Offshore Wind

Agenda – Part 1

Anne-marie Coyle
Sales Director, GE Offshore Wind

- **Presentation of GE Renewable Energy**
- **Haliade-X Offshore Wind Turbine**
- **Commercial Deployment, Service, Technology Development**

ONSHORE WIND

OFFSHORE WIND

LM WIND POWER

UNLEASHING LIMITLESS ENERGY

DIGITAL SERVICES

GRID SOLUTIONS

HYDRO

HYBRIDS

$15B REVENUE

80+ COUNTRIES

40,000+ GLOBAL EMPLOYEES

40,000+ WIND TURBINES INSTALLED GLOBALLY

25%+ OF WORLD'S HYDRO INSTALLED BASE

90% OF UTILITIES WORLD-WIDE USE GRID SOLUTIONS TECHNOLOGY

400+GW INSTALLED BASE THE WORLD'S LARGEST CLEAN ENERGY FOOTPRINT

>10% OF GLOBAL RENEWABLE ENERGY CAPACITY IS PROVIDED BY GE TURBINES

As of December 31, 2019

GE Renewable Energy - Our Journey

2003: Started with the acquisition of Enron's wind business out of bankruptcy for ~$300M

2015: Alstom Power and Grid deal: Created stand-alone Renewable Energy business adding offshore wind and hydro

2016: Increased R&D expenditures to expand portfolio and gain competitive edge

2017: Purchased LM Wind Power, bringing blade design and manufacturing in house

2018: Launched the Haliade-X, a bold move into offshore and across the 10 MW threshold

2018: Launched Cypress, the 5 MW onshore platform that creates new value for our customers in Europe and Asia

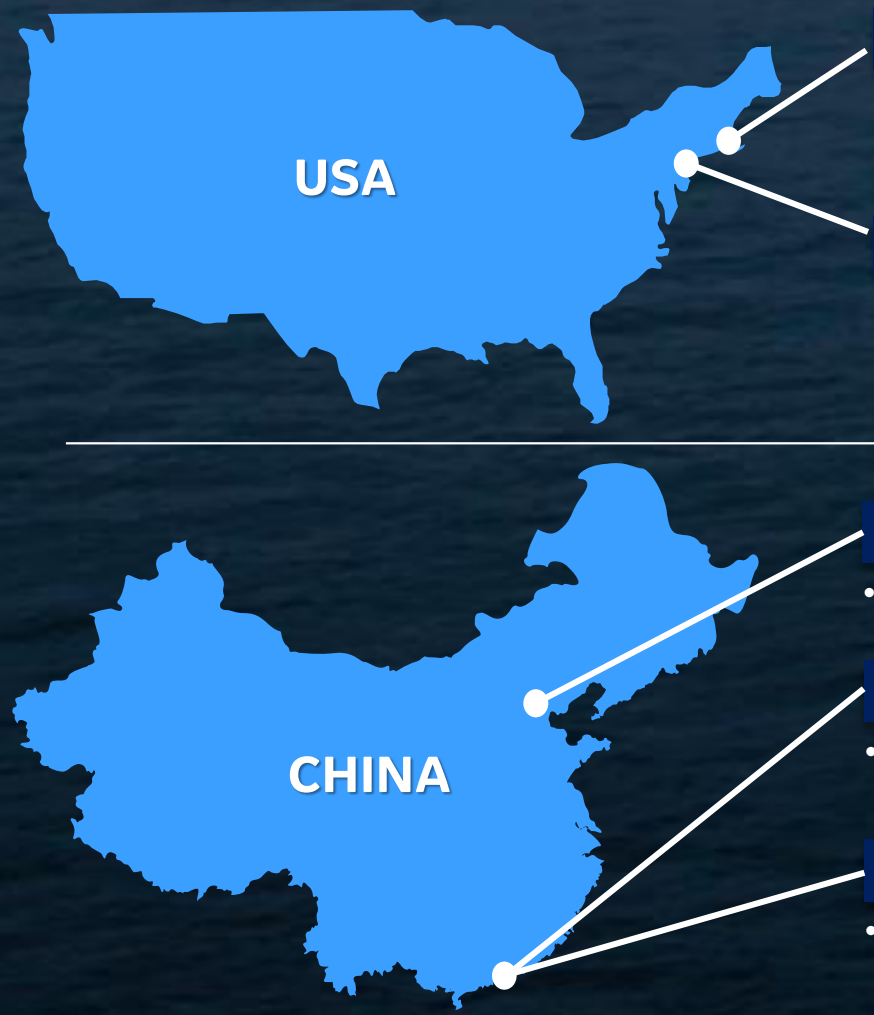
2019: Moved Grid, solar inverters and storage from the traditional power gen business into the Renewable Energy portfolio

2019: Created Hybrid business to combine emerging storage technology with renewable sources

Today **GE Renewable Energy** is a $15B business

Our mission is to unleash limitless energy by enabling affordable, reliable, sustainable, and accessible green electrons to power the world

Our Offshore Wind Footprint



Foxborough (MA)
- Sales and tendering

Quonset (RI)
- O&M (Block Island)

Beijing
- Offices

Jieyang
- Manufacturing site *(operational in 2021)*

Guangzhou
- Development Center

Hamburg
- Sales & tendering
- Project execution

Rotterdam
- Haliade-X 12 MW prototype

Ostend
- O&M (Osterild)

Cherbourg
- Blades site (LM)

Saint-Nazaire
- Manufacturing site

Le Carnet
- Testing site

Nantes
- Offshore HQ offices

Barcelona
- Engineering
- R&D

Haliade-X: POWER MEETS EFFICIENCY

GE's Largest, High Efficiency Offshore Turbine

Innovative Blade Design by LM Wind Power

Ideal for High to Medium Wind Speeds

NOMINAL CAPACITY
- 12-14 MW

CAPACITY FACTOR
- 60-64%

ANNUAL ENERGY PRODUCTION
- ~64GWh to ~74GWh

ROTOR DIAMETER
- 220 METERS

WIND CLASS
- IEC IB-IC

DESIGN LIFE
- 25 years & site specific life time ext.

HUB HEIGHTS
- 138 m

FREQUENCY
- 50 & 60 Hz

Design drivers:

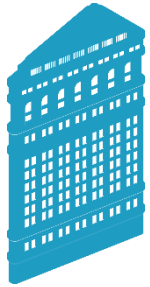
- Design for **EHS and ergonomics**
- **Highest Capacity Factor for Lowest LCOE**
- **Modular design** on **proven technology** for a simple, reliable & flexible assembly
- Flexibility inside the **plant and the global supply chain**
- **Standardization** to drive continuous improvement
- **Independent testing** of modules & full validation/commissioning in manufacturing plant
- **Simple interfaces** to avoid complex tooling & simple installation

HEIGHT

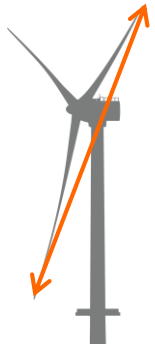
TOTAL HEIGHT OF THE HALIADE-X

853 ft /248 m

equivalent to **3X** the height of the **Flatiron Building**



x3

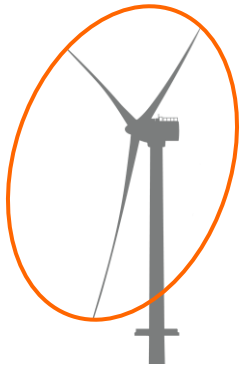


DIAMETER

OF THE ROTOR

722 ft /220 m

equivalent to **Golden Gate Bridge** tower height above the water



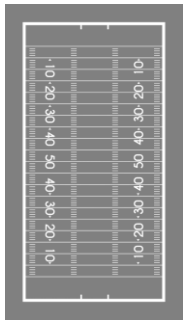
SURFACE

OF THE BLADE SWEEP

410,000 sq ft

38,000 m^2

equivalent to **7 American football fields**



x7

HALIADE-X 13 MW

GE Renewable Energy is developing **Haliade-X 13 MW**, the biggest offshore wind turbine in the world, with **220-meter rotor**, **107-meter blade**, leading capacity factor **(63%)**, and **digital capabilities**, that will help our customers find success in an increasingly competitive environment.

ONE HALIADE-X 13 MW CAN SAVE UP TO

52,000 metric tons of CO2, the equivalent of emissions generated by 11 vehicles in one year.

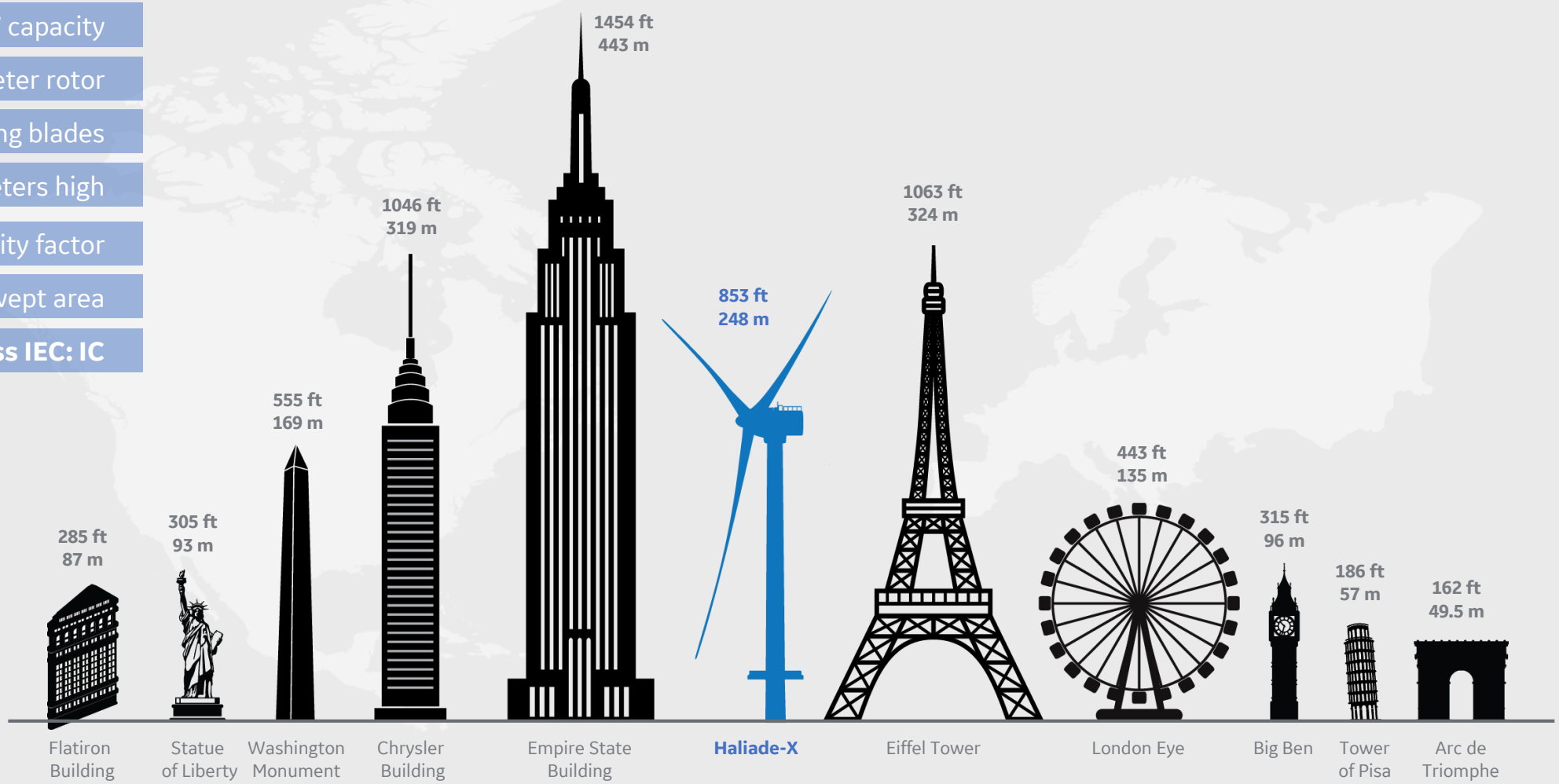
* According to the U.S. Environmental Protection Agency Greenhouse Gas Equivalencies Calculator.

HALIADE-X 13 MW-220

GE Renewable Energy is developing **Haliade-X 13 MW**, the biggest offshore wind turbine in the world, with **220-meter rotor**, **107-meter blade**, leading capacity factor **(63%)**, and **digital capabilities**, that will help our customers find success in an increasingly competitive environment.

One **Haliade-X 13 MW** can save up to 52,000 metric tons of CO2, the equivalent of emissions generated by 11,000 vehicles in one year.

- **13 MW** capacity
- **220**-meter rotor
- **107**-meter long blades
- **248** meters high
- **63%** capacity factor
- **38,000** m^2 swept area
- **Wind Class IEC: IC**



Haliade-X blade testing

Test blade 1

- Testing location is at OREC in UK.
- Pre-fatigue static test will consist of 4 individual tests in 4 main blade directions: 2 flap and 2 edge.
- Fatigue test flap wise and edgewise.
- Post fatigue static test: 4 individual tests in 4 main blade directions: 2 flap and 2 edge.

Test blade 2

- Testing location is at WTTC in US.
- Pre-fatigue static test will consist of 2 individual tests only in edgewise direction to leading edge and to trailing edge.
- Fatigue test edgewise.
- Post-fatigue static test: 2 individual tests only in edgewise direction to leading edge and to trailing edge.

Testing on 2 blades for accelerated de-risking

Haliade-X prototype installation

First 12 MW wind turbine ever installed! Now operating at 13 MW.

Haliade-X turbine prototype installation

Haliade-X: An international recognition

MILESTONES

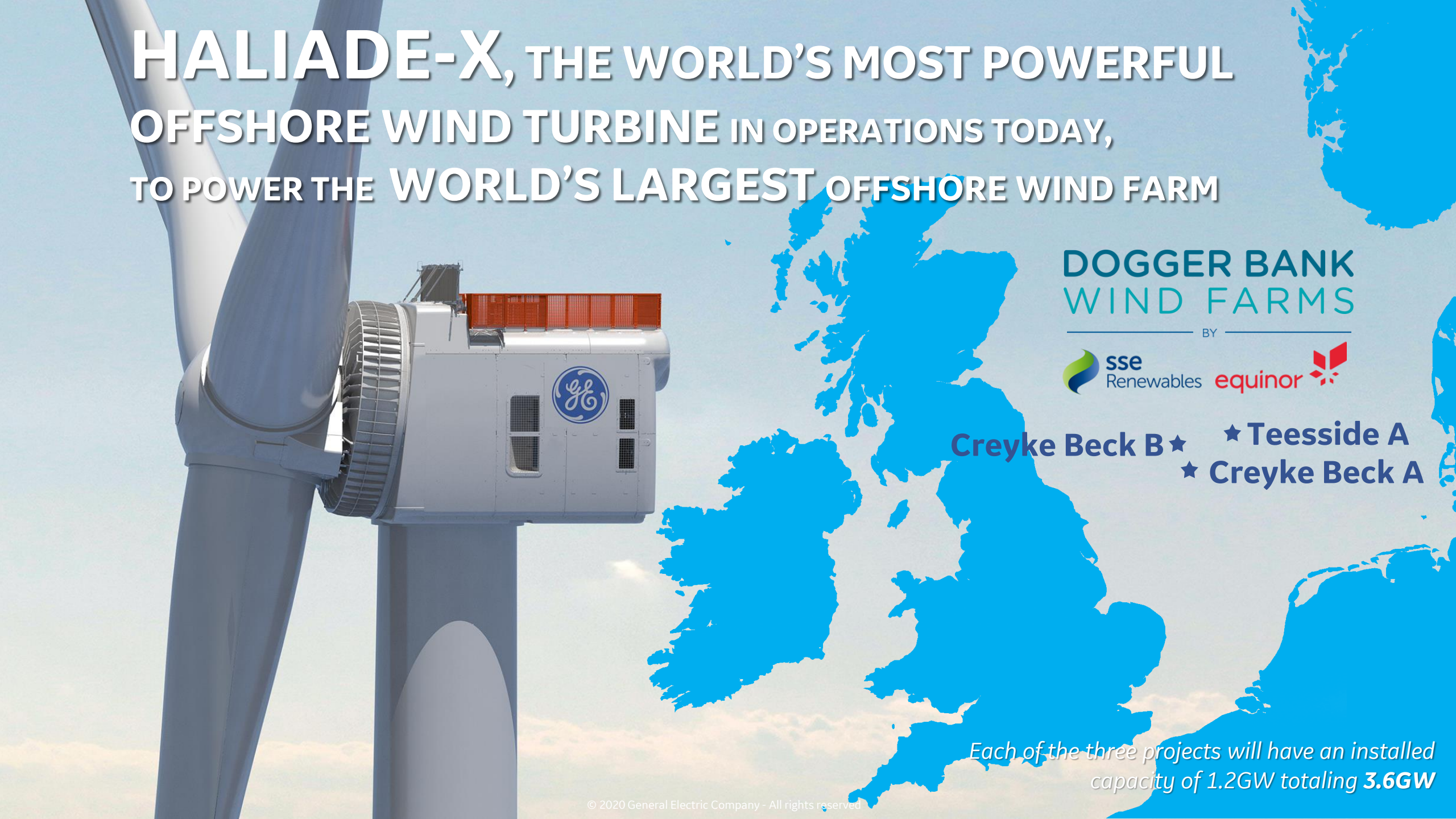
- NOV ‘19: Generated its 1st MW
- JAN ‘20: First wind turbine to ever generate **288 MWh** in one day!
- JUN ‘20: Provisional type certificate 12 MW-220 (DNV-GL)
- NOV ‘20: Broke its own record! **Generated 312 MWh in 24h!**
- NOV ‘20: **Full type certificate** 12 MW-220 (DNV – GL)

RECOGNITIONS

Best Sustainable Invention of the Year
TIME magazine – (DEC 2019)

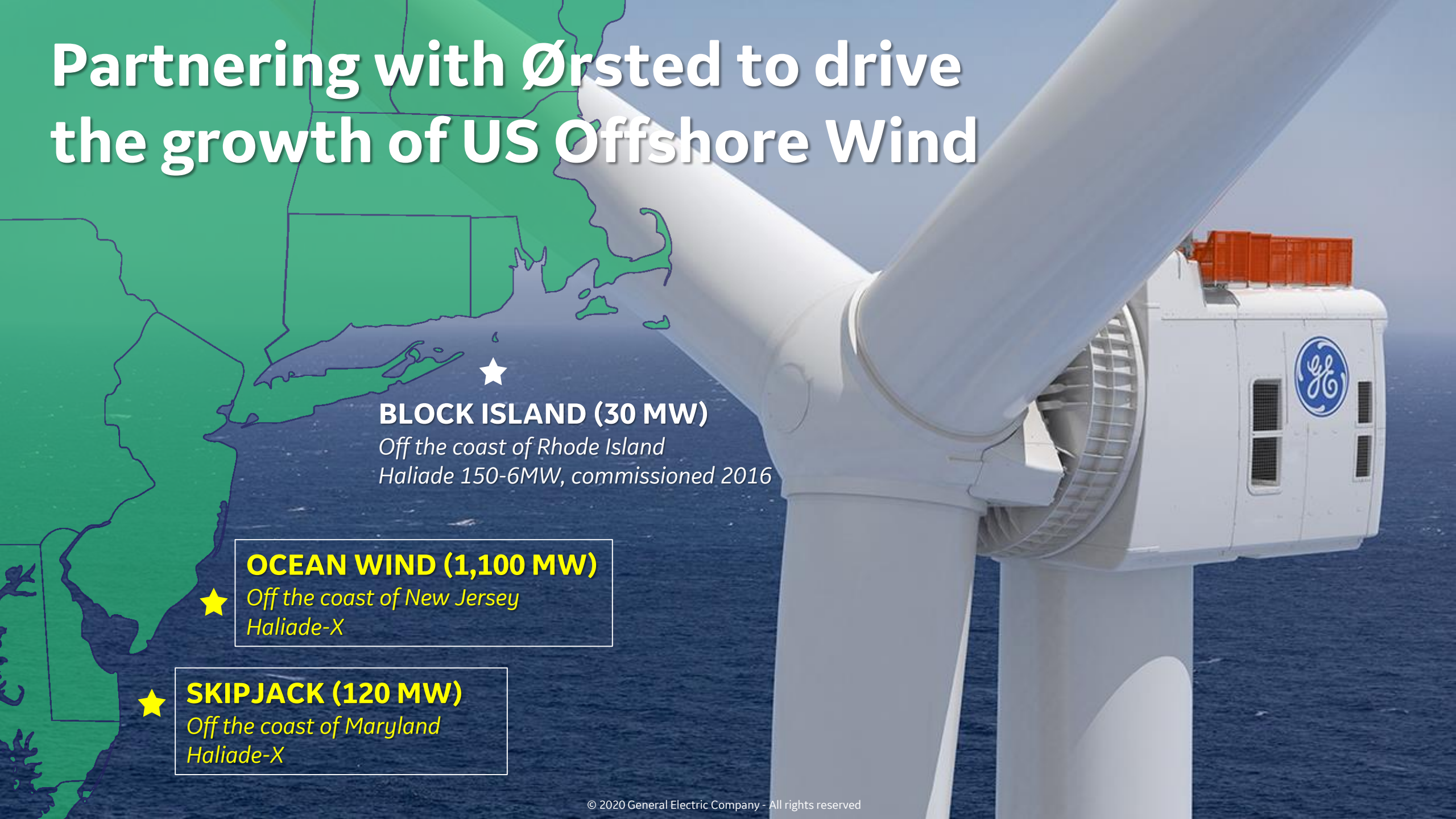
Best Wind Turbine of the Year
Wind Power Monthly magazine – (JAN 2020)

HALIADE-X, THE WORLD'S MOST POWERFUL OFFSHORE WIND TURBINE IN OPERATIONS TODAY, TO POWER THE WORLD'S LARGEST OFFSHORE WIND FARM



*Each of the three projects will have an installed capacity of 1.2GW totaling **3.6GW***

Partnering with Ørsted to drive the growth of US Offshore Wind



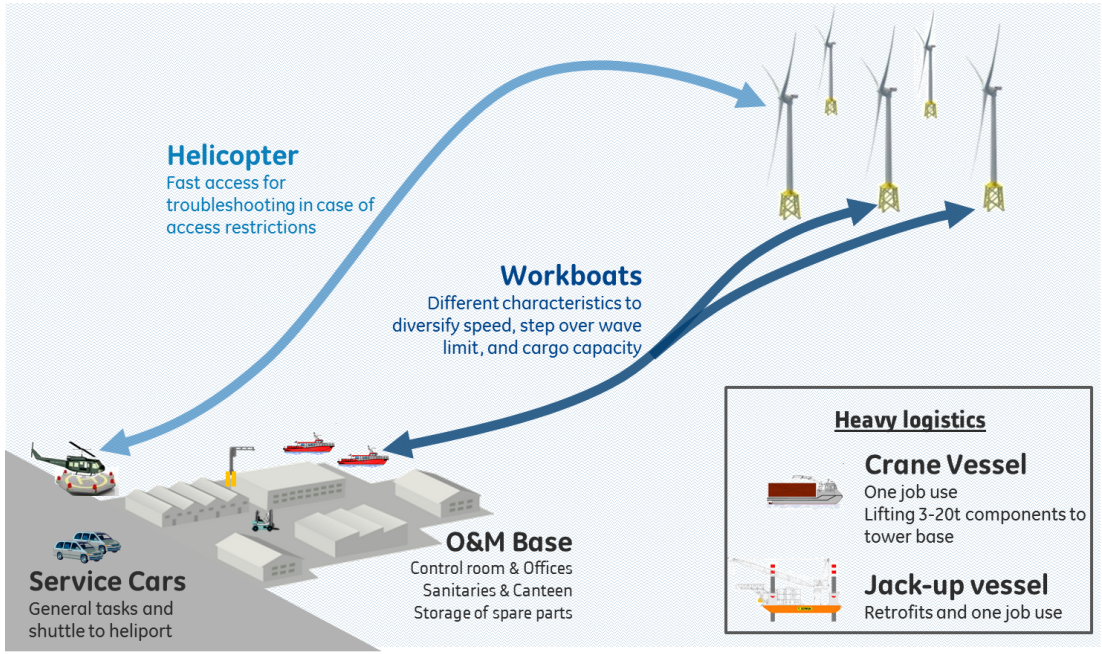
BLOCK ISLAND (30 MW)
Off the coast of Rhode Island
Haliade 150-6MW, commissioned 2016

OCEAN WIND (1,100 MW)
Off the coast of New Jersey
Haliade-X

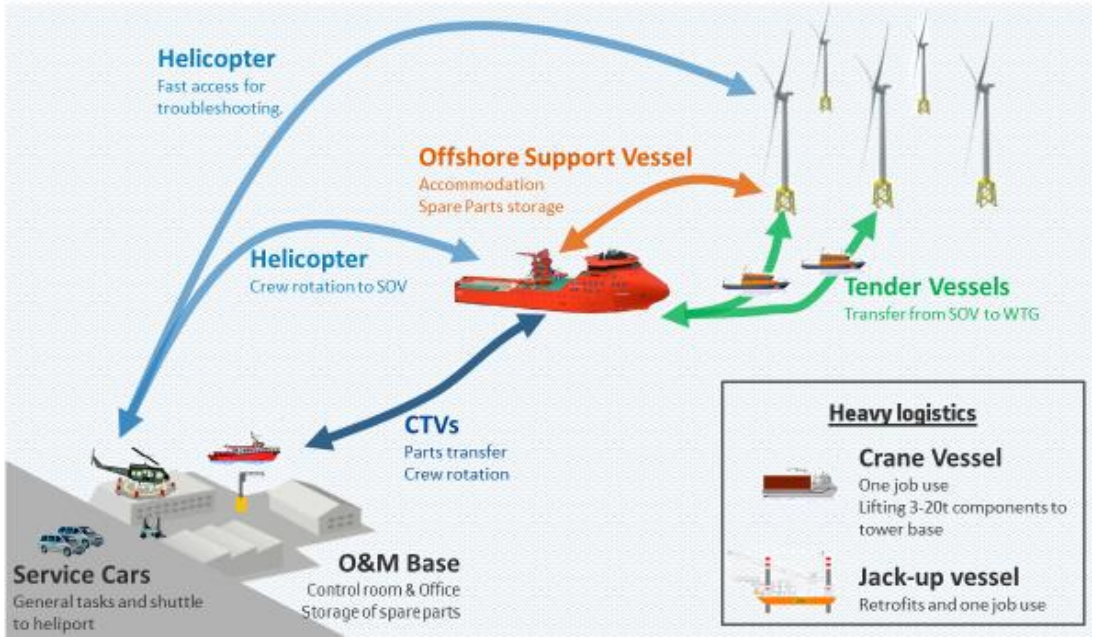
SKIPJACK (120 MW)
Off the coast of Maryland
Haliade-X

Accomodation onshore or on a vessel next to the wind farm

Onshore Stategy



Offshore Strategy



Site specific features and business case will lead the strategy choice

GE's "Stay Ashore!" Program

DESIGN VALIDATION

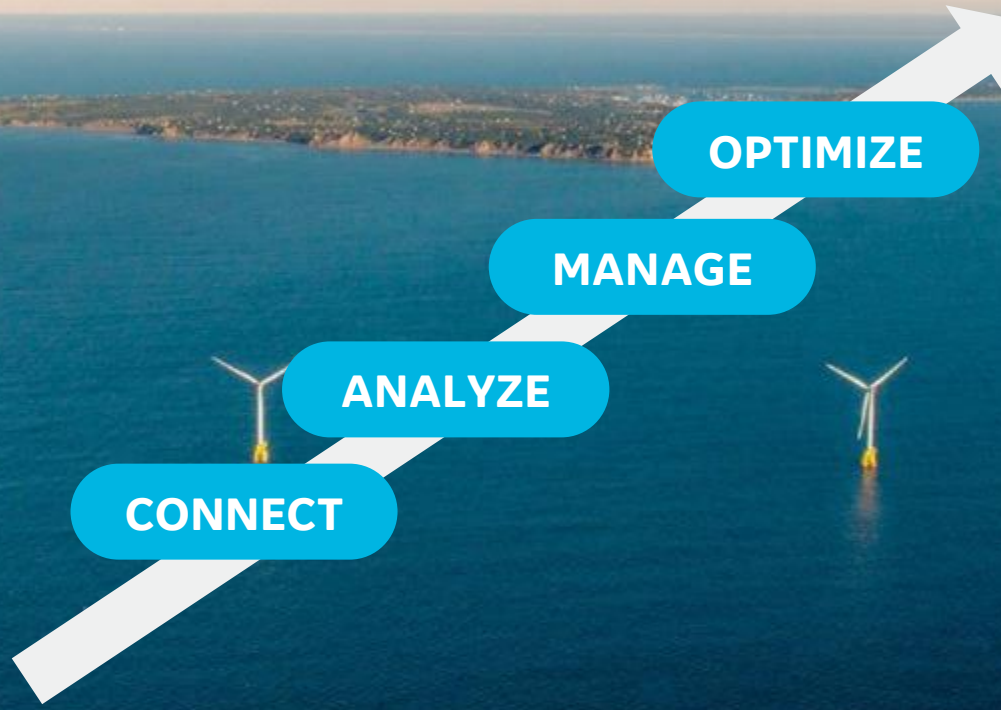
- Endurance Testing
- Thermal Performance
- Extreme Conditions

DIGITAL

- Remote Operability
- Digital Twin and Life Models
- Smart O&M Strategies

ROBOTICS

- Inspection and Repairs
- Repetitive Tasks
- Confined Space



OUTCOME

- **Increase Revenue**
- **Reduce Cost**
- **Reduce Risk**

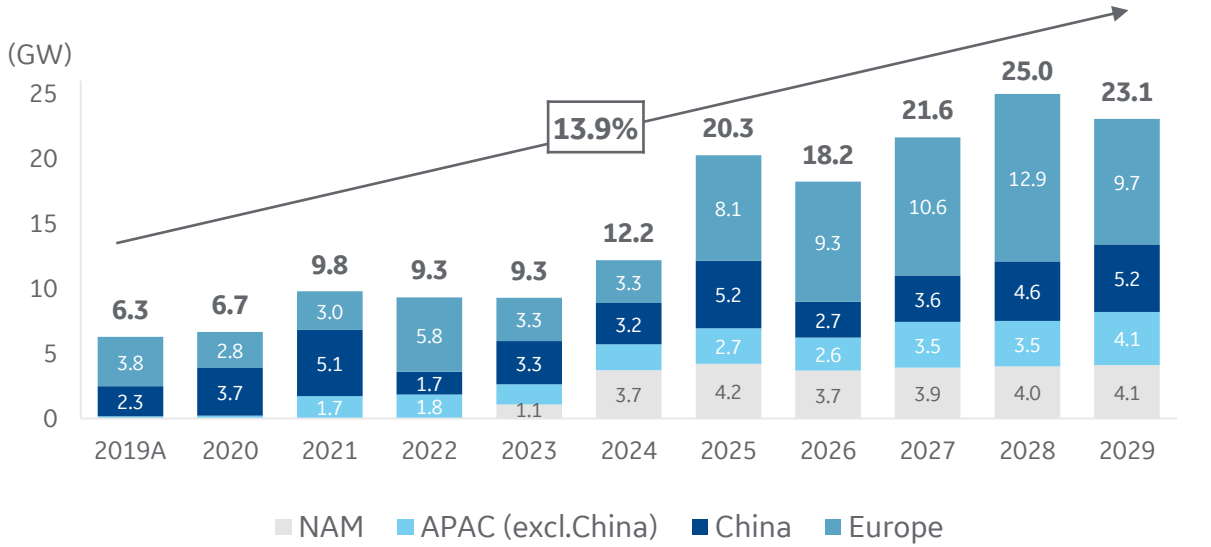
Reducing risk and OPEX through deployment of new technology

Agenda - Part 2

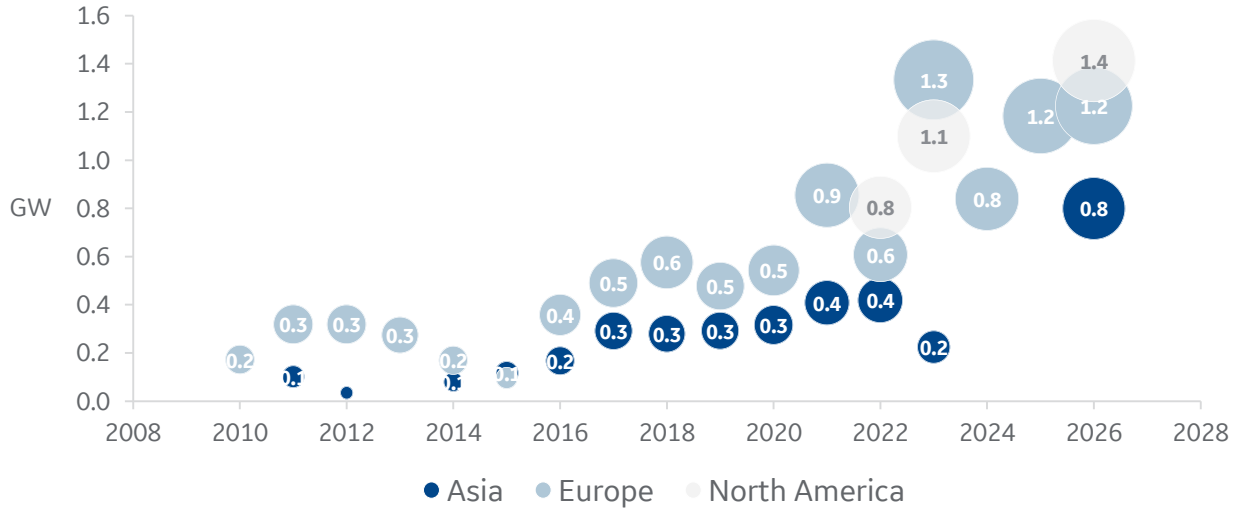
- **Market**
- **Project Cycle Time**
- **Balance of Plant Considerations**

Offshore Wind Segment Dynamics

Commissioning activity and forecast by region



Average project size by region and year



- Offshore Wind is evolving as a **cost effective** alternative to fossil fuel, achieving resilient **10+ GW/year capacity addition** from 2024 onwards
- Costs reduction in offshore wind power generation driven by **technological advances** and **increasing efficiency** in the global supply chain
- Introduction of **larger turbines** (with GE's 12 MW Haliade-X platform) allows customers to meet the challenges of a "subsidy-free" auction environment
- **EMEA** remains the **largest segment**, but China is growing rapidly. USA is poised for take-off, and momentum is building in APAC.

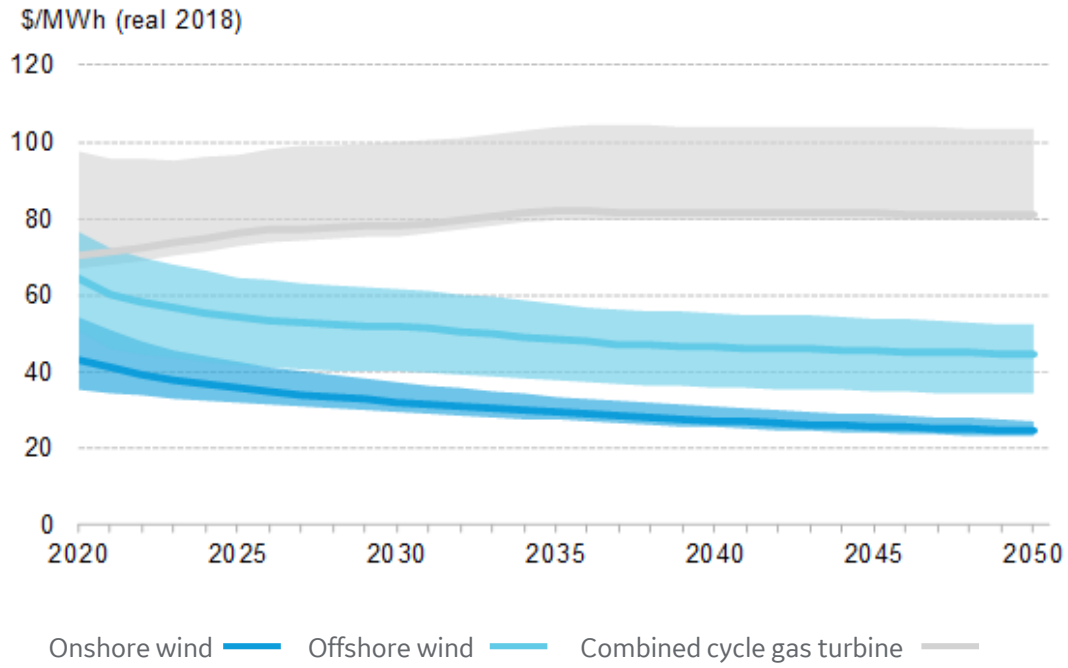
- **Larger projects** and **next generation turbines** are delivering economies of scale and contributing to cost reduction
- **CAPEX per MW** for individual projects is **decreasing** as offshore wind technology and industry develop
- Projects passed the 20km "comfort zone" and mostly are located at less than 60 km from shore. Dogger Bank, will push boundaries into the **150 km range**
- **Floating offshore** can unlock further capacity by end of the decade in countries with wind resources inaccessible for fixed foundation (e.g. South Korea, Japan, Ireland, Norway, Spain and Greece)

Offshore global commissioning expected to exceed 15 GW/year commissioning rate from middle of the decade

Sources: WoodMac (2Q 2020), 4C Offshore (Jun2020) - commercial projects excluding demonstration projects

Offshore wind competitiveness vs. other technologies

Offshore wind approaching the tipping point



Levelized Cost of Energy (LCOE) Forecast - UK

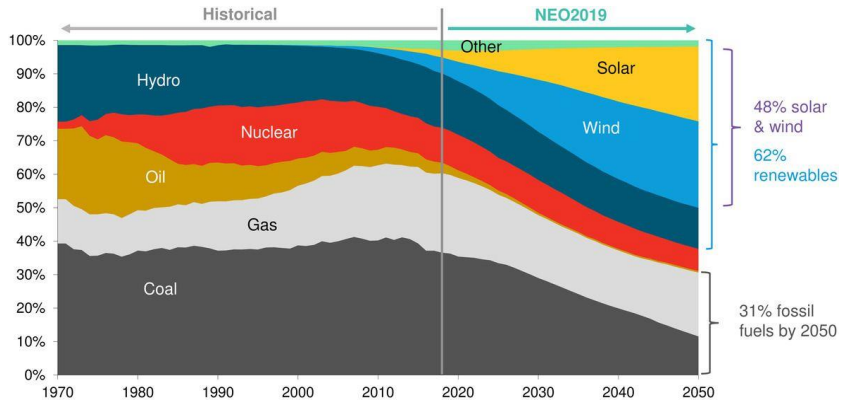
Source: BNEF (April 2020)

Market enablers for offshore wind competitiveness

- In markets with stable demand, offshore wind can substitute retiring large-scale plants
- In growth markets, offshore wind makes sense near coastal cities or to substitute cancelled fossil fuel or nuclear projects
- Offshore Wind is competitive at the right market conditions
  - Prerequisite: **Health, Safety & Environment** considerations
  - Key success factors: policy (**sustainable energy targets**, clear **consenting** process); **grid connection** (framework, technology)
  - Musts for industrialization: **marine infrastructure** (ports, vessels); **competitive supply chain** (full value chain: turbines, substructures, cabling, skills and equipment…); scale economies for large components

Offshore Wind Gaining Share

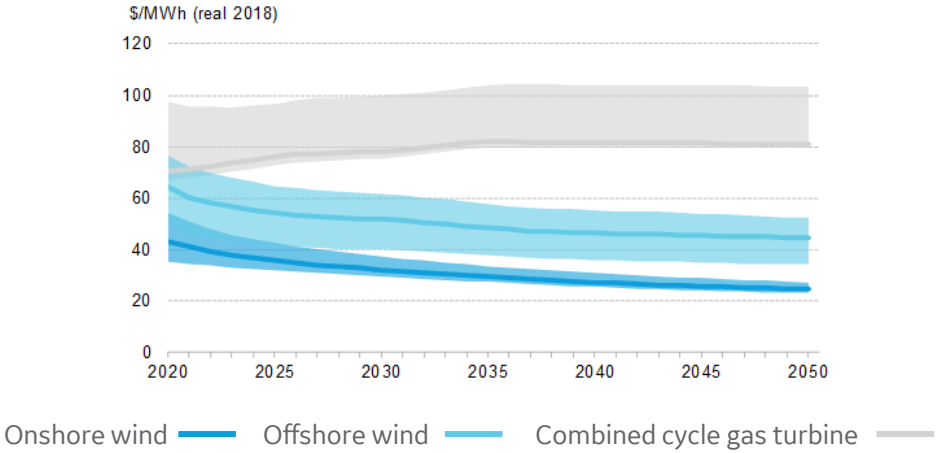
Offshore share in the global energy mix



Offshore Wind Supply as % of Global Energy Supply

- Offshore is expected to grow from a negligible % of global energy supply in 2020 to **4% of global energy supply** in 2050
- Offshore wind is **preferred** in markets where other renewables can't achieve necessary scale and/or onshore renewables deployment faces resistance or transmission limits
- In the past few years, governments (e.g., Denmark, UK, Netherlands, France, US states, Chinese provinces) have run **offshore-specific energy auctions** when the goal is to achieve scale using a renewable source

Where offshore is competitive



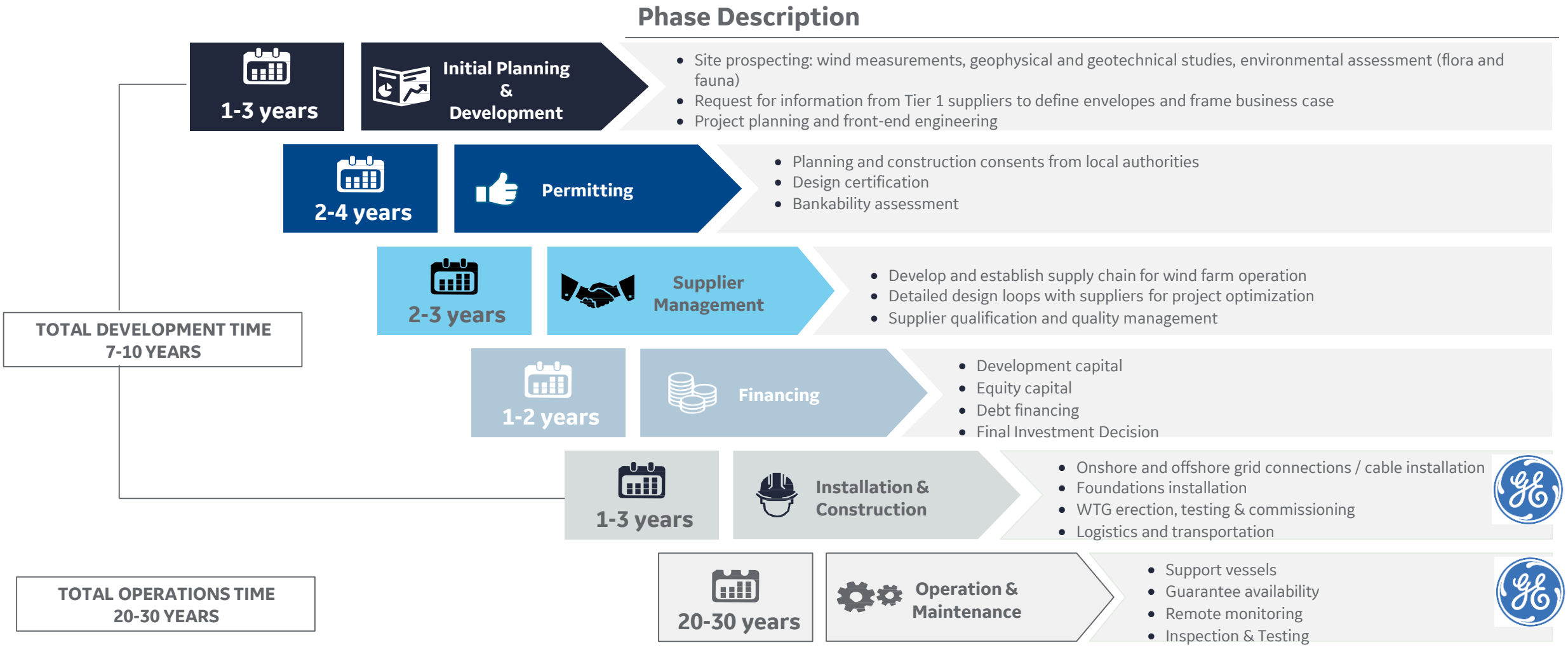
Levelized Cost of Energy (LCOE) Forecast - UK

- The **cost of offshore energy production** is **falling**, allowing offshore to compete with the other energy sources and gain share in the energy mix
- Offshore is **already competing** with thermal and other renewable resources in mature European markets and countries with high gas prices
- In certain countries (e.g., Germany, Netherlands, UK) offshore no longer requires public **subsidies** to achieve profitability (directly or through supply chain localization initiatives)
- Governments consider development in offshore an opportunity to **re-launch local economies** and create **jobs post-Covid**

Offshore wind gaining share of global energy production due to scale and competitive LCOE

Sources: BNEF (April 2020)

Typical Offshore Wind Farm Life Cycle



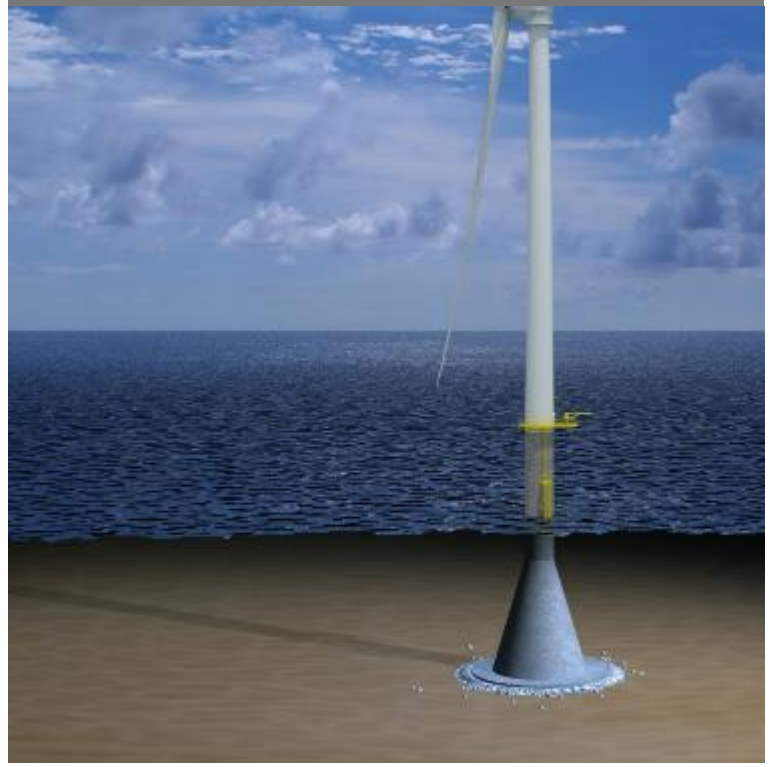
Offshore wind is a long-term cycle business with limited short term volatility

Haliade-X: Compatible with multiple foundation types

Monopile
Compatible with monopiles
up to 50 m water depth

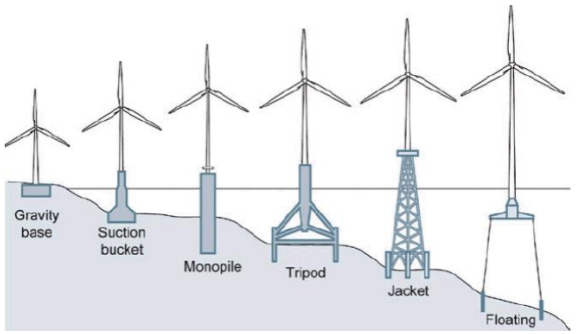
Jacket
For complex soil conditions
and/or deep waters

Alternatives
Pile cap and gravity-based structure
foundations for selected sites



designed to enable foundation selection based on project needs and lowest costs

Floating is a Mid to Long-term Emerging Market Opportunity



Foundation	Application	Advantages	Disadvantages
Monopiles	Most conditions, preferably shallow water with soft soil. Up to 12m diameter.	Simple, light and versatile. For depth up to 40-45m	Expensive installation due to large size. Difficult to remove at end of life
Floating	Deep water	Non-rigid, so lower wave loads. Opportunity to install turbine in the port with some concepts	High costs. Lower stability of foundation could impact power curve negatively.

Floating segment outlook

Floating market installed base (GW)	2020	2025	2030
Min	0.1	1.5	3
Max	0.1	3	15

Floating segment trends

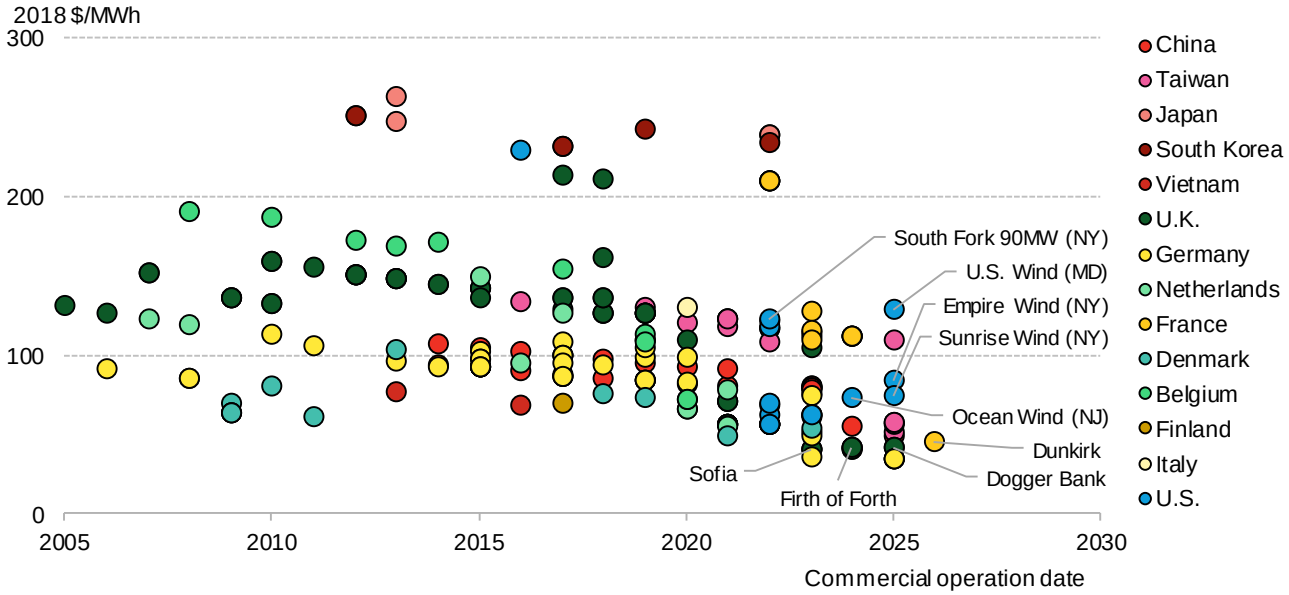
- Floating could represent around **2% install base worldwide** by 2030 due to demand from countries with limited shallow water resources
- **Moving from prototypes to commercial**: segment share can grow exponentially after successful demo operation & significant cost reduction
  - Pilot projects demonstrate that technology is **not yet ready to compete against fixed-bottom**; technically feasible, but currently too expensive
  - **CAPEX** of floating demonstrations is €5-15M per MW vs fixed bottom €2-3M per MW, cost reduction needed to make the technology competitive
  - **Supply Chain** to scale production requires major investments to enable growth of the segment
- Major players are positioning, especially the **O&G** entrants (Equinor, Shell, Total)
- "Game changers" could be **Scotwind** leasing areas (up to 24GW), as well as first commercial scale 250-500MW projects in France (tenders starting 2021)
  - **France** and **Korea** are the most advanced markets and represent more than 60% of the orders potential
  - **USA** could be the next largest market, with progress prior to end decade pending policy decisions (Maine and California)
  - **Norway** already moving forward on leasing for a 1GW site, with first projects potential prior to end decade
  - New markets to monitor for development in the second half: **Greece**, **Italy**, **Spain** … and **Japan** (first demo project auction 2020)

With enough tech improvement, floating market should take off … now is the time to learn, ready for mid-decade

Source: World Steel, EWEA, BNEF (Oct. 2019, Jul. 2020); Equinor (Jun. 2020), IEA (Oct. 2019), Wind Europe (Oct.2018)

Industry has achieved significant cost reduction in record time

Cost evolution leveraging industry expertise



Source: Source: BNEF 2H19 Offshore Wind Market Outlook
Notes: Figures refer to an estimated levelized price, taking into account tariff price (awarded or announced caps), length, inflation, a merchant tail assumption and a 25-year project lifetime

Stable regulation has facilitated cost drivers

- Key drivers for investment decisions determining cost reductions:
  - Clear, stable regulation
  - Certainty on revenue streams for developers and for supply chain
- Projects in mature markets now moving forward at **40-60 USD/MWh** depending on region and developer scope
- European industry has estimated that a minimum volume for **4GW/year** is necessary to continue driving cost reductions in offshore wind
- Key cost drivers:
  - Scale / Experience
  - Technology development
  - Cross-industry best practices

Technology development is the key cost driver

WTG most significant cost concept in offshore wind expenses

Turbine size has doubled in the last eight years

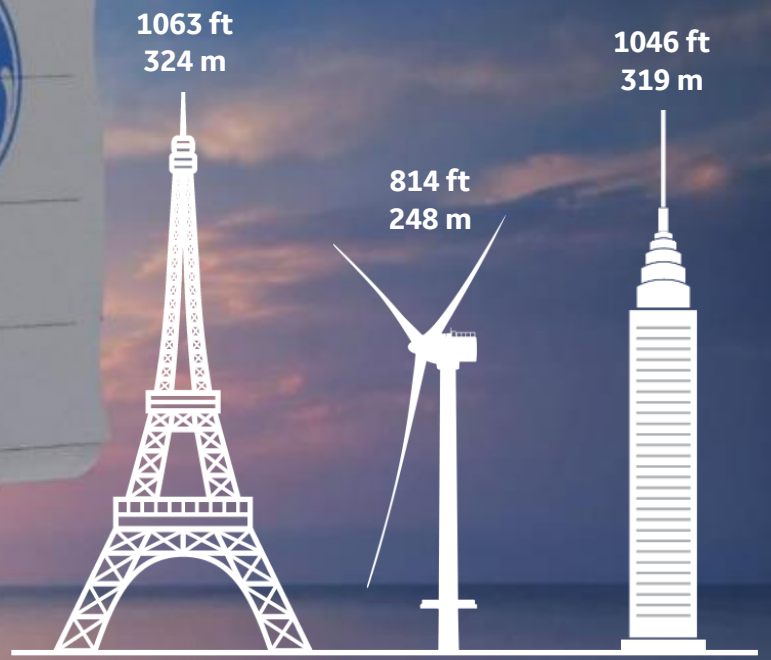
Higher output per unit installed optimizes balance of plant, installation and maintenance

Improved reliability and service strategies assure power output in harsh conditions

Innovation in design, materials and manufacturing driven by strong industry accelerates double-digit trajectory

Each Haliade-X generates enough clean power for up to 16,000 European households, and up to 1 million European households in a 750 MW configuration windfarm

GE Renewable Energy is investing more than 400 M USD over five years to develop Haliade-X

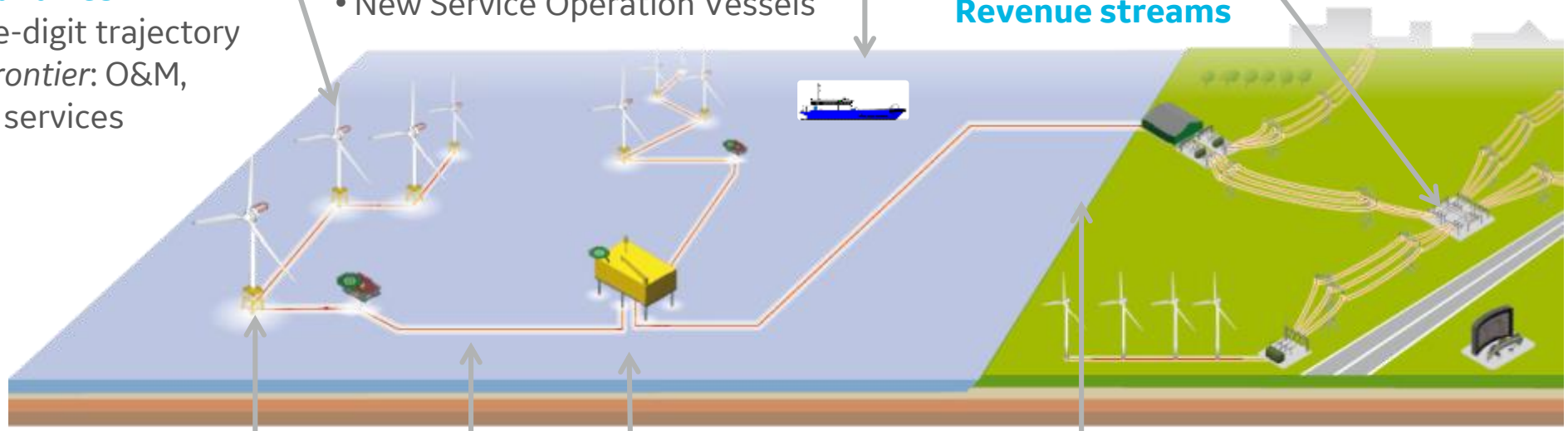


Innovation ongoing and opportunity across the value chain

Wind turbines
- Double-digit trajectory
- *Next frontier*: O&M, digital services

Vessels
- Purpose-built installation vessels
- New Service Operation Vessels

Next frontier:
Hybrids
Revenue streams



Substructures
- Larger monopiles, deeper waters
- Innovation in jacket
- Improvements in piling and hammering
- *Next frontier*: floating

Subsea cables
33-66 kV

Grid
- HVDC
- Modularity
- Static Voltage Compensation

Ports infrastructure adapted to offshore wind needs

Key take-aways

- Offshore wind is a proven technology. The industry has achieved substantial cost reductions, positioning offshore wind as competitive mainstream source of renewable energy.
- Offshore wind is not just onshore at sea but requires experienced players with deep pockets capable of taking forward large-scale power plant project.
- The right partners can achieve offshore wind success to meet coastal demand in the right framework (Health & Safety prioritization, stable policy and regulation, port infrastructure, grid connections…)
- Such partners are capable of taking forward the tremendous potential in technology development for continuous cost optimization.
- Visibility on stable volumes with a long-term horizon allows supply chain development… “glocal” for economies of scale… excessive local content requirements affect competitiveness.
- Counterproductive policy could put this success at risk: sustainable development is a public/private collaboration