip
  - Piles - 2.7mØ x 40m, 150MT each (approx.)
  - Pile Installation and Driving by hammer
TRANSPORTATION AND INSTALLATION
TRANSPORTATION STRATEGIES

• **Transit Strategy**
  - Main wind turbine installation vessel (WTIV) sails into port, loads and then carries parts and material out to the wind farm site where it will perform the installation. It will then return to port for the next load.

• **Feeder Strategy**
  - WTIV remains in the field and is supplied by one or more feeder barges which ferry parts and material out from the port to the wind farm site. The WTIV lifts the material off the Feeder Barge which then returns to port for more material. The feeder barges are smaller units with no main crane.
• Large Deck Capacities:
  • Transit option (4 Turbines)
    • 3450m$^2$ of deck space
    • 6400te of deck load
  • Feeder option (2 Turbines)
    • 1800m$^2$ of deck space
    • 3400te of deck load
CHALLENGES - MARINE OPERATIONS

- Need to transit and accurately position installation vessel at least 100 to 300 times in quick succession so a dynamic positioning system should be installed.
  - Lack of ready inventory of DP capable tugs/supply boats/crane barges in the area
  - Handling multiple units in close proximity for an extended period of time increases the SIMOPS risk
- Ports limit maximum beam to 150ft. Draft must be less than 28.5 feet.
- Vessels will not be able to enter ports with bridges

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INSTALLATION METHODOLOGY

- PIN-PILE INSTALLATION – Winter
INSTALLATION METHODOLOGY

- JACKET INSTALLATION – Early/Late in Season
- TURBINE INSTALLATION - Summer
OUR SOLUTION
• Design Philosophy
  • Wind is not like offshore oil. It is a repetitive industrial process not a one-off operation.
  • Reduce the risk of schedule delay through improved operability and simplicity of operation
  • Reduce personnel exposure in small boats, over the side or at height
  • Maintain positive control of all loads at all times
  • Provide flexibility to perform more than one function
  • Increase operational weather windows
  • Stay on-location and operate year-round
  • Ease loading options in port
• Satisfy all Class and USCG requirements
• Design to the 50yr winter storm per SNAME 5-5A
• Provide a 1500te crane with a minimum 30m lift radius
• Self-propelled (≥ 9 knots) and self-installing with a DP-2 system
• Minimize preload time using cross-loading on 4-legs.
• Continuous jacking system (24m/hr) to speed up going on location
## Main particulars

### Principal dimensions

<table>
<thead>
<tr>
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<th>Value</th>
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<tbody>
<tr>
<td>Hull length</td>
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<tr>
<td>Hull width</td>
<td>42.0 m</td>
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<tr>
<td>Hull depth</td>
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<tr>
<td>Leg length max. (incl. spud-can)</td>
<td>92.0 m</td>
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<tr>
<td>Leg Length max. under Hull</td>
<td>± 69.0 m</td>
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<tr>
<td>Water depth (survival)</td>
<td>50-55 m</td>
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<td>Pre-load</td>
<td>9,800 t</td>
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<tr>
<td>Variable load</td>
<td>6,400 t</td>
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<tr>
<td>Deck area</td>
<td>3,450 m²</td>
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<tr>
<td>Deck load</td>
<td>10 t/m²</td>
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</tbody>
</table>

### DP-2

- Accommodation: 90 PoB
- Jacking moves: 150 / yr

### Main crane

- Leg type: 1,500 t
### NG-3750C FEEDER

**Main particulars**

**Principal dimensions**
- Hull length: 70.5 m
- Hull width: 38.0 m
- Hull depth: 6.5 m
- Speed: 7 kn

**Leg length max. (incl. spud-can)**: 86.0 m
**Leg Length max. under Hull**: ± 68.0 m
**Water depth (survival)**: 50 m

**Variable load**: 3,400 t
**Deck area**: ± 1,800 m²
**Deck load**: 10 t/m²
**DP-2**:
**Accommodation**: 12 PoB

**Jacking system**
- Positive Engagement
- Continuous hydraulic, “Pin in Hole”
- Pre-load: 3,750 t
- Jacking moves: 150 / yr

(Ref. 120.)

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FINANCES
AVERAGE PRICE FOR 9800C-US (WTIV): $222 million

10 years of work at $220,000 /day is required to generate an internal rate of return of at least 10%

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<th>Duration Months</th>
<th>Month</th>
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<tr>
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</tbody>
</table>
AVERAGE PRICE FOR 3750C (Feeder): $87 million

20 years of work at $85,000 /day is required to generate an internal rate of return of at least 10%

| Activity               | Duration Months | Month 1 | Month 2 | Month 3 | Month 4 | Month 5 | Month 6 | Month 7 | Month 8 | Month 9 | Month 10 | Month 11 | Month 12 | Month 13 | Month 14 | Month 15 | Month 16 | Month 17 | Month 18 | Month 19 | Month 20 | Month 21 | Month 22 | Month 23 | Month 24 | Month 25 | Month 26 | Month 27 | Month 28 | Month 29 | Month 30 | Month 31 | Month 32 | Month 33 | Month 34 | Month 35 | Month 36 |
|------------------------|-----------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| START NG-3750          |                 | X       |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| ENGINEERING            | 9               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| PROCUREMENT            | 12              |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| CONSTRUCTION           | 18              |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| LAUNCH                 |                 |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| COMMISSIONING          | 3               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| SEA-TRIALS             | 1               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| END NG-3750            | 0               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
• CONCLUSIONS

• The WTIV requires 10-years of work.

• This will require not one project, but an identified pipeline of projects that a group of states, developers and federal agencies cooperate on.

• However, if the full potential of the offshore wind area on the East Coast is realized (and not just the sample considered here!) then not one, but several vessels may be justified
THANK YOU FOR YOUR KIND ATTENTION
Thank you for attending our webinar

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Northeast Wind Resource Center: www.northeastwindcenter.org
DOE Wind Exchange: http://energy.gov/eere/wind/windexchange