US Offshore Wind – Technology Opportunities and Challenges

GE RENEWABLE ENERGY

NAE Offshore Energy Wind Colloquia

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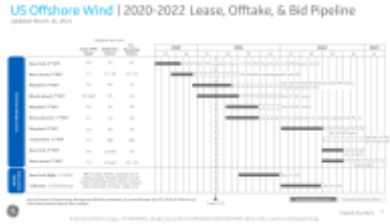
US Offshore Wind | Multiple drivers converging to push industry

Underlying Wind Resource

Strong offshore wind resources close to major load centers. Continental shelf off the East Coast is well-suited for fixed foundation technology

State Government Support



State government offshore wind targets now exceed 30GW and a dependable pipeline of offtake auctions has been established

Federal Government Support

Biden administration highly supportive of offshore wind, new BOEM leadership, Investment Tax Credit extension and permit grants

Experience Transfer

equinor EDF Ørsted IBERDROLA OW

Existing developers are driving the first generation of US projects, bringing proven technology, experience, and capital

Key product levers to drive down cost of offshore wind

Key cost drivers	Cost (LCOE) Sensitivities	Turbine needs
	If reduced by 10% / *If increased by 10%*	
Capacity Factor	-9% / 11%	Rotor size, electrical efficiency ↑
CAPEX *(capital expense)*	-8% / (60€/MWh) 8%	Turbine rating ↑ to drive BOP cost ↓
WACC *(weighted average cost of capital)*	-5% / 5%	Proven design, 97.5%+ availability
OPEX *(operating expense)*	-2% / 2%	Remote operability, maintenance ↓

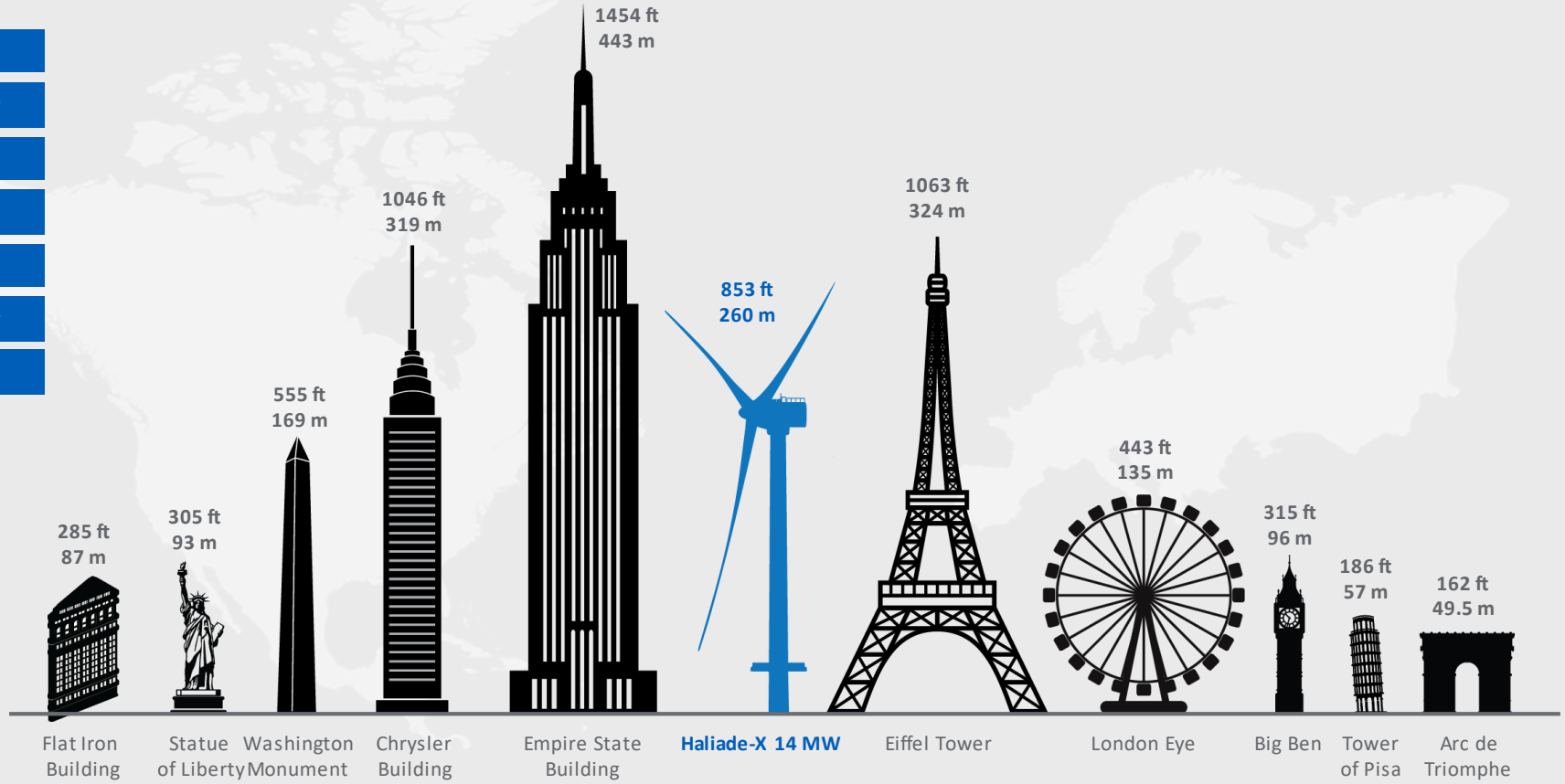
-10% -5% 0% 5% 10%

Turbine scale is biggest driver for cost reductions … Longer rotors & higher power rating

*LCOE Sensitivity Source: BNEF

Offshore systems scale to new heights

- **14 MW** capacity
- **220**-meter rotor
- **107-meter-long** blades
- **260** meters high
- **74 GWh** gross AEP
- **61%** capacity factor
- **38,000** m^2 swept area



Component scale demands a reinvention of manufacturing

Size requires breakthrough thinking on how to manufacture in a LEAN and cost-effective way




Learning at scale … Haliade-X prototype installation



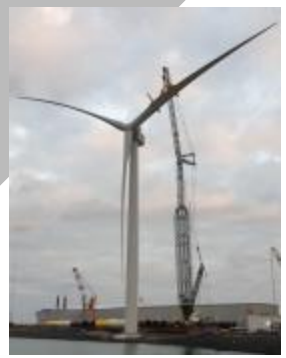

New technology risk reduction is key ... *at all stages of development*

	Component	Integration	System	Wind Turbine
SCOPE	Design specifications Component level reliability Certifications (CE marking)	Mech & elec integration Functional tests at subsystem level	Performance Reliability Lifetime	Type certificate Turbine level performance assessment
LOCATION	Supplier facilities Laboratory	Turbine factory Tower factory	Full nacelle test Blade test bench	Prototype (Rotterdam, NL)









Lowering the cost of Service … avoiding costly engagement

Photo credit: Ulstein Group

Supply chain development … *shaping solutions for growth*

Regional tenders → Development to meet regulatory criteria

Volume will drive confidence in supply chains

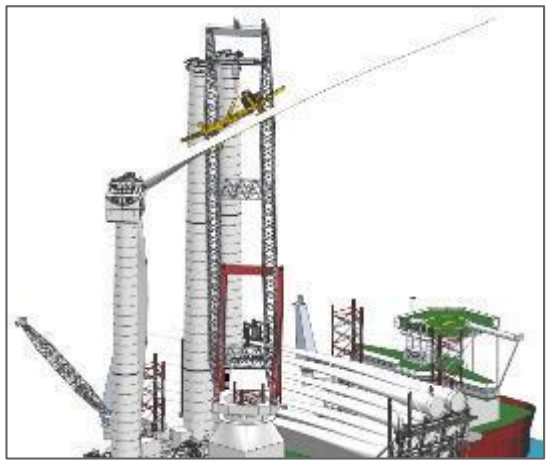
Ports, suppliers and servicers as emerging areas of investment

Offshore operations … *improvements to enable growth*

Logistic and installation vessels

- Few specialized vessel to carry offshore wind components
- Obsolescence of existing installation vessel fleet for the next turbines
- Markets restrictions: i.e. Jones act

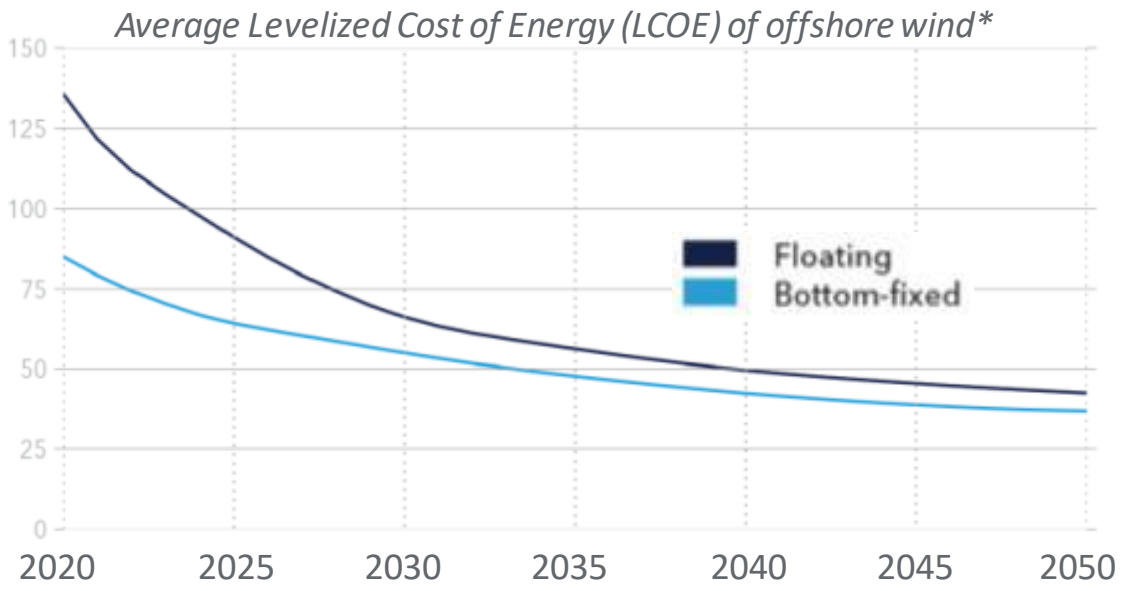
Harbors & skills



- Inadequate access for logistics & installation vessels
- Not enough storage capacity
- Lack of experience and trained staff

Floating wind power … *niche segment with growth potential*

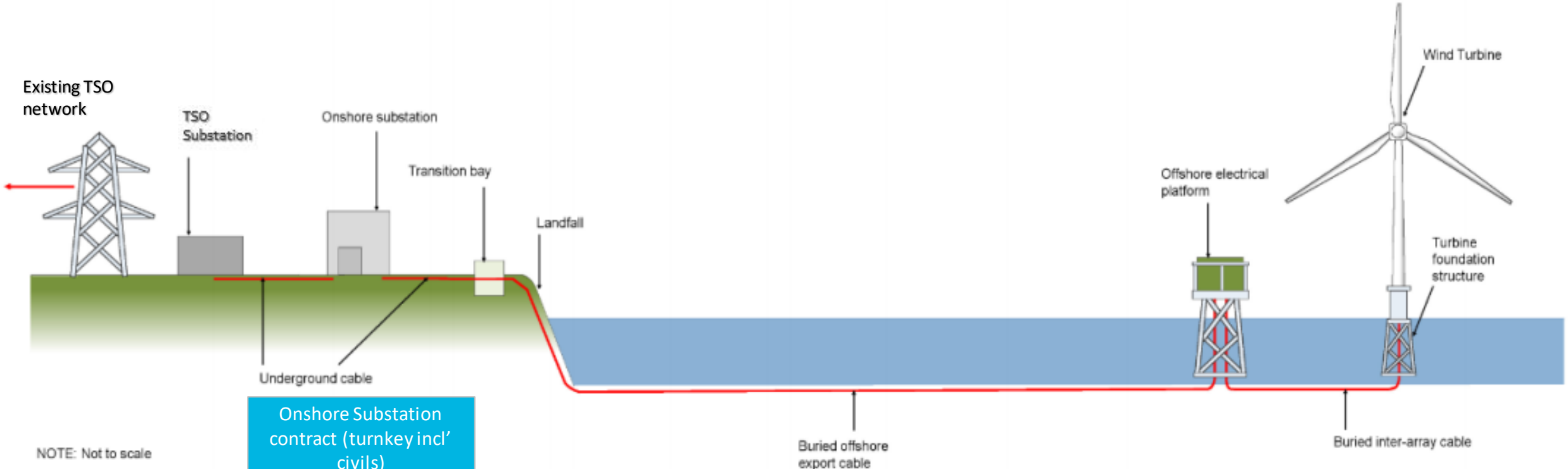
DOE: “60% of US offshore wind resources are in deep water areas that would require floating foundations”



*Sources: BNEF 1H21 OFW Market Outlook, VOC21, DNV 2020 Energy Transition Outlook, IWEA December 2020

Industry challenged on cost and technology … commercial growth expected in late ‘20s

Grid connection for offshore wind farms



Onshore Substation contract (turnkey incl' civils)

Onshore Export Cable Supply

Onshore Export Cable Installation

Offshore export cable supply

Offshore export cable installation

OSP Topside electrical equipment supply

OSP Topside Fabrication

OSP Foundation supply

OSP Topside + Jacket T&I

Wind Turbines

Wind Turbines installation

WTG foundations supply & install

Array Cables Supply + install

Full Grid Code Design responsibility for onshore + offshore S/S equipment

Grid solution provider

Fabricator

other scope

HVDC for offshore wind connection

Offshore wind energy on path to grid parity