We Have To Shake Our Fossil Energy Habit:
Is Floating Offshore Wind In Oregon The Best Solution?

A presentation prepared for
Shoreline Education for Awareness

29 March 2022

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This presentation is about humans
and about how humans value & interact with the ocean

I am more familiar giving presentations about

- The biology of marine life
    - Seabirds
    - Whales & dolphins
    - Seals & Sea lions
- Coastal ecosystems
    - Estuaries
    - Seagrasses

This presentation is designed to familiarize SEA Docents with the topic of offshore wind energy so that docents who interact with visitors to the Oregon coast can engage in informed conversations regarding the prospect of using the ocean as a place to produce electricity.

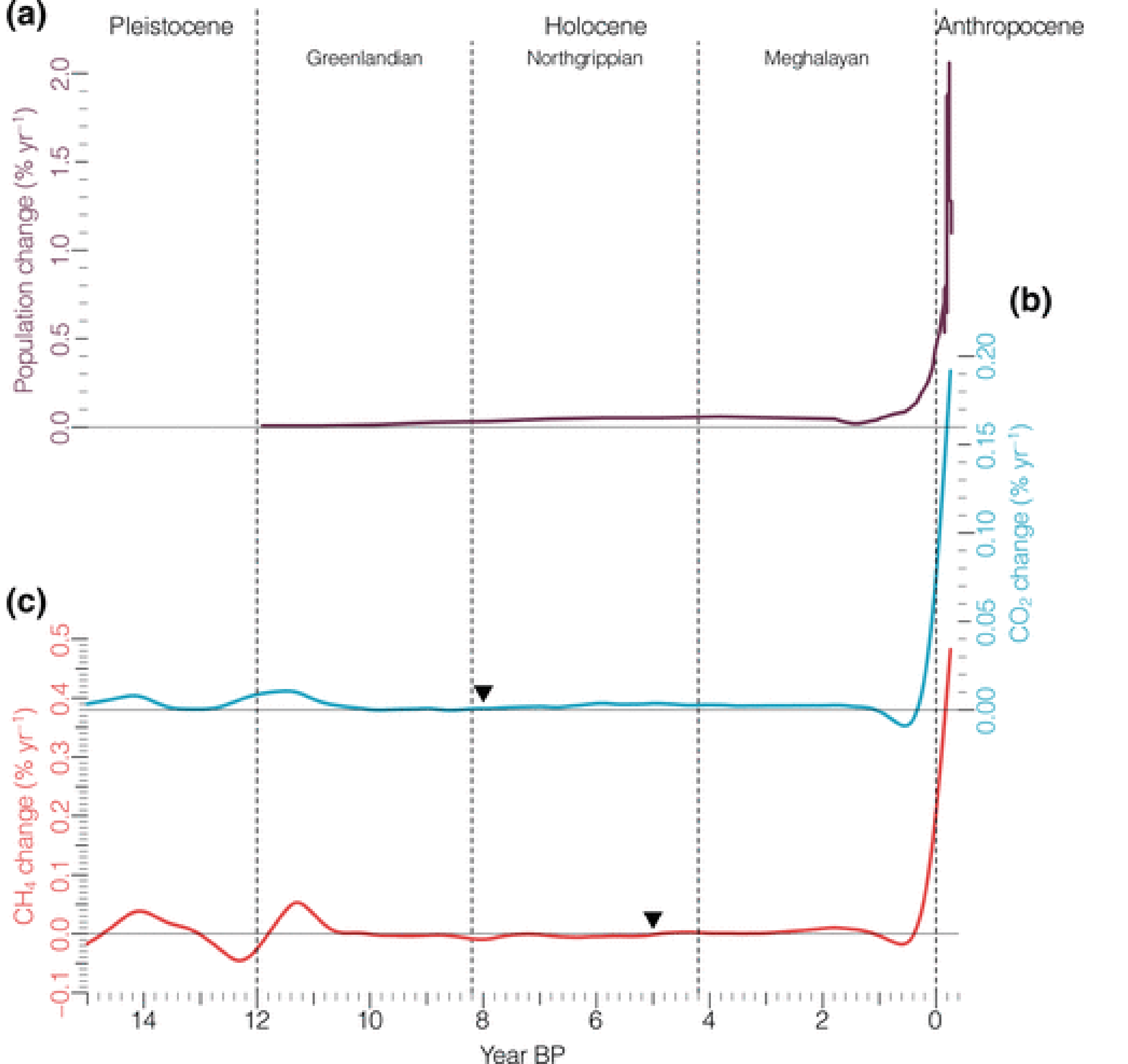
Welcome to the Anthropocene!
The Age of Humans
AKA “The Great Acceleration”

Humans are making lasting marks in earth’s geological record

From 1950? Until?

Markers of the acceleration

- Population growth
- <u>*The “thermo-industrial revolution”*</u>
    - ***Modification of the carbon cycle***
        - ***Combustion of fossil fuels***
        - *Deforestation*
- Growth of global road network
- Damming of major rivers
- Global loss of wildlife (extinctions)
- Plastics
- The “bomb”



Humans *can* & *have* changed the planet

Now What?

We've done it and didn't even know we could!

Now we *know* humans can change the world

But…..

<u>Can humans change our planet to what we want?</u>

The Bad news?

Change is *rapid* in the Anthropocene….

The Good news?

Change is *rapid* in the Anthropocene!!!

Earth’s climate system is changing rapidly and it doesn’t look good

To stabilize earth’s climate system

We need to *change* and *change* quickly!

Right?

Quickly yes, but
Only fools rush in….
Mind the Logical Gap:

People are hungry!
Hunger is urgent!
Caviar and rice are both food……

Therefore, caviar and rice are both vital to reducing hunger….

To choose the most effective solutions we must understand the *relative speed and costs* of the solutions

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjlhbCb4Nz2AhX5IDQIHSDoDbAQFnoECCoQAQ&url=https%3A%2F%2Fwww.eesi.org%2Ffiles%2FAmory_Lovins_032x21_v3.pdf&usg=AOvVaw3AMXofm5TRHGXBGfYLhhCn

How to choose a decarbonization solution?

The most *effective* decarbonization solutions pay attention to *carbon, cost, and time*-not just carbon

Protecting climate requires

- avoiding the most carbon
- at the least cost
- in the least time

Cheaper faster solutions

Avoid *more* carbon per dollar or per year

Costly or slow solutions

Avoid *less* carbon per dollar or per year and
make climate change impact worse than it could have been.

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjlhbCb4Nz2AhX5IDQIHSDoDbAQFnoECCoQAQ&url=https%3A%2F%2Fwww.eesi.org%2Ffiles%2FAmory_Lovins_032x21_v3.pdf&usg=AOvVaw3AMXofm5TRHGXBGfYLhhCn

Is Floating Offshore Wind Energy The Most Effective Decarbonization Solution?

There are many
<u>Decarbonization Solutions</u>

- **Wind energy**
  - Onshore Wind
  - Offshore wind
    - Fixed bottom wind
    - Floating Wind
- **Use less energy (conservation)**
- **Nuclear energy**
- **Hydrokinetic energy**
  - Conventional Hydro
  - Wave
  - Currents
- **Geothermal energy**
- **Solar energy**
  - Photovoltaic
  - Thermal

<u>Wind energy</u>

- **History and Trends**
- **Policy update**
- ***<u>FOSW Physical characteristics</u>***
  - *Space and spacing*
  - *Manufacturing*
  - *Installation*
  - *Cabling*
  - *Conditioning*
  - *Grid connection*
  - *Maintenance*
  - *Decommissioning*

<u>How to compare/choose</u>

- ***COST***
- ***SPEED***
- **Scale**
- **Subsidies/incentives**
- **Economic Displacement**
- **Capacity Factor**
- **Resource intensity**

Why Offshore Wind in Oregon and Why Now?

State of Oregon Wind Energy Study

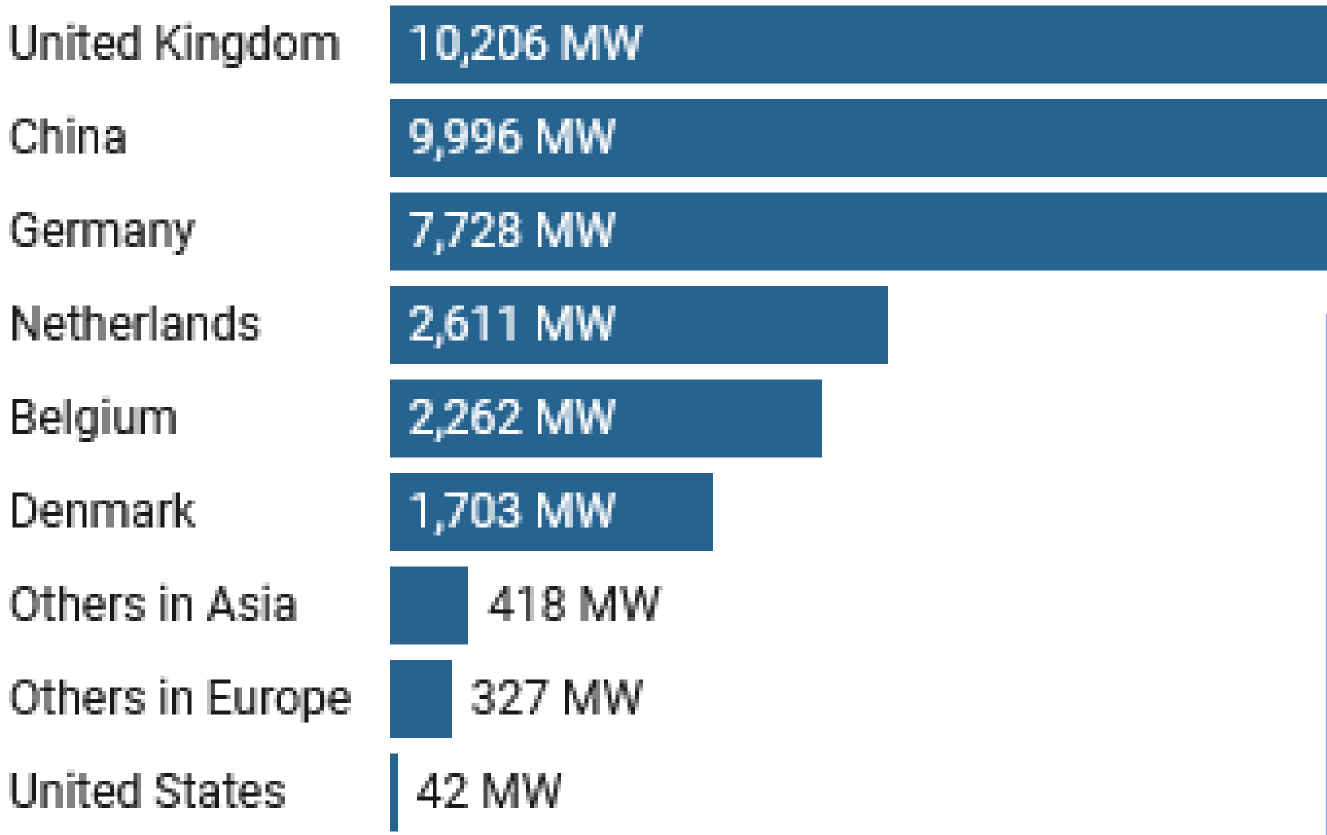
- **HB 3375 passed 2021**
- **Identify the benefits and challenges of 3 GW FOSW by 2030**
- **ODOE report to Oregon Legislature by Sept 2022**
- **Focused on technical feasibility only**
- **Will *not* evaluate social or ecological aspects**

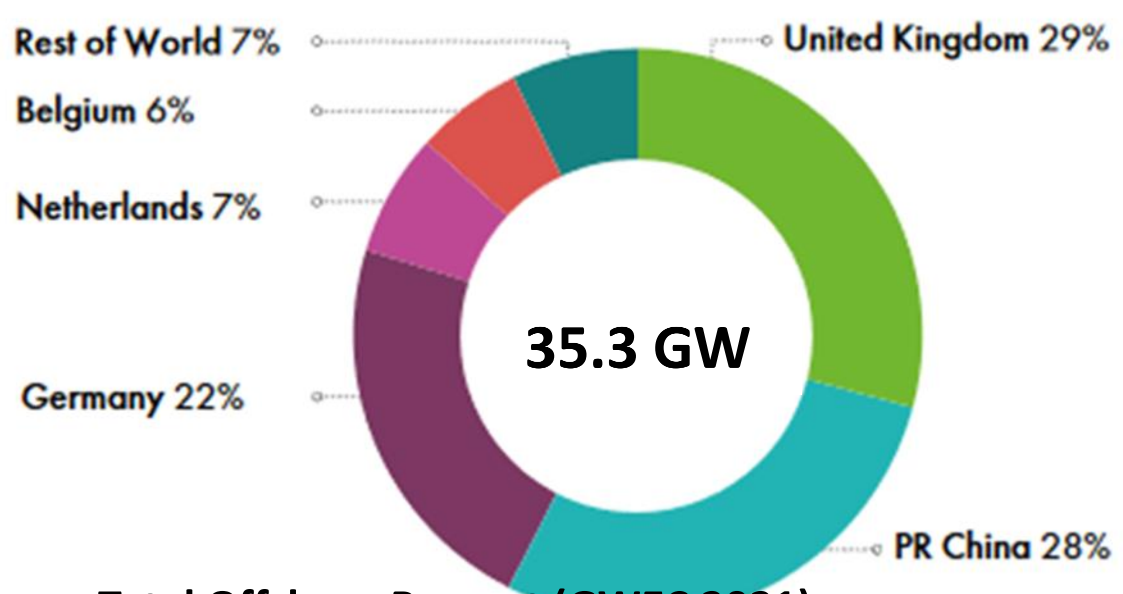
Federal Offshore Energy Lease Activity

- **Presidential Executive Order "30 GW of OSW by 30"**
- **Process run by Federal Bureau of Ocean Energy Management (BOEM)**
- **Mission of BOEM: oversee leases in federal waters (formerly MMS)**
- **Intergovernmental Renewable Energy Task Force**

USA: a latecomer playing catch up?

President Joe Biden's plan to have 30,000 megawatts of U.S. offshore wind power capacity by 2030 would nearly match today's global total.

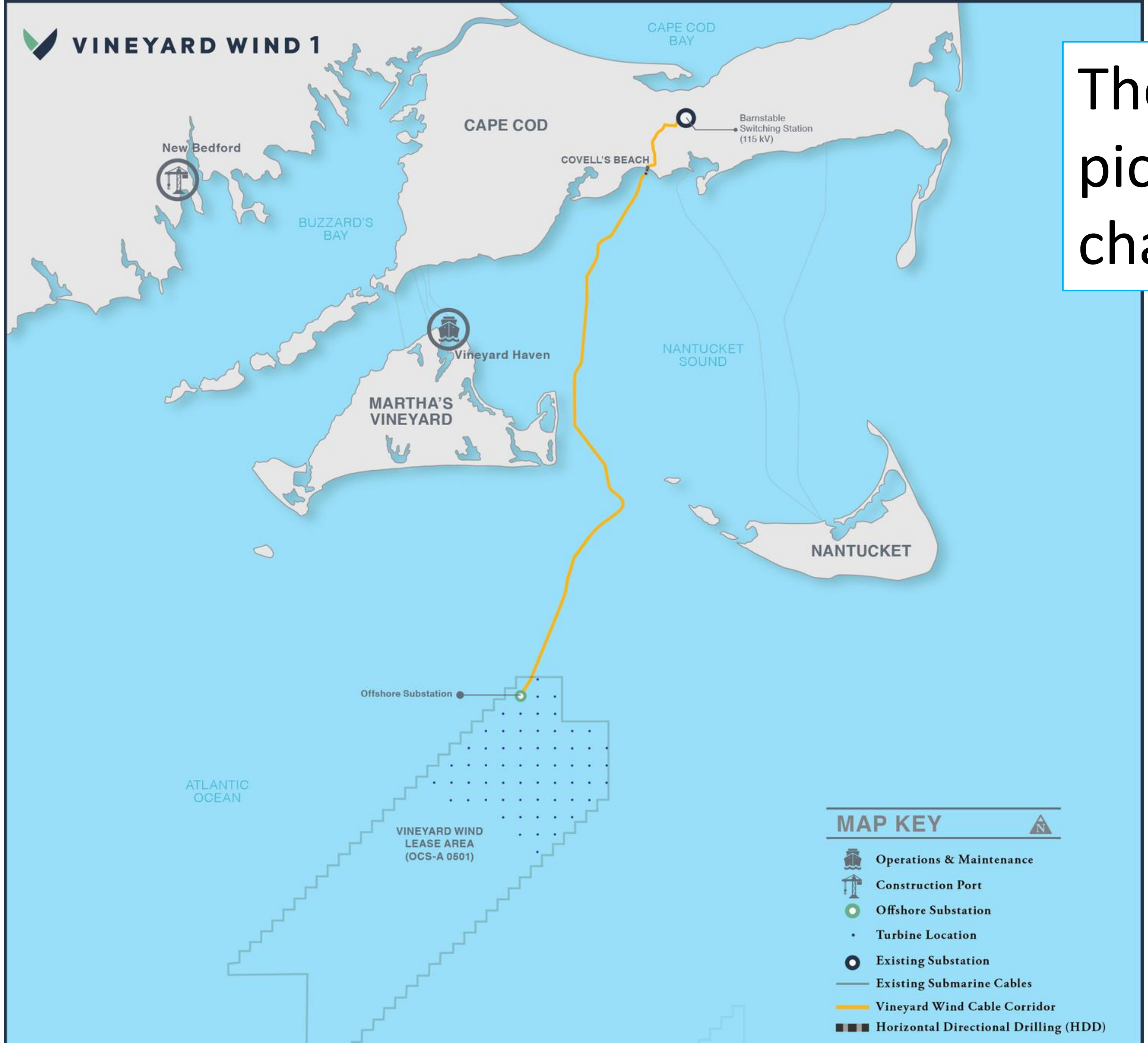




Total Offshore Percent (GWEC 2021)

Installed capacity measured in megawatts

Chart: The Conversation/CC-BY-ND • Source: Global Wind Energy Council • Get the data



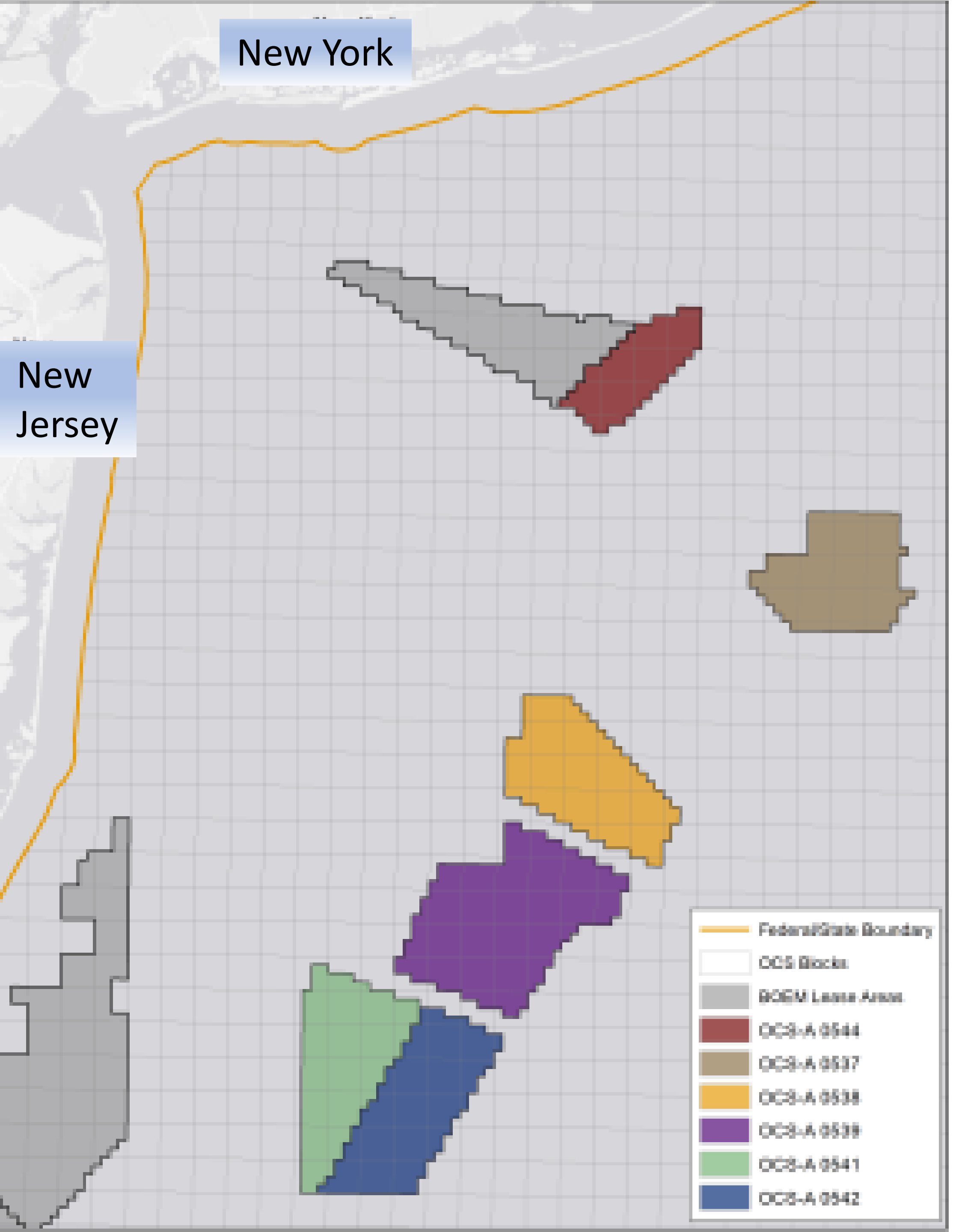
The US Offshore wind energy picture is changing… and changing rapidly!

EXAMPLE #1
VINYARD WIND PROJECT.

- Lease approved May 2021
- Utility-scale wind farm: 800MW*
- 10+ yrs pre-lease sale planning
- 62, 12 MW Turbines proposed
- 15 miles off Martha's Vineyard,
- First power expected 2023.
- Room in lease area for expansion

* 2021 U.S. offshore capacity is 42 MW

https://theconversation.com/us-approves-its-first-big-offshore-wind-farm-near-marthas-vineyard-its-a-breakthrough-for-the-industry-160747



The US offshore wind energy picture is changing and changing rapidly!

EXAMPLE #2:
New York Bight Offshore Wind Lease Areas
6 leases approved: February 2022
Total Ocean Area Leased: **763 Square Miles**
Lease value: $4.37 billion
Estimated wind power potential: **5,600 MW**
Minimum depth: 102 feet (31 m)
Maximum depth: 206 feet (63 m)
Closest Distance to NY: 20 nmi
Closest Distance to NJ: 27 nmi
Room in lease areas for expansion
Population of NY Metro Area: 20.3 Million

Example #3

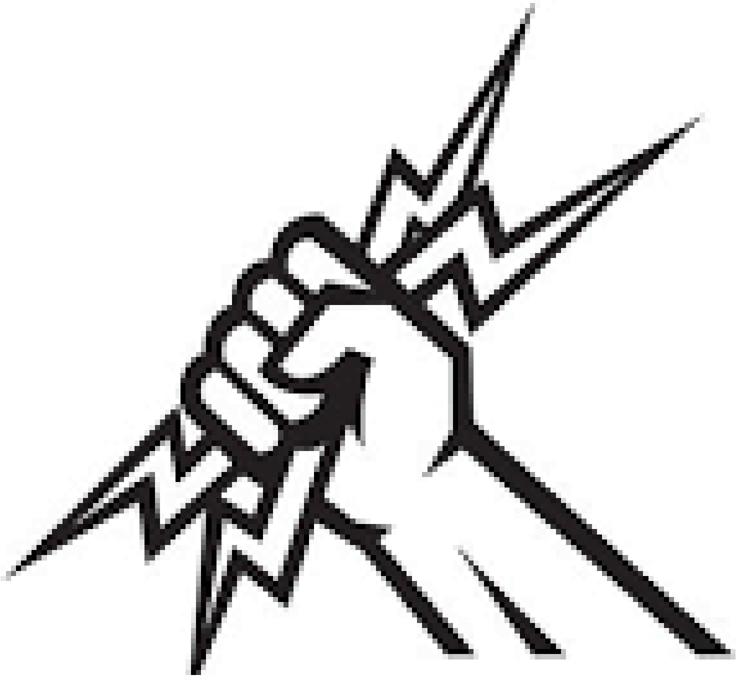
Bureau of Ocean Energy Management Proposed Oregon offshore wind "Call Areas"

- "Call Area" = **2,181 square miles**
- Map released February 2022
- "Call Area" not the same as "Lease Area"
- Estimated Call Area wind potential: **17 GW**
- **Shallowest depth 650 feet** (200 m)
- Deepest depth 4,065 feet (1,300 m)
- BOEM target: Auction wind energy areas with **3 GW** potential in 1st Quarter 2024

- *BOEM is also preparing several wind lease areas off the California Coast.*

How much Electricity is 3 Gigawatts?

Electric power measured is measured in Watts



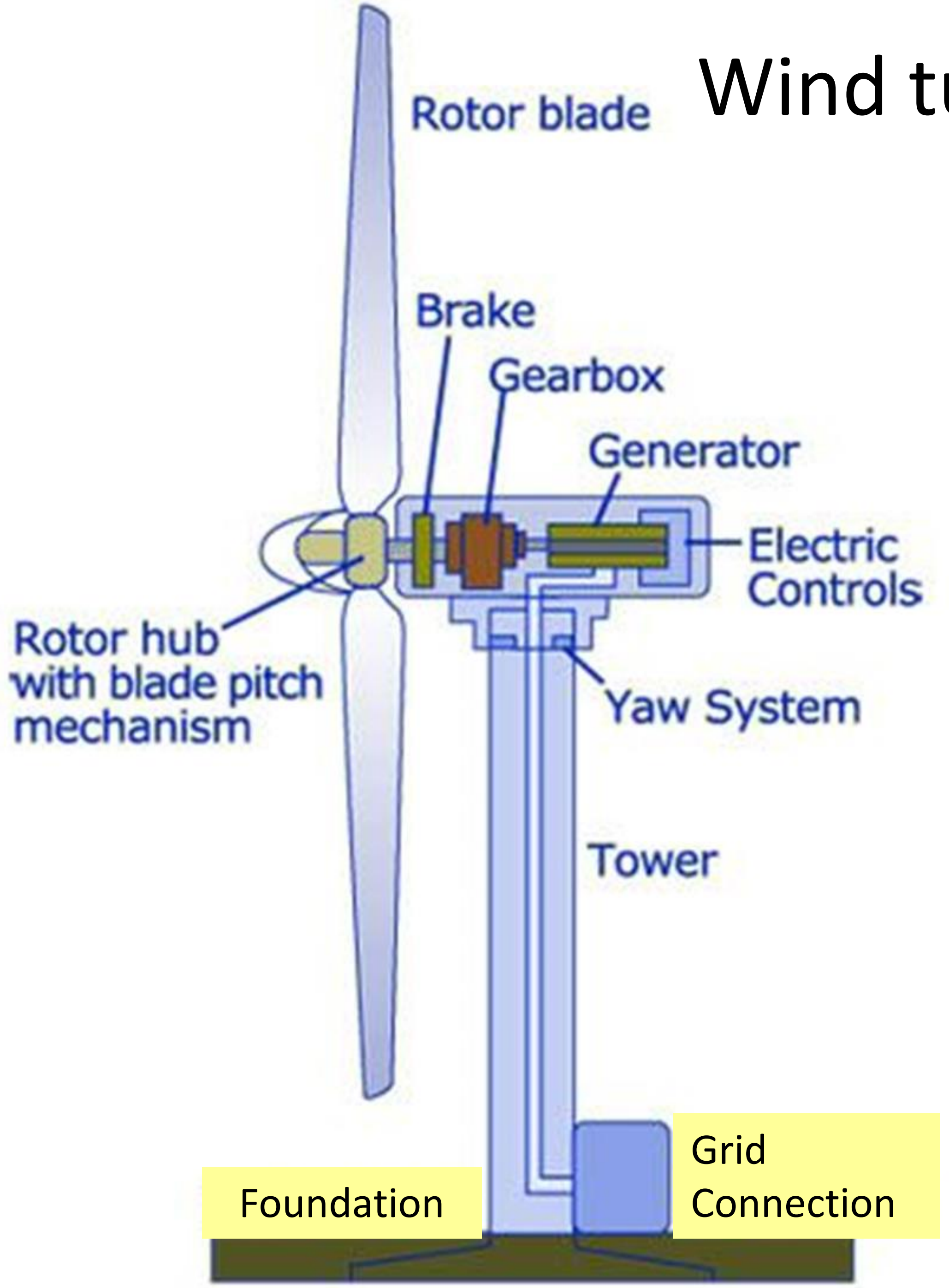
1 Gigawatt (GW) = 1,000 Megawatts (MW)

3 Gigawatts (GW) = 3,000 Megawatts (MW)

- Single wind turbines produce between 2 MW and 15 MW
- Wind "farms" combine groups of turbines to produce 100's of MW to > 1 GW
- A typical coal fired electric plant produces 550 MW (e.g Boardman, OR)
- Bonneville Dam = 1.24 GW Dalles Dam = 1.88 GW John Day Dam = 2.16 GW
  (= 5.3 GW = enough electric energy to supply 4.4 million homes)
- The total capacity of U.S. electricity plants was approximately 1,100 GW in 2012

https://www.ucsusa.org/resources/how-electricity-measured

Wind turbine generators are nothing new



70,800 *onshore* wind turbines
operating in the **US** as of Jan 2022
In over 1,500 wind farms

But only 7 *offshore* wind turbines
operating in the **US** as of Jan 2022
In 2 wind farms

***Wind Turbines Big* & getting bigger**
GE's Halide-X 12 MW Turbines
Weigh 600 tons each
IEA's 15 MW Turbines
Weigh 821 tons each
https://www.sciencedirect.com/science/article/pii/S1364032120308601

Example:
Onshore wind farm
Bigelow Canyon Wind Farm

- Columbia Gorge, Oregon
- One of 1,500 US wind farms
- 220 turbines, 2.3 MW each
- 200’ tall towers
- 450 MW (nameplate capacity)
- 39 square miles (25,000 acres)
- Simple foundations
- First power 2007
- Co-located with wheat agriculture
- Operated by Portland General Electric

The annual **continental** U.S. wind potential of 68,000 TWh greatly exceeds annual U.S. electricity consumption of 3,802 TWh. ***(17x)***
https://css.umich.edu/factsheets/wind-energy-factsheet

Example:

<u>*Offshore*</u> fixed bottom wind farm

Wikinger Wind Farm

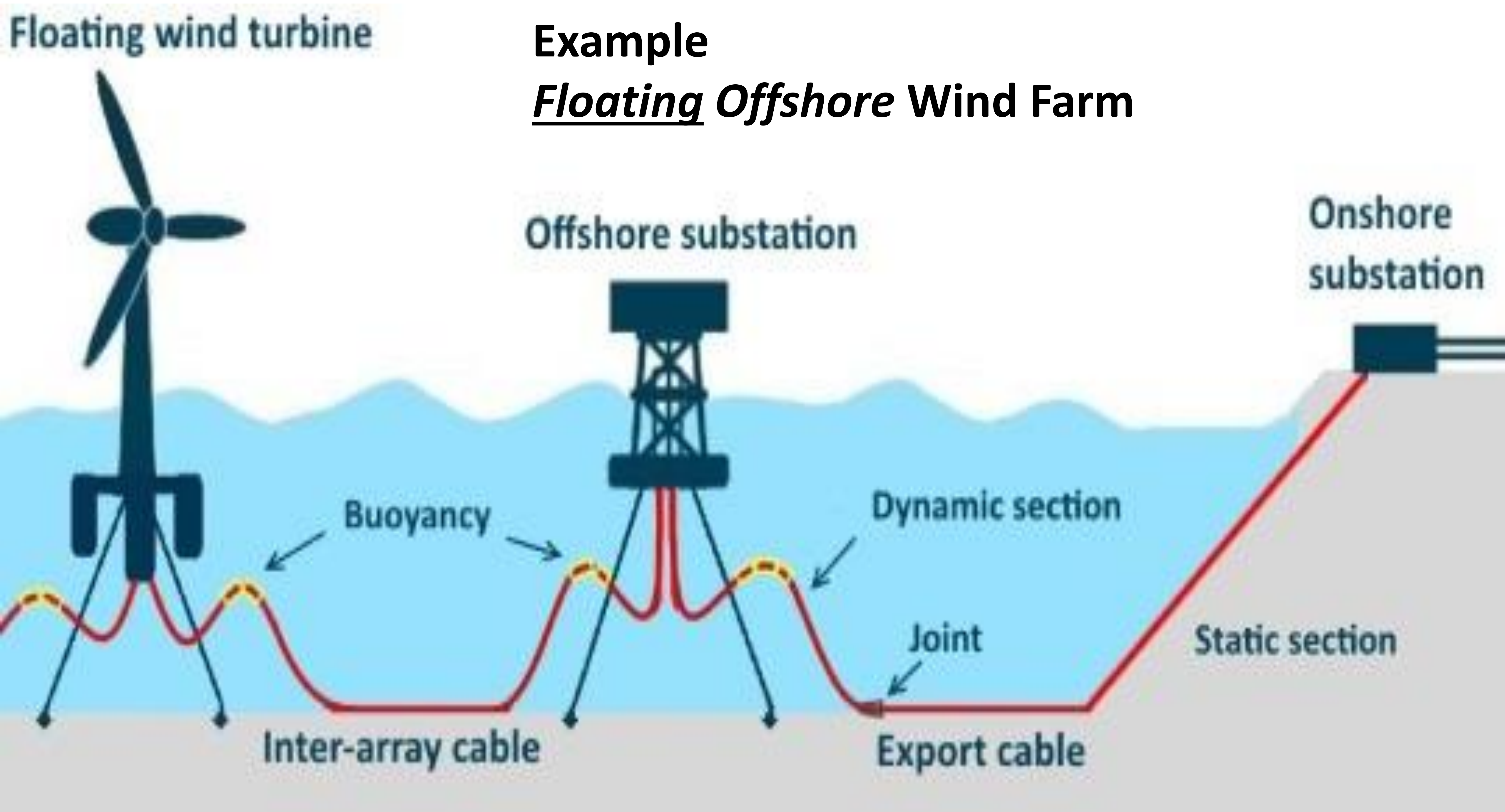
- Baltic Sea: NE coast of Germany
- One of 162 OS wind farms worldwide
- 70 turbines, 5 MW each
  (222 Tons each, 15,540 tons total)
  200'tall towers
- 350 MW (nameplate capacity)
- Water depth 130 feet (40m)
- First power 2018
- 70 **Jacket Foundations**
  (620 tons each, 43,400 tons total)
- 280 pilings to hold the foundations,
  (150 tons each, 42,000 tons total)
- **Offshore sub station** (8,500 tons)
- > 109,000 total tons of steel
- Assembled at sea

Between 2002 and 2020: Global <u>*Offshore*</u> wind power grew from 0.0160 GW to over 31 GW.

https://www.irena.org/newsroom/articles/2016/Oct/A-Gale-of-Innovation-the-future-of-offshore-wind

https://www.rystadenergy.com/newsevents/news/press-releases/global-installed-offshore-wind-capacity-to-see-37pct-growth-in-2021-fueled-by-china/

Example
Floating ***Offshore*** Wind Farm



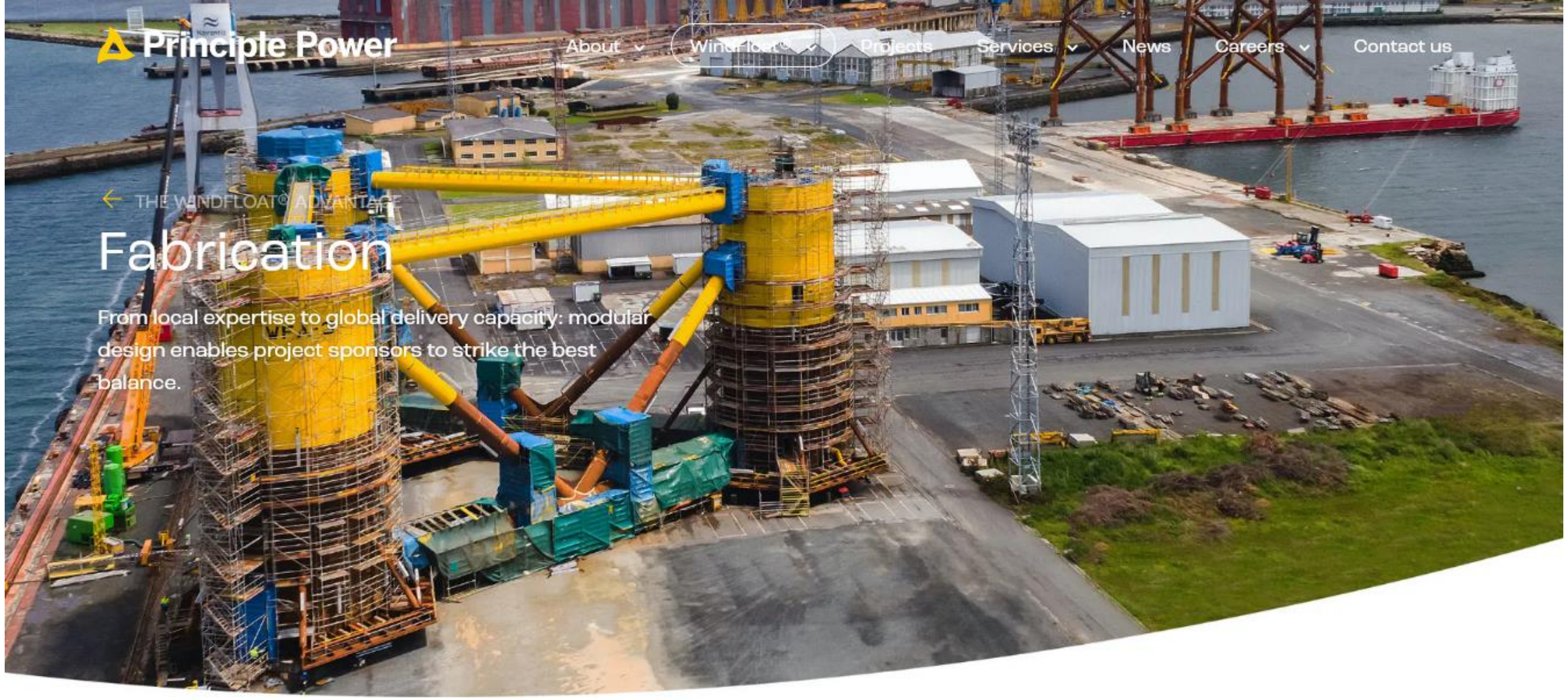
https://www.sciencedirect.com/science/article/pii/S0142061521003677

Example
__Floating__ Offshore Wind

Principle Power Turbine Assembly

- Semi-submersible foundation
  - Three legs
  - Attached to bottom with mooring lines
    Turbines move around
  - Steel construction (22,000 tons each)
- Tower, turbine, and rotors attached to foundation *while in port*
- Assembled unit towed to mooring location

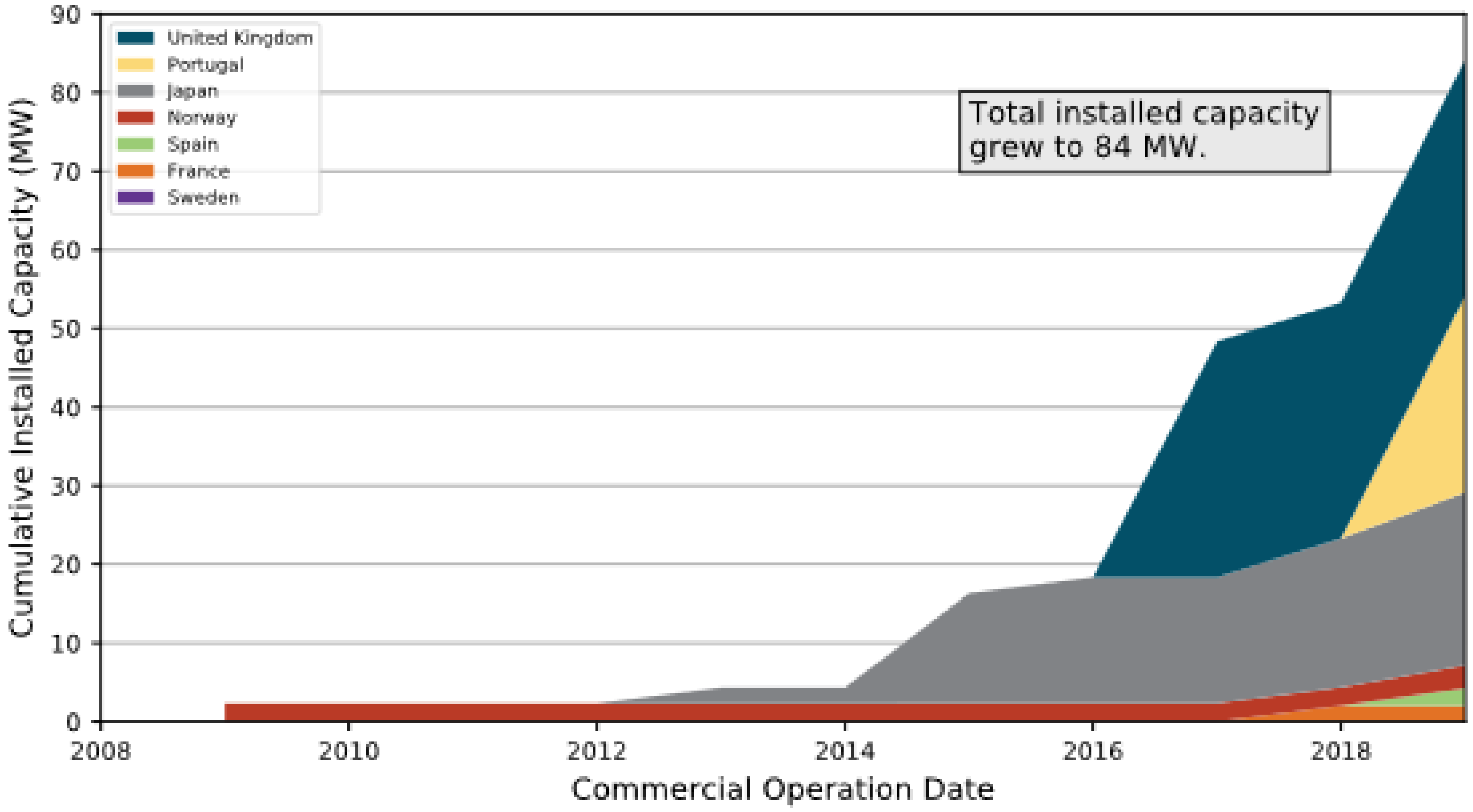
Example: *Floating* Offshore Wind farm



Wind Float Atlantic

- 20 KM offshore of Portugal
- **Three 20,000+ ton Semi submersible floating platforms as foundations**
- Three 8.4 MW turbines
- 330’ tall towers
- Anchored to the seabed 320’ below with **3 catenary mooring lines each**
- First full-scale project to use semi-submersible technology
- First floating wind farm in continental Europe
- First floating wind farm to secure bank financing
- First platform anchored 2019
- Fully operational July 2020

Cumulative Installed Offshore Floating Wind Capacity by Country to Date



- At the end of 2019, there was 84 MW of installed floating wind capacity globally, growing by 36 MW from 2018.
- Of this installed capacity, there are 16 projects, with 9 projects (62.13 MW) in Europe and 7 (22.06 MW) in Asia.
- Two pilot-scale projects comprising 3 and 5 turbines have been installed in Portugal (2020—labeled as 2019) and Scotland (2017), respectively.

Credit: Walt Musial NREL 2020

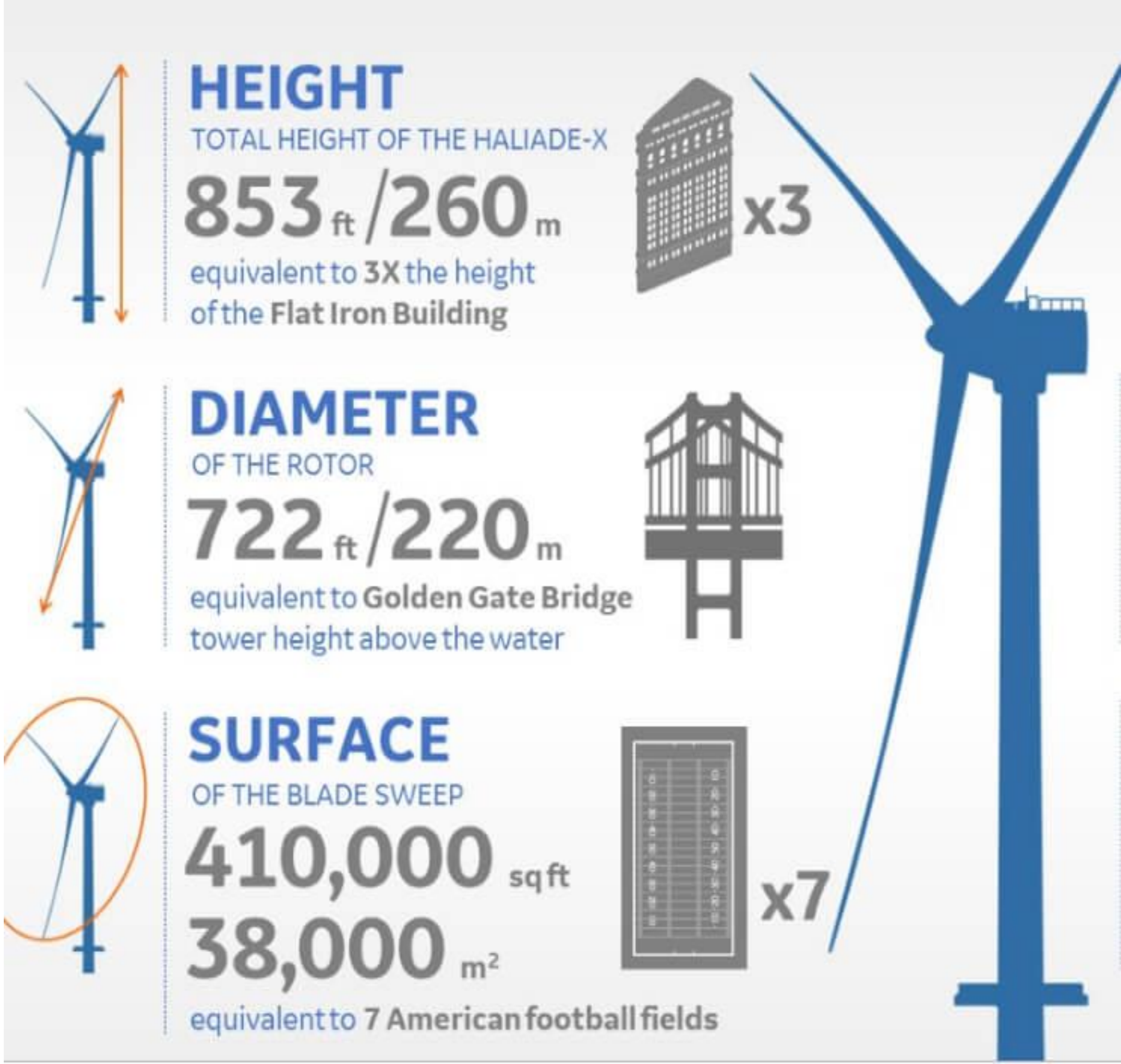
Example

GE Halide X 12 MW wind turbine:

- 3 pc. Tower 837 tons
- Nacelle +727 tons
- 3 Blades +165 tons

1,729 tons each

250 units required to produce 3 GW

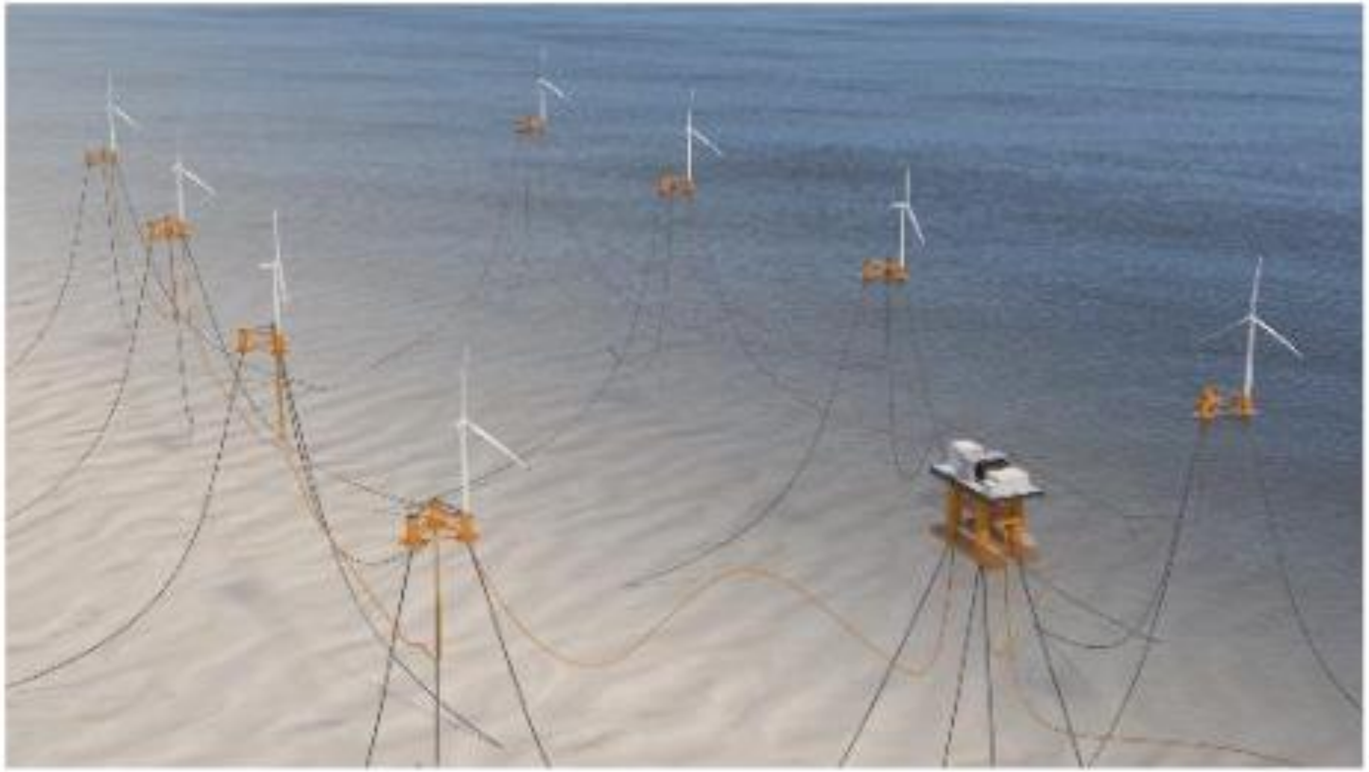


Hollandse Kust Zuid will be the first offshore wind farm to install a new series of wind turbines: the Siemens Gamesa Direct Drive 11 MW. These 140 new turbines will be the biggest ever to be installed at scale. March 2021

Vattenfall and Siemens Gamesa are working together on the development of the new 11 MW Siemens Gamesa wind turbines for offshore Wind Farm Hollandse Kust Zuid. Each carbon fiber rotor will have a 200 meter diameter Each blade is 320’ long

https://group.vattenfall.com/press-and-media/newsroom/2021/140-wind-turbines-with-a-rotor-diameter-of-200-meters-for-wind-farm-hollandse-kust-zuid

Balance of Station – Non-Turbine Equipment



Credit: Walt Musial NREL 2020

- Floating substructures
- Dynamic array cables connecting turbines
- Mooring and anchor system
- Installation and assembly
- Offshore and onshore substations
- Export cable (main electric cable to shore)
- Decommissioning after 25-30 years

Non-turbine Costs Account for 75% of the Total Capital Cost for a Floating Wind Farm

Typical Catenary Mooring Line/Anchor Configurations

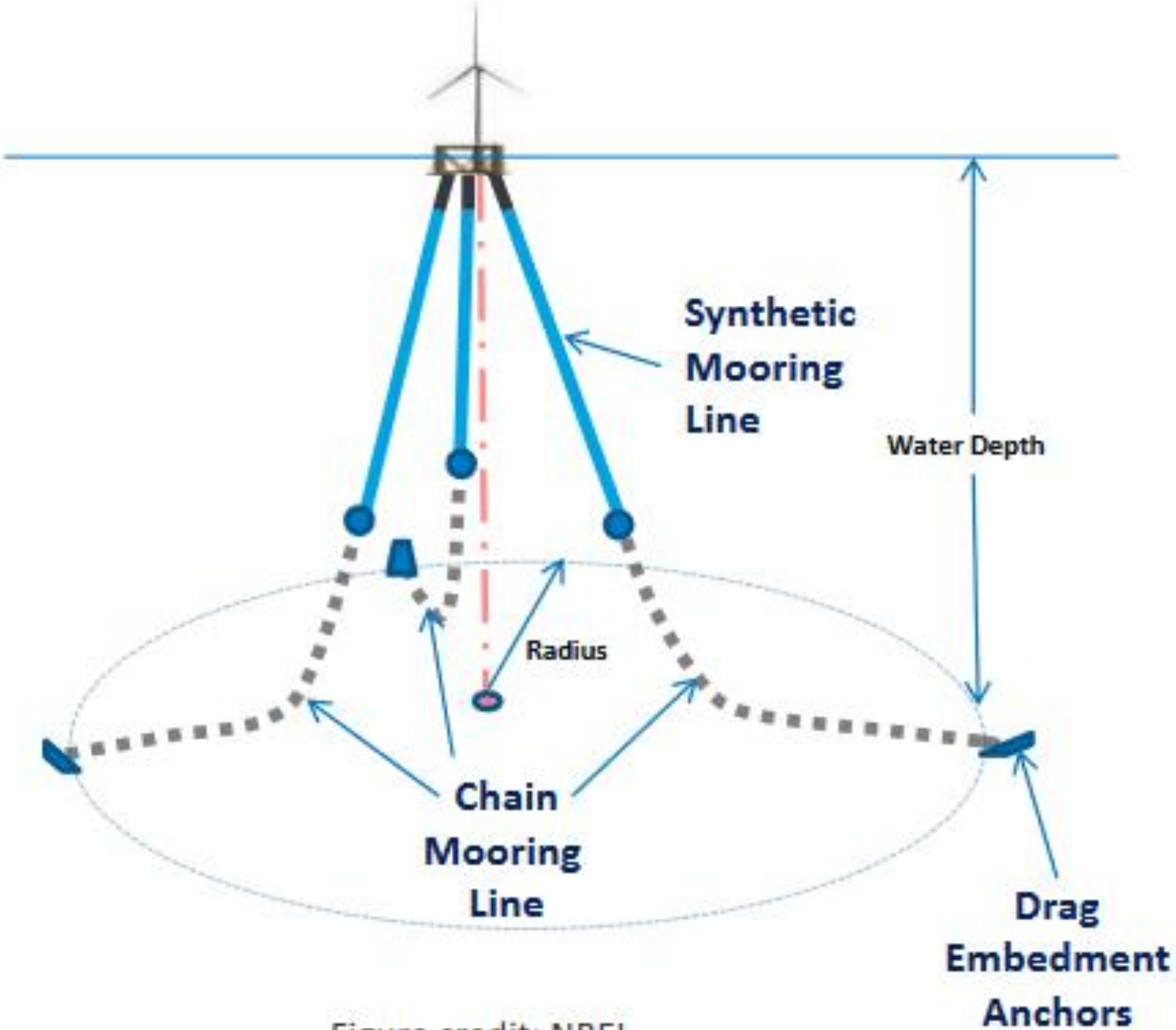
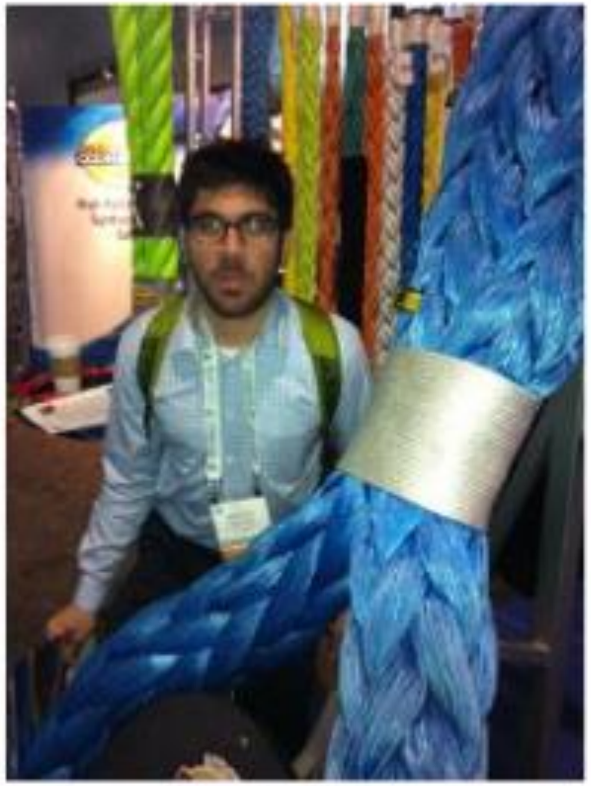


Figure credit: NREL



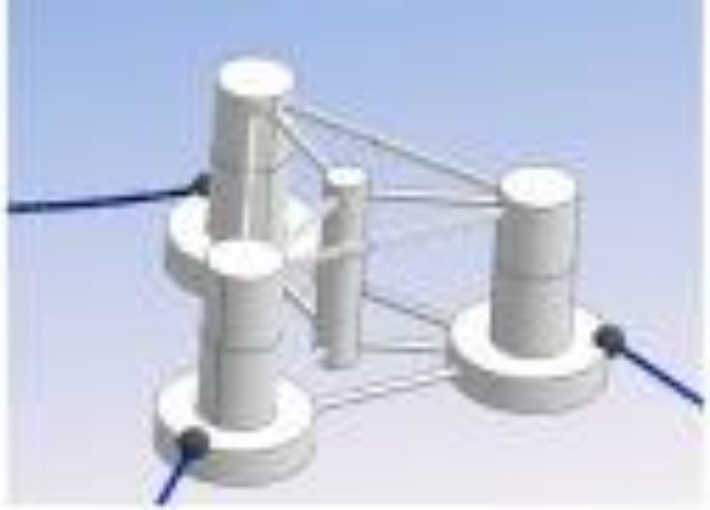
Synthetic Mooring Line

Photo credit: Walt Musial

Drag Embedment Anchor Penetration 10m (33 ft)

Mooring lines are at least 4 times longer than the water depth

Credit: Walt Musial NREL 2020



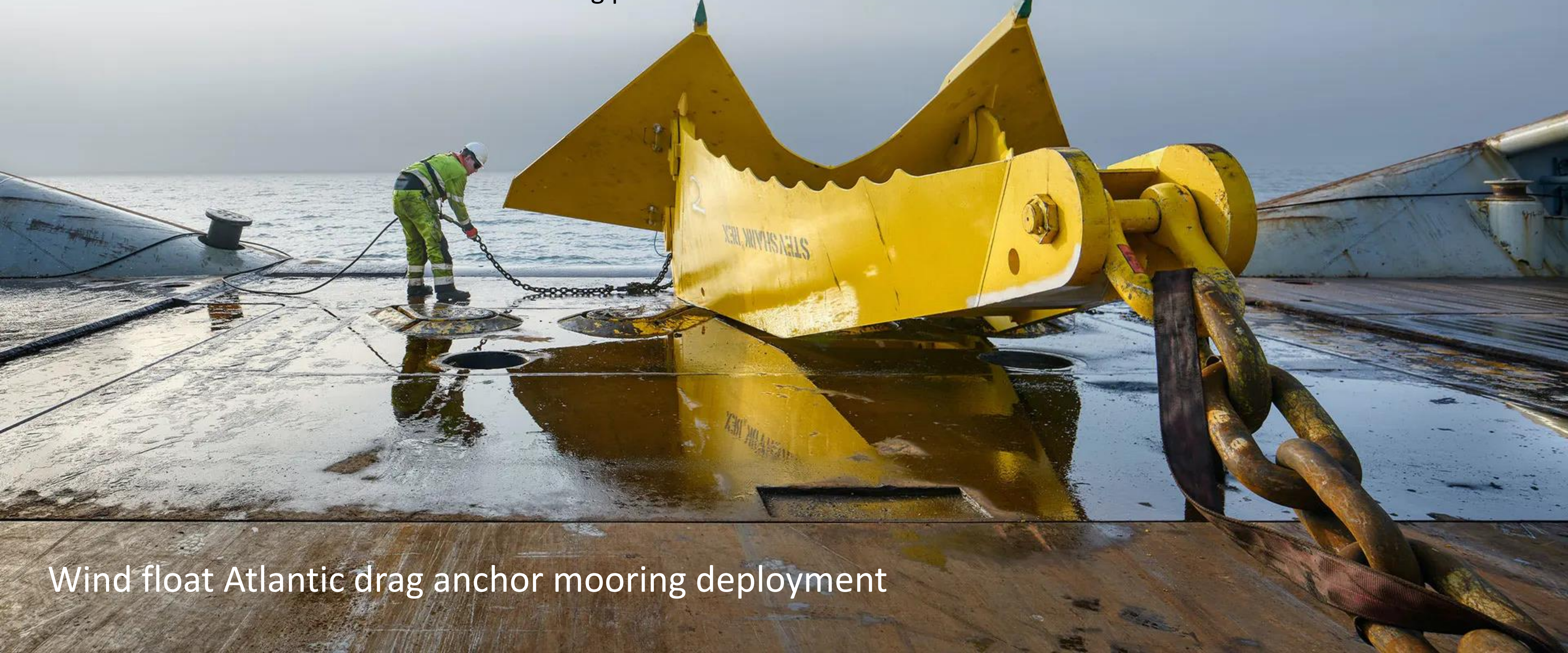
Mooring array for a 3 GW FOSW farm in Oregon:

650 m = Typical water depth in Oregon Call Areas
1,950 m = Typical length of each mooring cable.
(cable length = 3 - 8 x depth for catenary anchor system)
X 3 mooring cables and anchors per turbine assembly
X 200, 15 MW floating turbine assemblies
600 anchors attached to 727 miles of mooring chain and cable

https://www.sciencedirect.com/topics/engineering/floating-offshore-wind-turbine

Example
Floating wind platform anchor

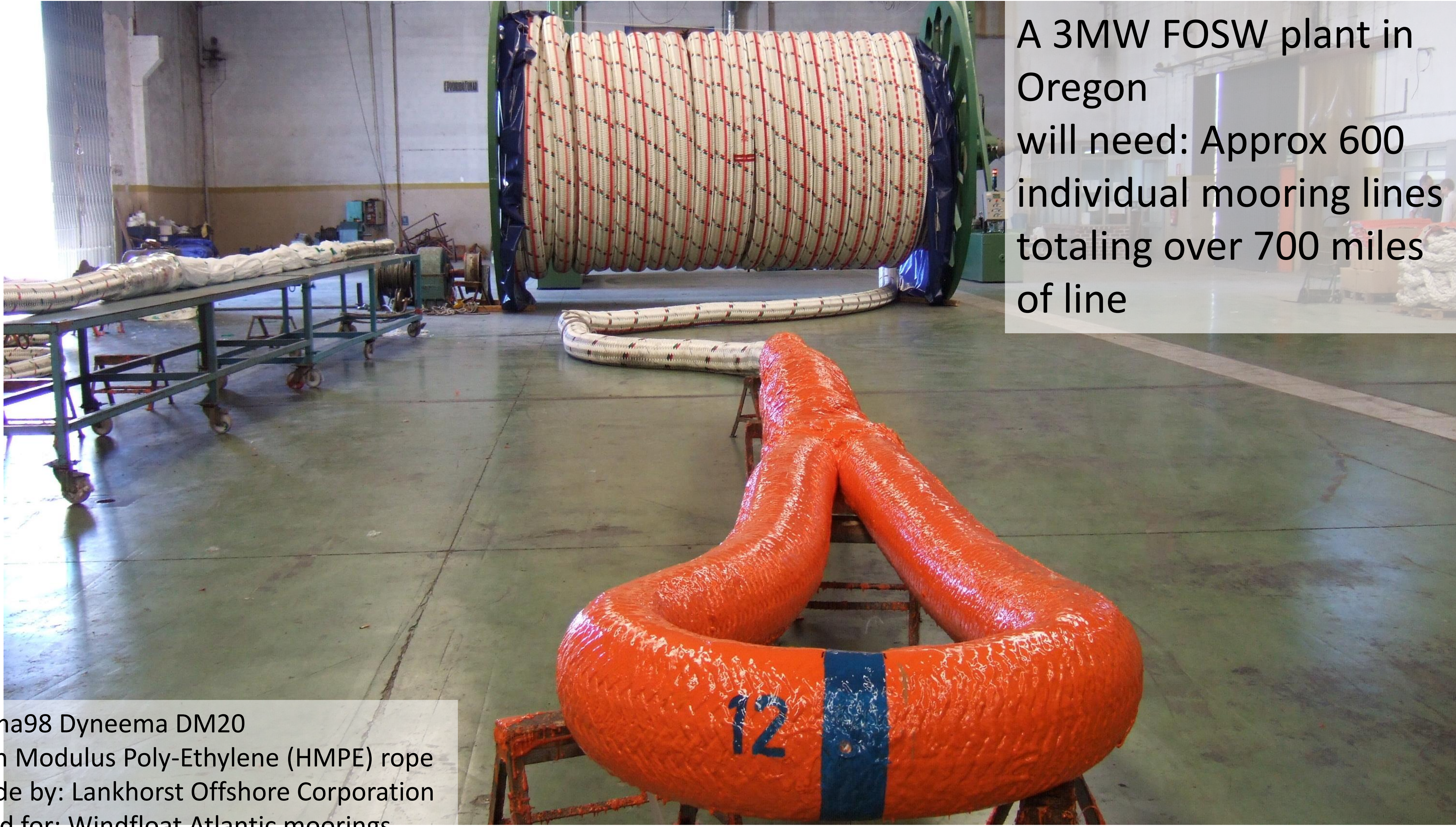
FOSW farms require substantial mooring and anchoring installations
3 or 4 anchors are used to secure each floating platform.



Wind float Atlantic drag anchor mooring deployment

Mooring Anchor Deployment vessel “Horizon Arctic”

https://www.dock90.com/nl



A 3MW FOSW plant in Oregon
will need: Approx 600 individual mooring lines totaling over 700 miles of line

Gama98 Dyneema DM20
High Modulus Poly-Ethylene (HMPE) rope
Made by: Lankhorst Offshore Corporation
Used for: Windfloat Atlantic moorings

Floating Wind Turbines have Dynamic Array Collection Cable

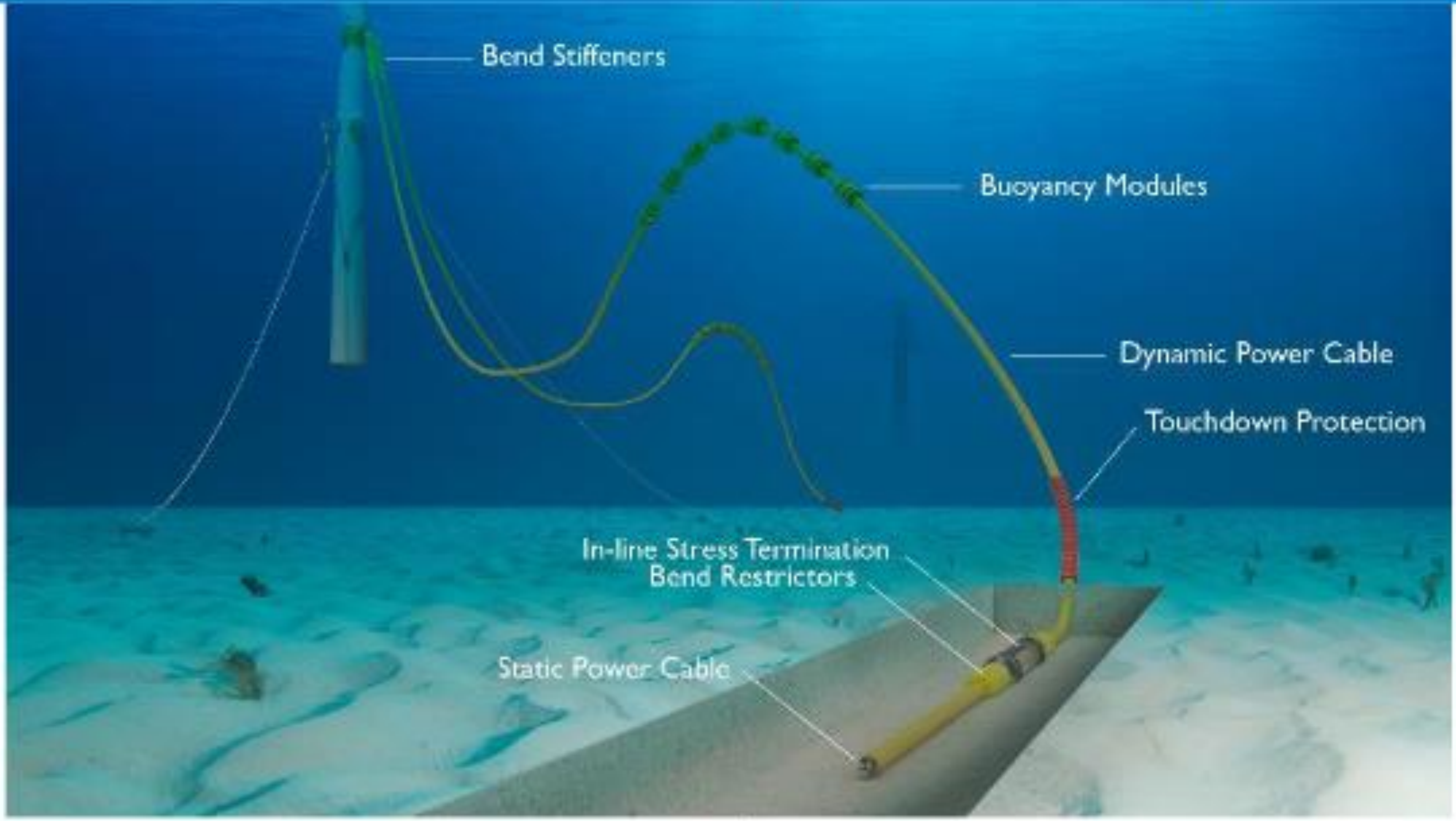


Figure credit: NREL

- Dynamic array cables compensate for movement of floating platform
- Numerous design features help isolate the static cable from platform movements
- Subsea cables may be buried or secured along ocean floor

Credit: Walt Musial NREL 2020

Typical three-core undersea cable with optic fibers, lead sheath and wire armor

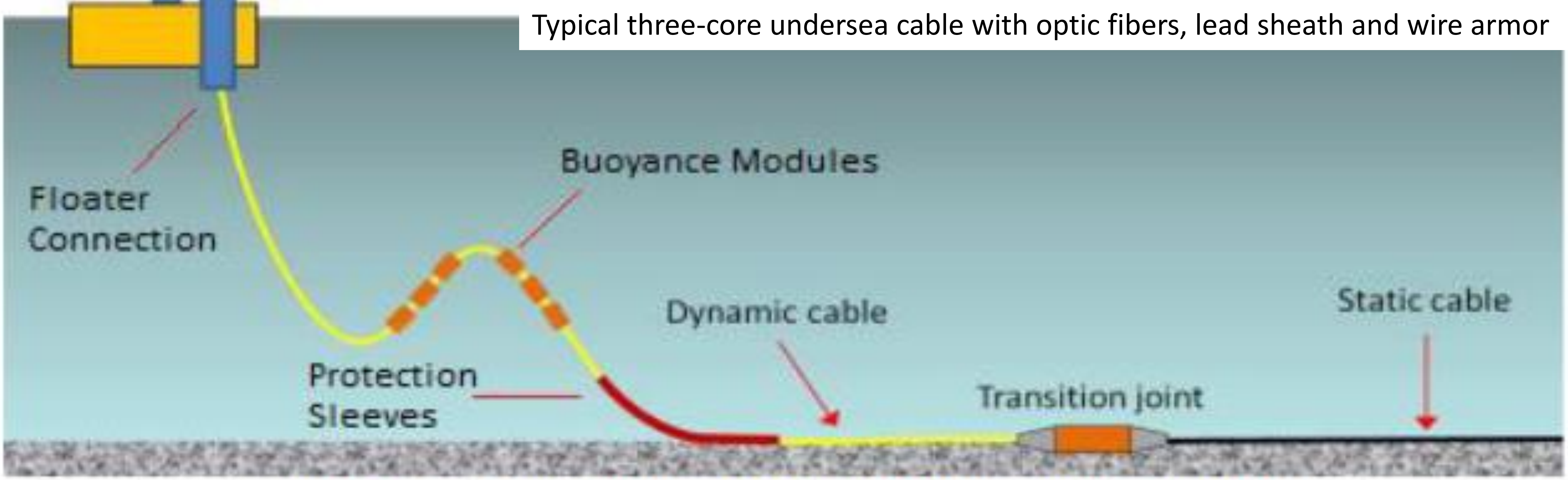
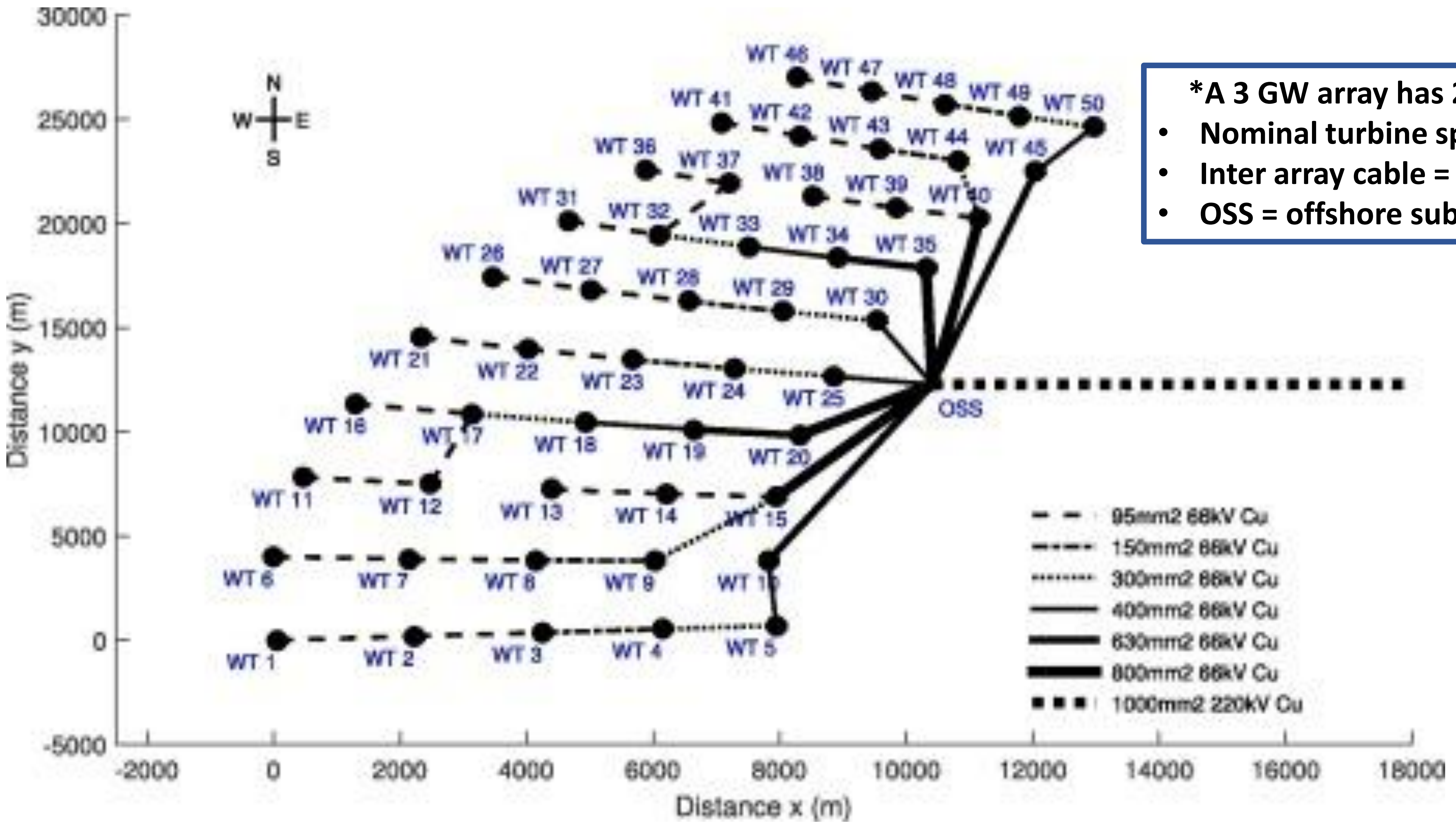


Figure 3.4-1 – Components of a Dynamic Cable System, Source: [1]

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjhj7bEpOr2AhVGFjQIHZdoDvoQFnoECAMQAQ&url=https%3A%2F%2Fcorewind.eu%2Fwp-content%2Fuploads%2Ffiles%2Fpublications%2FCOREWIND-D3.1-Review-of-the-state-of-the-art-of-dynamic-cable-system-design.pdf&usg=AOvVaw3NFuipsqgYAqKNPokjRivx

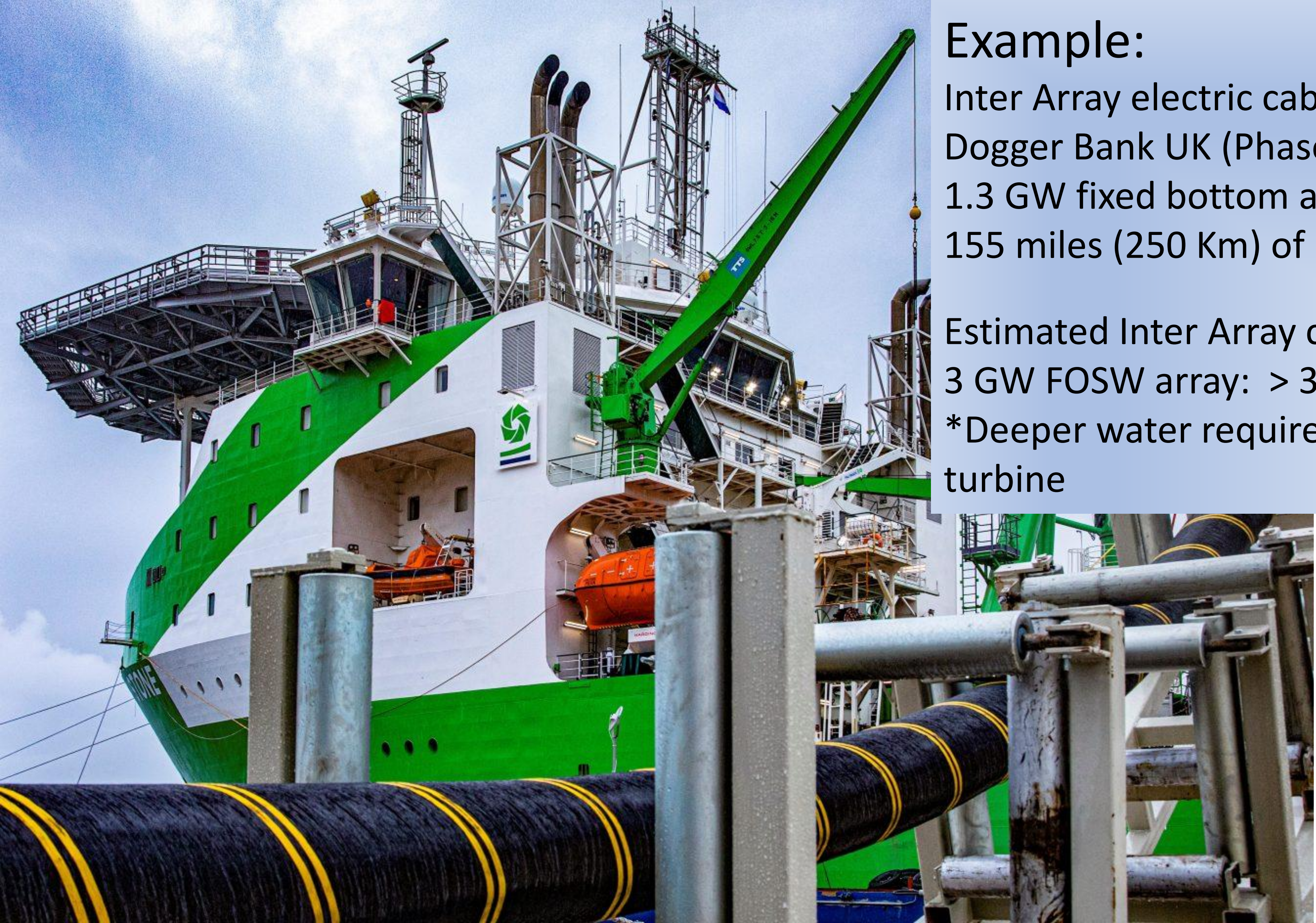
Example of an inter array cable layout for a 50*-turbine array



*A 3 GW array has 200+ turbines

- Nominal turbine spacing = 7X rotor dia
- Inter array cable = hundreds of miles
- OSS = offshore substation

https://www.sciencedirect.com/science/article/pii/S0142061521003677



Example:

Inter Array electric cable system
Dogger Bank UK (Phase three)
1.3 GW fixed bottom array (shallow)
155 miles (250 Km) of inter array cable

Estimated Inter Array cable length:
3 GW FOSW array: > 350* miles of cable
*Deeper water requires more cable per turbine

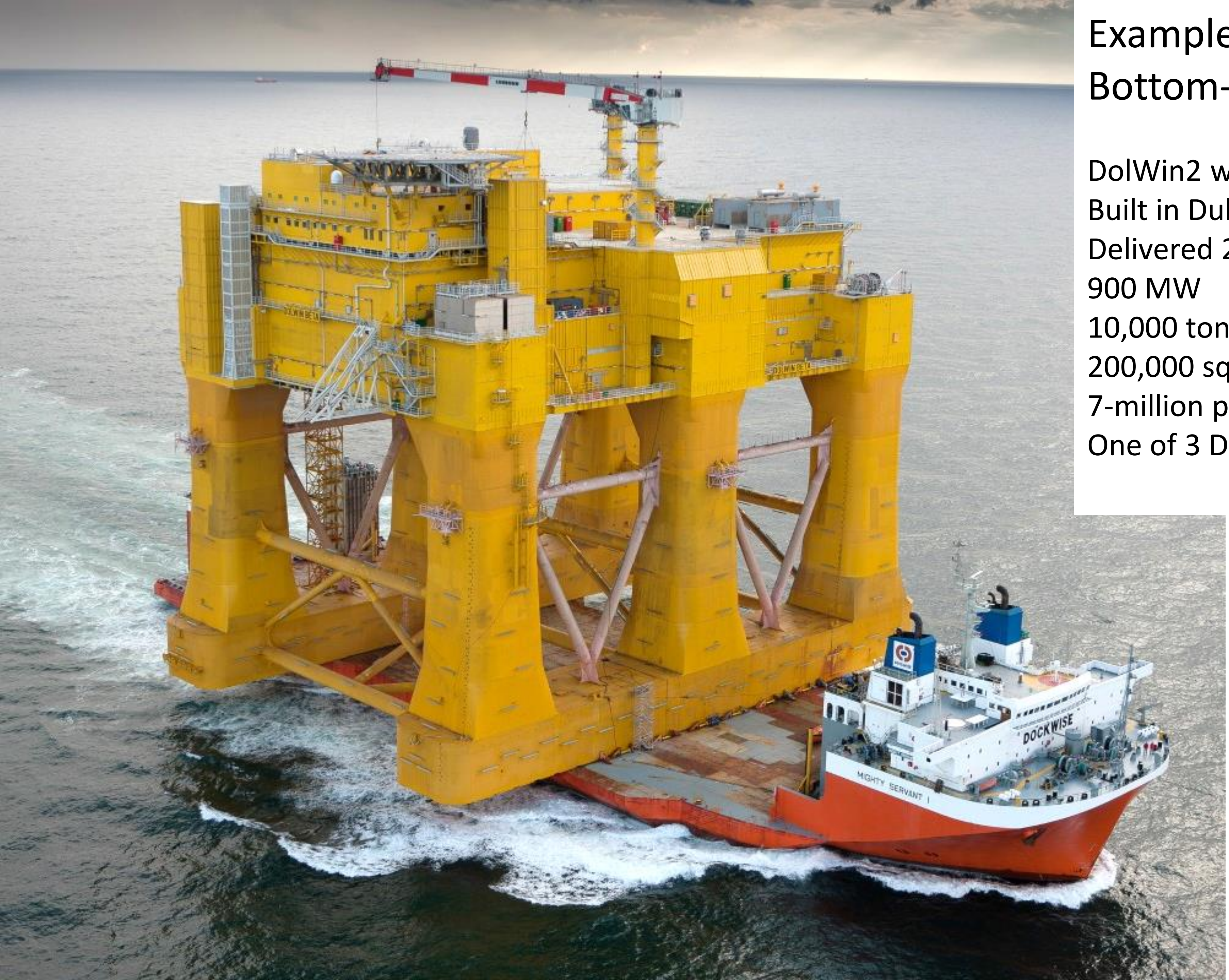
Van Oord Cable laying service vessel “Nexus”

Constructed: 2014
Crew members: 90
Cable carousel capacity: 5,000 tons

Deadweight: 7,000 tons
Length overall: 402 feet
Fuel capacity: 399,000 gallons

Offshore Substation

- Power from each turbine is collected at a high voltage substation for transmission to a shore substation
- *Floating substations are being developed* with high voltage dynamic cables that allow the substations to move with the waves
- Substations weigh thousands of tons: e.g. Wickinger bottom mounted substation (shown) off Germany weighs 8,500 tons
- Weight and size of substations require massive floating foundations: on par with floating offshore oil rigs
- *Floating* offshore substations are assembled at port and towed to installation location.



Example
Bottom-fixed Offshore substation

DolWin2 windfarm in Germany
Built in Dubai by ABB Ltd.
Delivered 2014 by Drydocks World shipyard
900 MW
10,000 tons
200,000 sq m of painted surface
7-million person hours to construct
One of 3 DolWin wind farm substations

Port Requirements for Floating Offshore wind projects

Major Activities of Offshore Energy Development

- Component manufacture, transport, and staging
- Shoreside component assembly
- Turbine assembly tow out, and mooring installation
- Inter array and transmission cable installation
- Siting, fabrication, tow out, mooring, operation and maintenance of offshore and onshore sub
- Operation, and maintenance of the array
- Decommissioning and Removal

Cluster Ports:

- Facilities for fabrication, construction, staging, & assembly.
- Can support to more than one windfarm
- Have a significant number of purpose- built facilities for each development phase.

Fabrication Ports

- Construction, staging, & pre-assembly of device components
- Transport hub for device components & materials
- Fabrication of nacelle, blade, foundation, cable, generator, hub, cable

Quick Reaction Ports

- Crew Transfer
- Minor maintenance& repairs
- Operations homeport
- Homeport for pre-installation surveys (bathymetric, benthic)

Assembly Ports

- Support final assembly of devices
- Provide staging & storage areas for components
- Marine tow to installation location
- Potential cable-laying & mooring installation & monitoring base

Example:

Dogger Bank bottom fixed wind farm in England will use Able Seaton Port for a wind turbine marshalling port
Dredged depth of Able Seaton is 15 meters (49 feet)
(Current dredged depth of Coos Bay channel is 37 feet)

Able Seaton Quay Capacity
60 tons per square meter

Example

Hull UK

- Siemens’ offshore wind turbine manufacturing facilities.
- Required filling 18.5 ac of the Humber Estuary at Alexandra Dock with 1.02 million cubic yards of material in 2017
- New 650 m-long quay wall
- Berth space for three offshore wind installation vessels
- New 18+ acre heavily reinforced concrete deck
- Heavy lift cranes
- First blade produced 2017
- Industrial brownfield site
- Tower assembly and loading
- Supports multiple wind farms

Floating wind foundation fabrication site: Hywind offshore energy project. Pori, Finland

Semi submersible spar foundation
under construction in Pori, Finland

Shoreside turbine assembly
Wind Float Atlantic-2
Portugal

Saipem 7000

Heavy lift semisubmersible crane

- 3rd largest floating crane
- 14,000-ton lift capacity
- 172,000 tons displacement
- Boom length 140 m (459 feet)
- Vessel length 197 m (646 feet)
- 12 thrusters w/ 21,500 total hp
- Transit draft 34 feet
- Heavy lift draft 90 feet
- Crew up to 700 persons
- Fully chartered

Some floating wind turbines may require final assembly in deep calm water

Installing a 1,140-ton 6MW turbine assembly on 10,500-ton floating spar foundation substructure in Norway prior to tow out to installation site

One of 5 turbines destined for Statoil's 30MW Hywind Scotland floating wind farm

The Cost of Floating Offshore Wind

OCS Study BOEM 2020-048

Energy cost considerations

1. **Cost per installed energy unit (e.g. $/MW)**

2. **Levelized cost of energy produced (e.g. $/kWh)**
    - Cost of construction
    - Subsidies
        - Renewable energy Investment tax credits
        - Renewable energy Production tax credits
    - Sale/Purchase price/KWh

3. Opportunity cost* for development sector

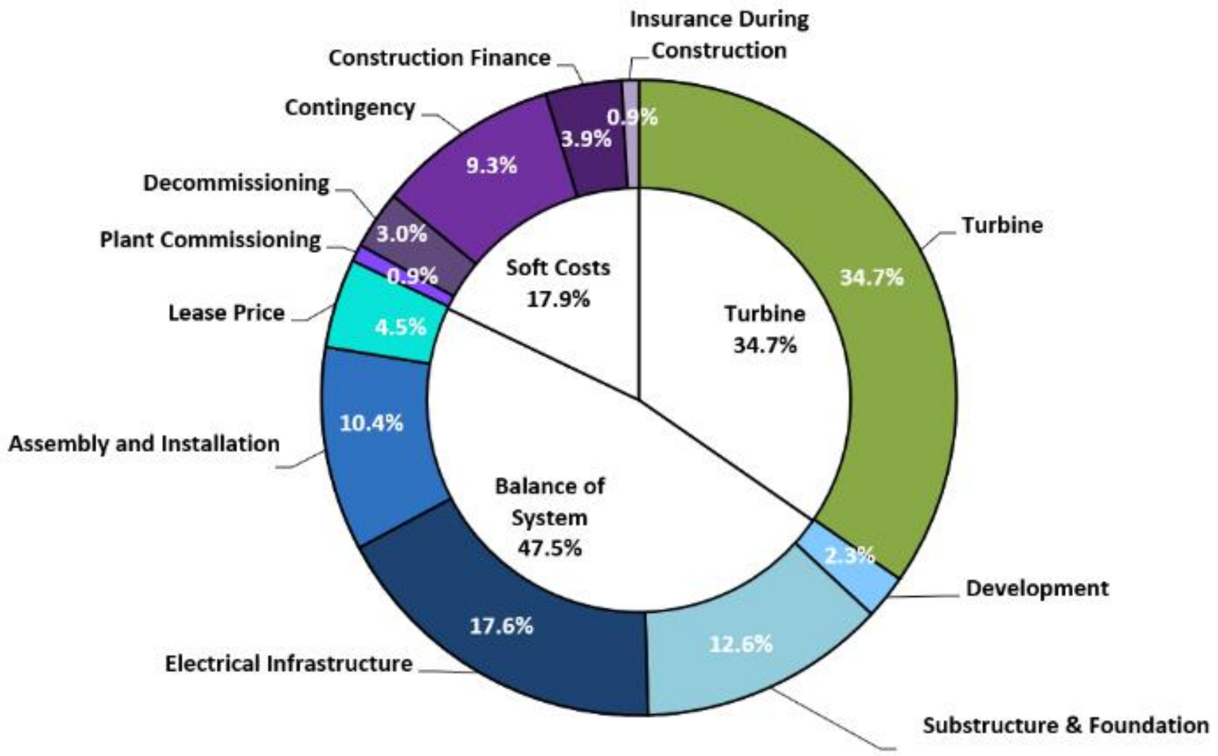
Transition from offshore oil and gas production to offshore wind

4. Opportunity cost* for federal treasury

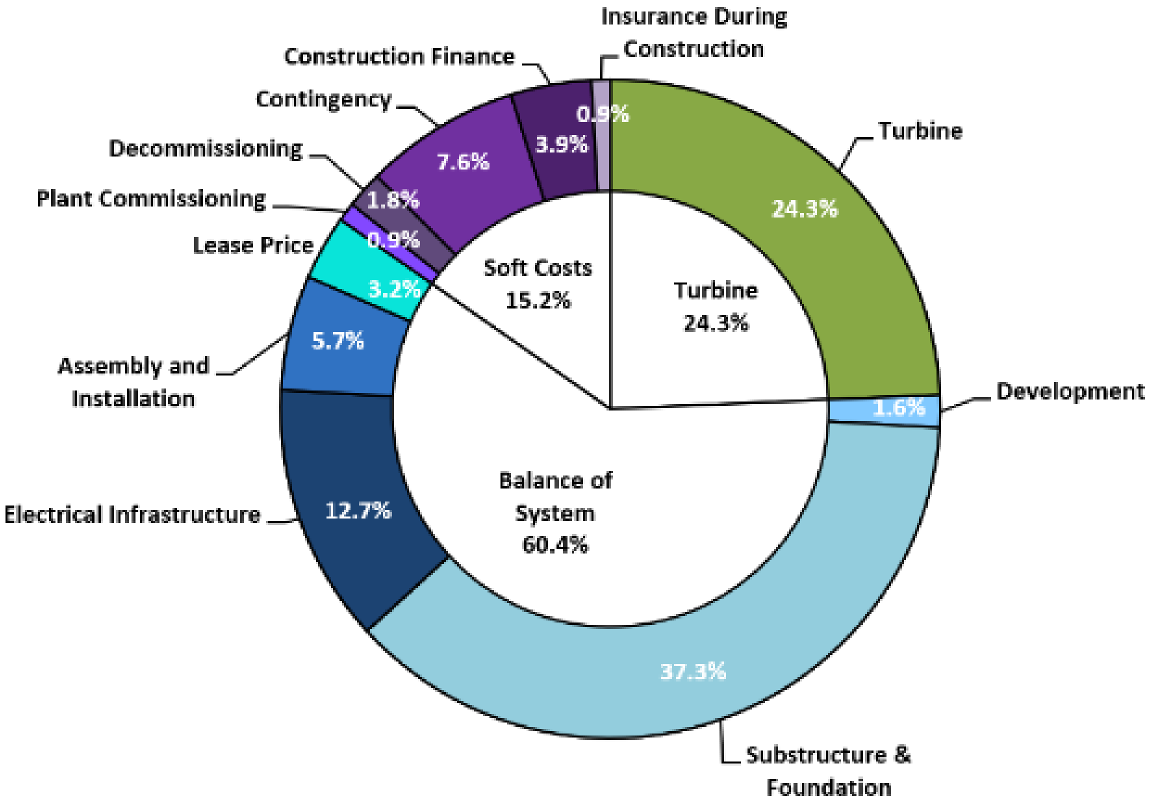
Transition from offshore oil and gas lease $$ to offshore wind lease $$

****Opportunity cost*** is the potential loss from a missed opportunity—
the result of choosing one alternative and forgoing another
"What will we *lose* if we don't do this"

Floating offshore wind is ***almost twice*** as expensive as bottom-fixed offshore wind



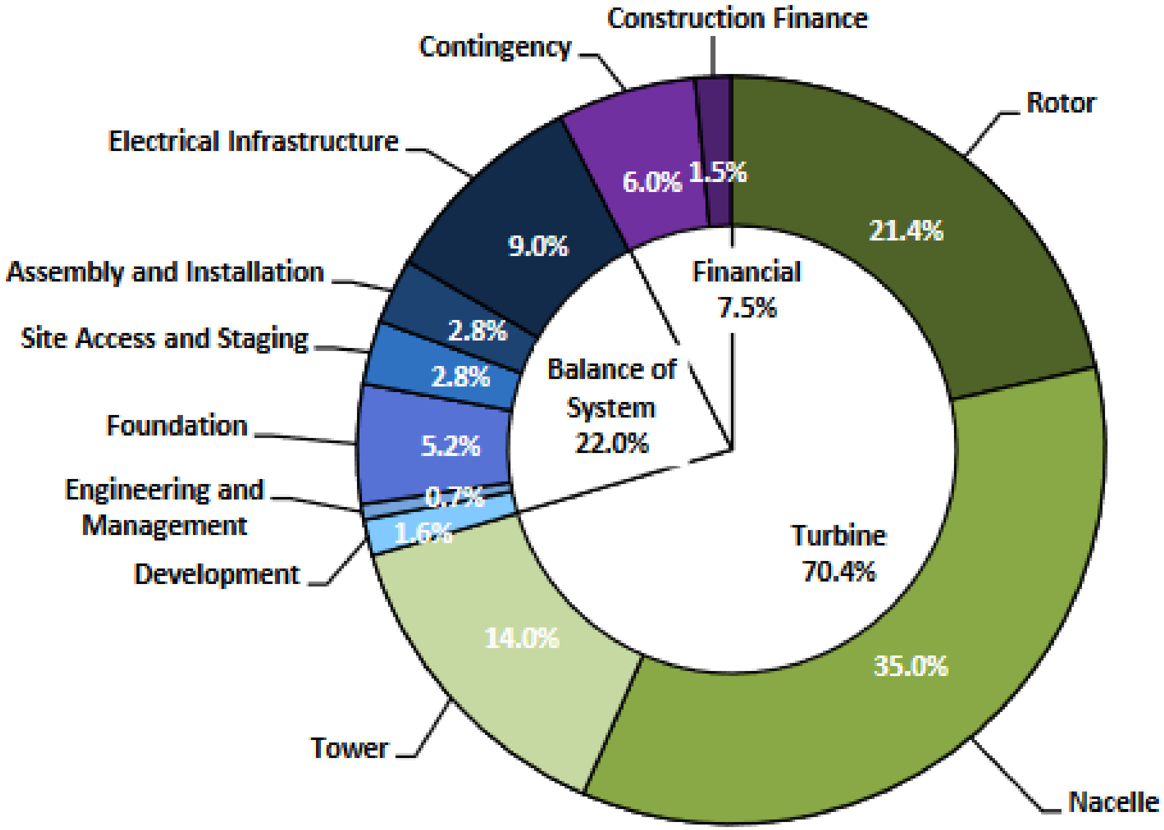
Fixed Bottom $3,756 per KW
$51 per MWh



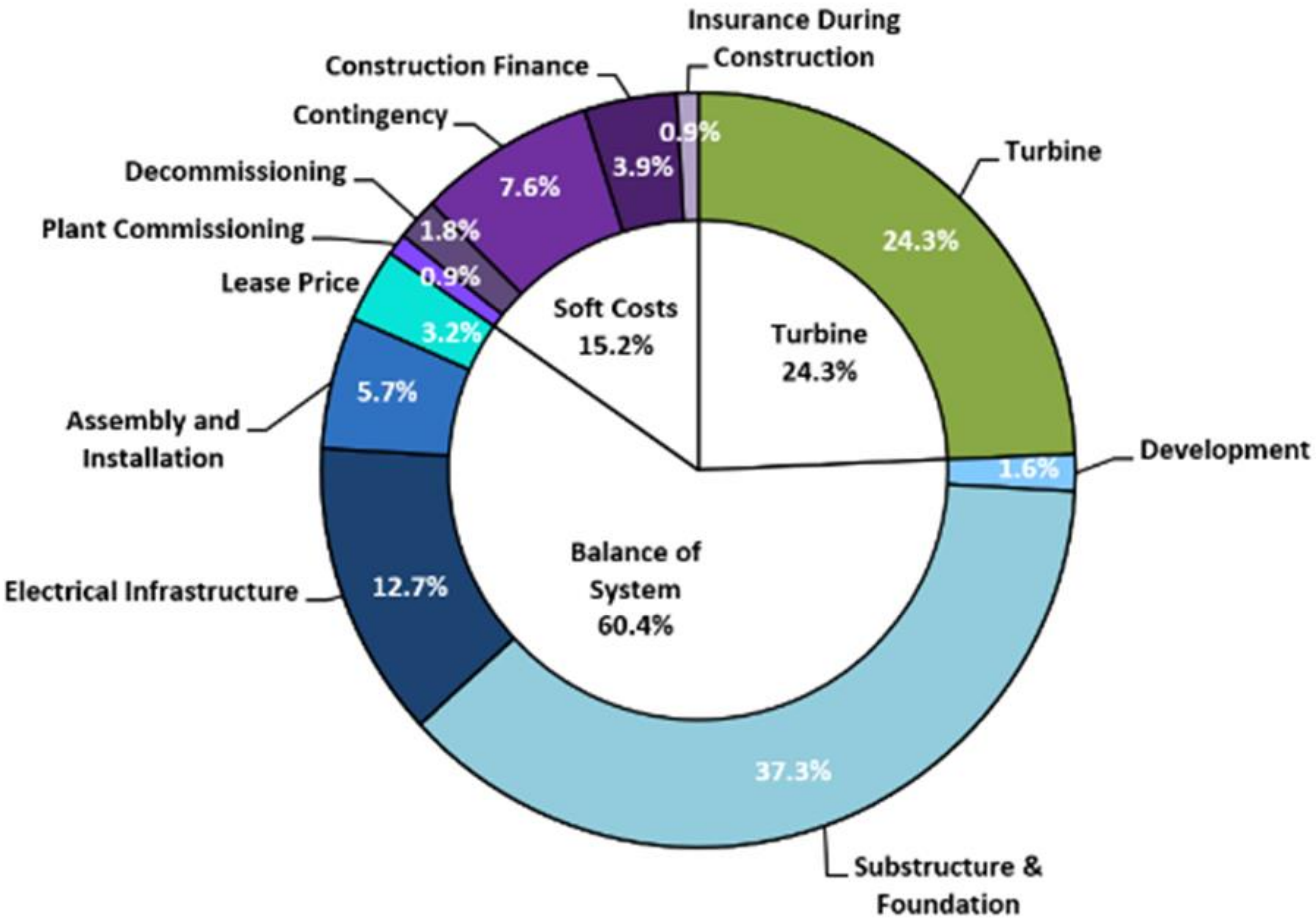
Floating $5,328 per KW
$91 per MWh

The Capital Expenditure Costs of Offshore Wind: Fixed Bottom vs. Floating Source: NREL

Floating offshore wind is
4 times more expensive than land-based wind



Land based wind
$1,462 per KW
$22.80 per MWH



Floating wind
$5,328 per KW
$91 per MWh

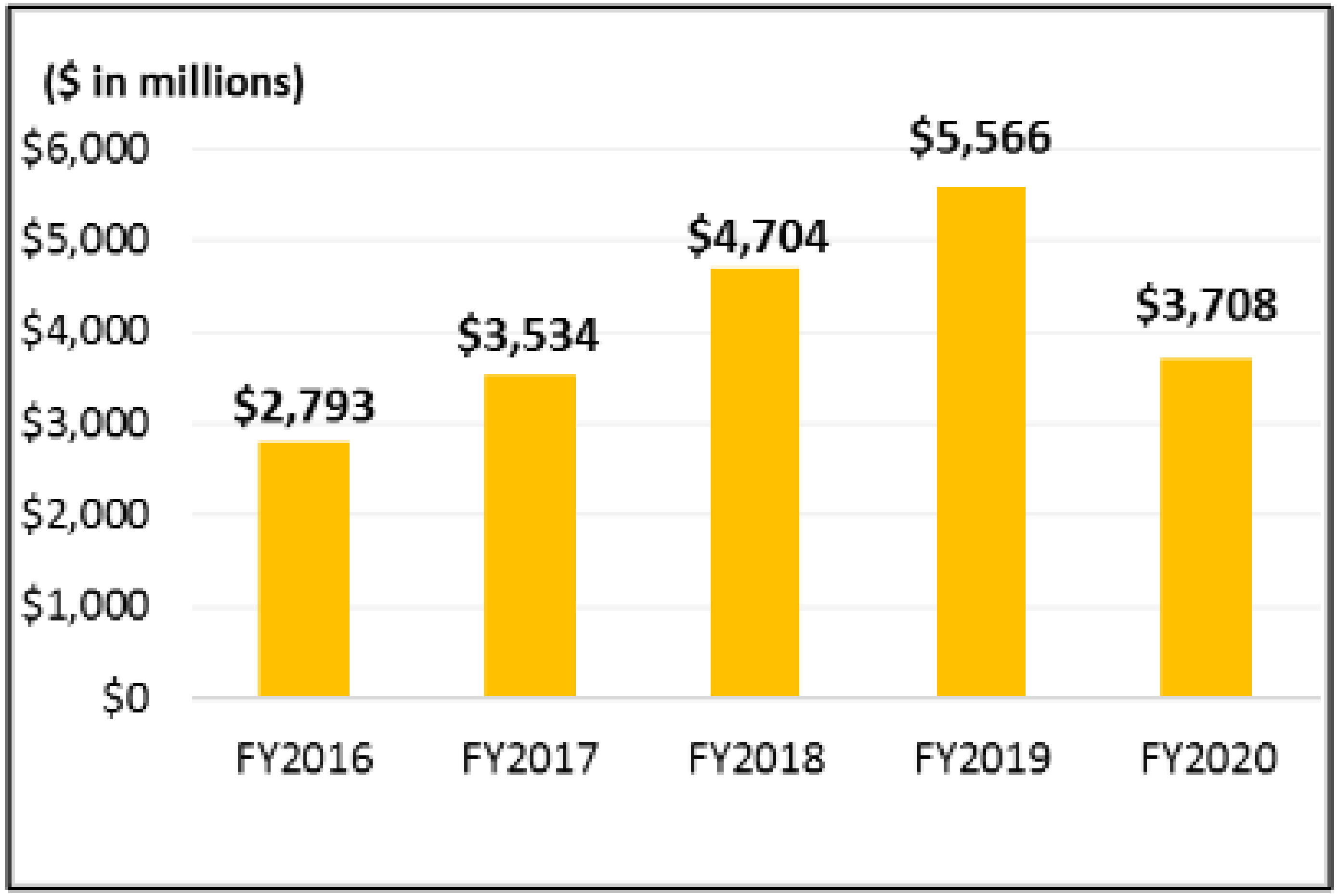
Source NREL

Opportunity cost Considerations: Federal Treasury

Decarbonizing the US energy supply will phase out a major source of revenue for the US treasury.

When offshore Oil and Gas revenues go away, It will leave a $5.5 + Billion per year hole in the US Budget.

Figure 2. Federal Offshore Oil and Gas Revenues for the Full Fiscal Year, FY2016-FY2020



Offshore O&G production represented 72% and 25% of federal oil and natural gas production in 2019

To lease or not to lease... There is ***huge*** fiscal pressure on governments to privatize public trust ocean resources:

BOEM*: If no more Oil & Gas lease revenues then what?
US Treasury:
What is the cost of NOT leasing the ocean for wind?

From the 1950s to at least 2002, drilling for oil and gas on US federal lands and waters produced the second largest source of revenue for the federal government other than taxes.

*BOEM's singular statutory purpose?
- Lease the ocean for energy

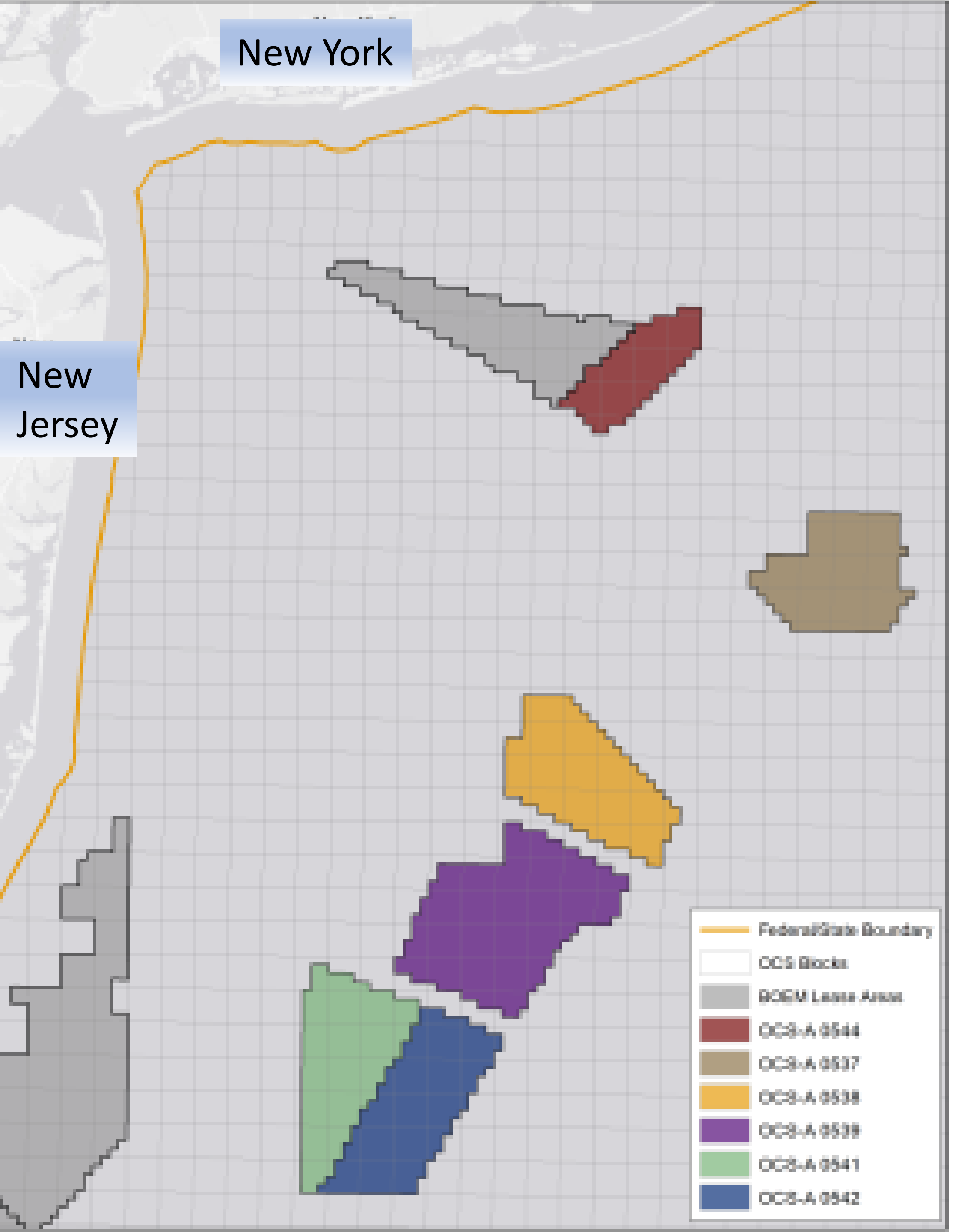
Ocean wind energy area locations
- different from Oil and gas areas
- Oil + wind $$ = a revenue boost?

UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF OCEAN ENERGY MANAGEMENT	Office Sterling, VA	Renewable Energy Lease Number OCS-A 0520*
COMMERCIAL LEASE OF SUBMERGED LANDS FOR RENEWABLE ENERGY DEVELOPMENT ON THE OUTER CONTINENTAL SHELF	Cash Bonus and/or Acquisition Fee $135,000,000.00	Resource Type Wind
Paperwork Reduction Act of 1995 statement: This form does not constitute an information collection as defined by 44 U.S.C. § 3501 et seq. and therefore does not require approval by the Office of Management and Budget.	Effective Date April 1, 2019	Block Number(s) See Addendum A

This lease, which includes any addenda hereto, is hereby entered into by and between the United States of America, ("Lessor"), acting through the Bureau of Ocean Energy Management ("BOEM"), its authorized officer, and

Lessee	Interest Held
Equinor Wind US LLC	100%

*This US ocean lease area is approximately 128,811 acres (201 square miles)



Example

Lease revenue

New York Bight Wind Lease Areas

February 2022

6 Leases awarded:

Total Ocean Area Leased: **763 Square Miles**

Lease value: $4.37 billion

Estimated wind power potential: 5.6 GW

Fixed Bottom

depths = 206 feet (63 m) max 102 feet (31 m) minimum

Closest Distance to NY coast : 23 mi

Closest Distance to NJ coast: 31 mi

Population of NY Metro Area: 20.3 Million

The total capital required to build offshore wind is massive

Investors understand the **opportunity cost** of *not* investing in OSW

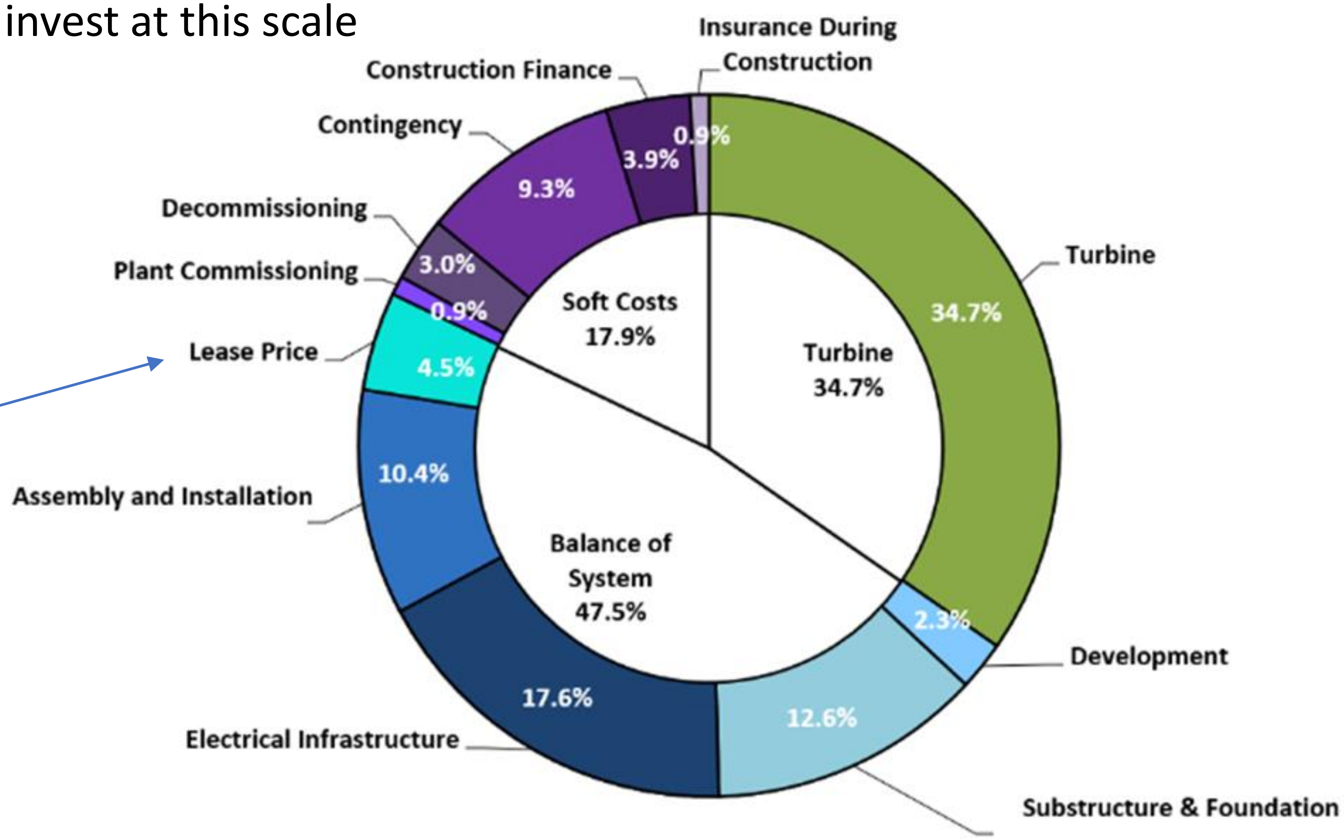
The 6 wind farms to be built in the NY bight represent a $96+ billion CapEx investment

Very few players have capacity to operate offshore and invest at this scale
The worlds biggest offshore oil and gas sector players currently dominate overall investment in the offshore wind sector

Value of 6 NY Bight Leases = $4.37 billion

NREL estimates price of the lease @ 4.5% of total construction cost

Accordingly, the estimated total cost to construct the first 6 wind farms in the NY bight = $96 Billion



Fixed Bottom offshore wind CapEX
Source NREL

US is not alone:

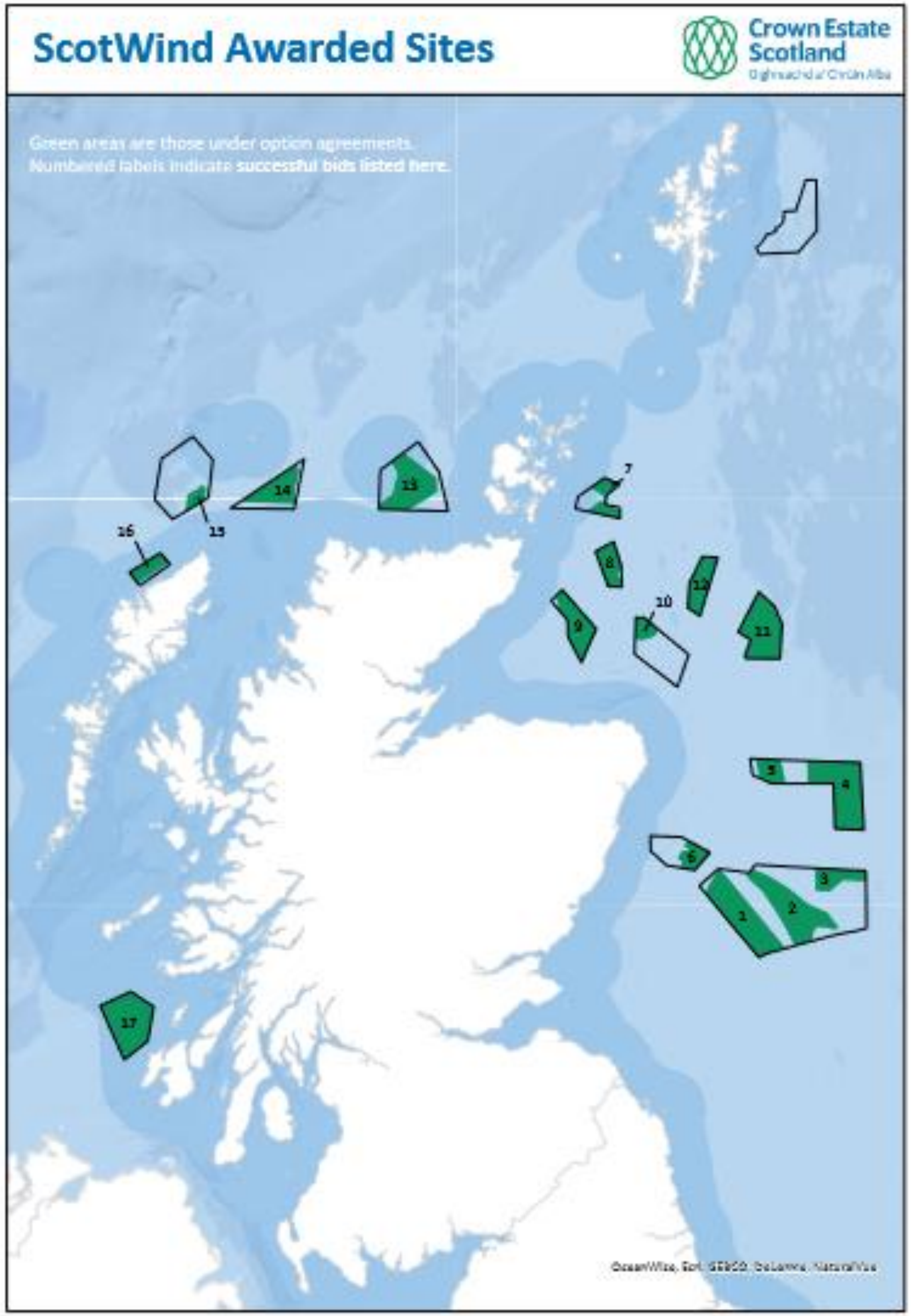
Worldwide: Governments face huge fiscal pressure to lease the ocean

Example:

17 January 2022:
Scotland Selected
17 OS wind projects
2,703 square miles
24.8 GW
Fees = $920 B (USD)

Map reference	Lead applicant	Option Fees	Technology	Total capacity (MW)
1	BP Alternative Energy Investments	£85,900,000	Fixed	2,907
2	SSE Renewables	£85,900,000	Floating	2,610
3	Falck Renewables	£28,000,000	Floating	1,200
4	Shell New Energies	£86,000,000	Floating	2,000
5	Vattenfall	£20,000,000	Floating	798
6	DEME	£18,700,000	Fixed	1,008
7	DEME	£20,000,000	Floating	1,008
8	Falck Renewables	£25,600,000	Floating	1,000
9	Ocean Winds	£42,900,000	Fixed	1,000
10	Falck Renewables	£13,400,000	Floating	500
11	Scottish Power Renewables	£68,400,000	Floating	3,000
12	BayWa	£33,000,000	Floating	960
13	Offshore Wind Power	£65,700,000	Fixed	2,000
14	Northland Power	£3,900,000	Floating	1,500
15	Magnora	£10,300,000	Mixed	495
16	Northland Power	£16,100,000	Fixed	840
17	Scottish Power Renewables	£75,400,000	Fixed	2,000
Totals		**£699,200,000**		**24,826**

ScotWind projects selected



OK, Floating offshore wind is staggeringly expensive
Is it the most effective way to decarbonize the planet?

We are trying to save the planet, right?

The shallow water ocean has been rapidly industrialized
Should earth’s Anthropocene era also be marked
by the rapid industrialization of the deep-water ocean realm*?

Is FOSW the best plan to fix the planet or
is it just the next phase of “The Great Acceleration”?

More than 15,000 offshore wind turbines are forecast to be installed globally by 2025, rising to 26,900 by 2030. This will be a 270 percent increase from 2020’s 7,233 installed turbines, (Source UK-based research firm Clarksons Platou Renewables)

In the next 3 years: 45,000 offshore wind turbine blades will have been transported around the world to assembly destinations.

In the next 8 years? 80,700 offshore wind turbine blades will have been moved from the point of manufacture to the assembly location

Wind Turbine component transport vessel “Bold Wind” transporting blades for 5 offshore turbines

***Just because we can doesn’t mean we should**

It’s true, a spinning wind turbine produces no carbon emissions…. BUT

Some “Green energy” is “greener” than others

Simply *making the steel* for the 350 MW Wikinger bottom fixed offshore wind farm will produce Carbon Dioxide emissions equal to more than 43,800 passenger vehicles for an entire year*

This estimate *does not* include the Carbon Dioxide emissions associated with

- **Component fabrication**
- **Component transport**
- **Component assembly**
- **Component installation**
- **Operation, and maintenance**
- **Decommissioning**

The 350 MW Wikinger bottom mounted offshore wind plant will use over 109,000 tons of steel

More than 201,650 tons of CO_2 will be emitted to make the steel for this renewable energy project.

*In 2018 every ton of steel produced emitted on average **1.85 tons** of carbon dioxide

https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

*A typical passenger vehicle emits **4.60 metric tons CO_2E/vehicle /year**

https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references

Wind technology is the most copper-intensive form of renewable power

It will consume the largest amount of copper over the next ten years in this sector.

Over 650 GW of new *onshore* wind and 130 GW of new *offshore* wind capacity will be installed between 2018 and 2028. This will consume in excess of 5.5Mt of copper

Approximately 58% of copper consumed within wind installations is through cabling.
Between 2018 and 2028, new wind turbine installations will consume over 3 Mt of copper for collector and distribution cabling

https://www.woodmac.com/press-releases/global-wind-turbine-fleet-to-consume-over-5.5mt-of-copper-by-2028/

Floating offshore wind:

The *most* copper intensive form of wind power.. by far

Overall, *Offshore* wind energy has significantly higher copper use than *onshore* wind.

Copper intensity at British bottom fixed offshore wind farms may be as high as 22,000 lbs./MW. [Falconer, 2009],
At this rate a 3 GW *fixed-bottom* OSW farm uses more than 66 million pounds of copper

The copper use rate for *bottom fixed* OSW is > 40% higher than the use rate for *onshore* wind

Floating OSW is even *more* copper intensive than *bottom fixed* OSW

Cabling accounts for >80% of total copper usage in offshore wind farms or 16,346 lbs./MW.

- Increased water depths of FOSW increase tower to seabed distances and inter array cable lengths
- Increased distances from shore of FOSW requires longer, larger diameter transmission cables

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiFuYGl4Mv2AhXxJzQIHXj3BjgQFnoECAMQAQ&url=https%3A%2F%2Fdocs.wind-watch.org%2FCopper%2520use%2520in%2520wind%2520farms.pdf&usg=AOvVaw374khpEsT2HumqkKFtaVVt

https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiwp6y36sr2AhViJTQIHSorAJ8QFnoECCcQAQ&url=https%3A%2F%2Fwww.copper.org%2Fpublications%2Fpub_list%2Fpdf%2Fa6198-na-wind-energy-analysis.pdf&usg=AOvVaw32kfEImPNOWoLamIEawiqg

Example

Carbon footprint of Offshore Wind turbine blade Transport

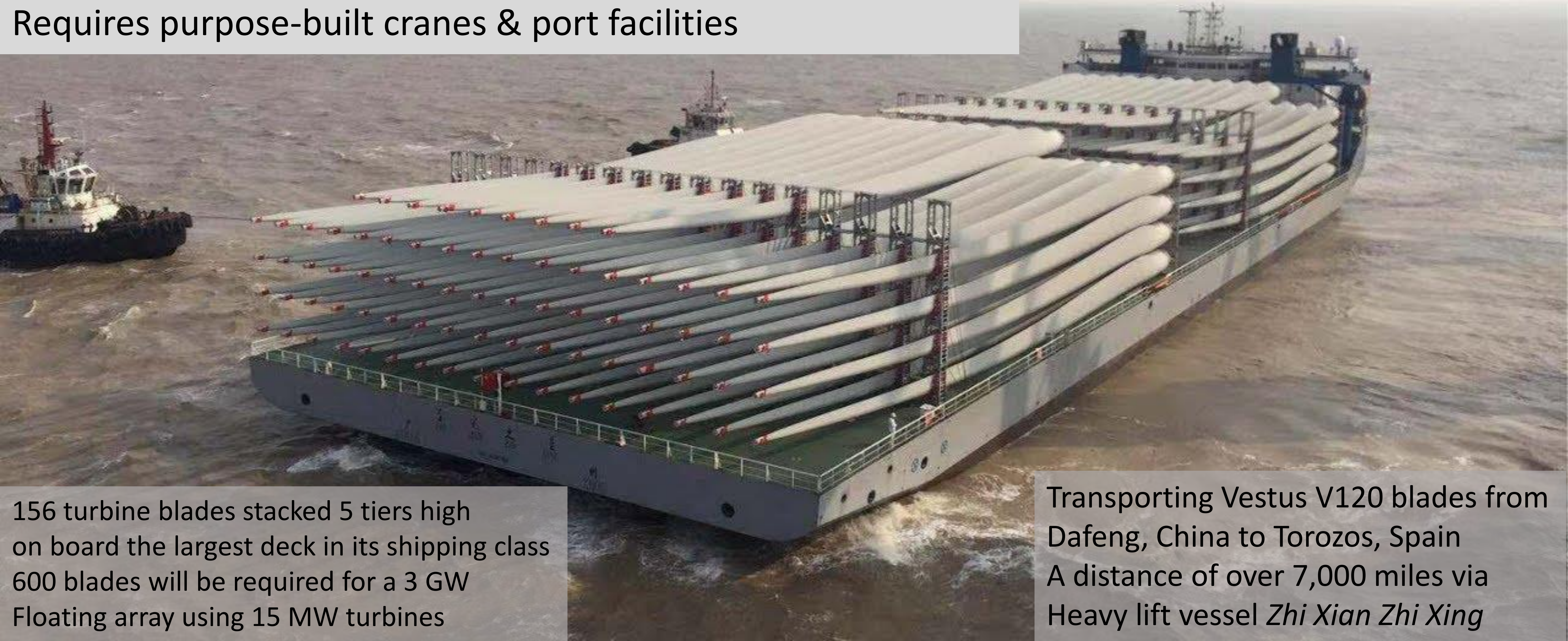
OSW Blades are so large overland transport often not feasible

Huge parts must be manufactured at or near a port facility

Transport requires specialized transport vessels

Requires purpose-built cranes & port facilities

Vestas



156 turbine blades stacked 5 tiers high
on board the largest deck in its shipping class
600 blades will be required for a 3 GW
Floating array using 15 MW turbines

Transporting Vestus V120 blades from
Dafeng, China to Torozos, Spain
A distance of over 7,000 miles via
Heavy lift vessel *Zhi Xian Zhi Xing*

6,000 sq meters of loading space

Heavy lift vessel *Zhi Xian Zhi Xing* transporting Vestus V120 blades from Dafeng, China to Torozos, Spain
A distance of over 7,000 miles

Planning and production → Production and acquisition → **Installation and commissioning** → Operation and maintenance → Decommissioning and repowering

The Rotra Vente, a wind turbine component transport vessel
Loading a Siemens wind turbine nacelle at Siemens' manufacturing facilities in Cuxhaven, Germany

Time to attain results matters

- OSW projects have longest (years to decades) planning and development timelines
- Market analysts predict a global shortage of Wind Turbine Installation Vessels
- Construction of Jones Act compliant Wind turbine transport, installation and service vessels likely to create multi-year delays
- Supply chain bottlenecks for components (e.g. cable, blades) likely to create delays.

The Jones Act: A *big* factor in US OSW supply chain

The Jones Act is a US law that requires all vessels

- ***shipping merchandise and passengers between two U.S. points must be U.S. built and registered (flagged) &***
- ***must be owned and crewed by U.S. citizens or residents*** (U.S. Customs and Border Protection 2020).

To avoid supply chain bottlenecks developers must build all new U.S.-flagged Wind Turbine Installation Vessels or

develop a Jones-Act-compliant strategy using foreign-flagged WTIVs & U.S.-flagged feeder vessels. Market analysts predict a global shortage of WTIVs

As of Aug 2021, no Jones-Act-compliant wind turbine installation vessels existed

Construction of the first-ever, Jones-Act-compliant Wind Turbine Installation Vessel began in 2020.

Rendering of Jan De Nul's Voltaire offshore installation vessel will be one of the largest vessels able to install the next generation of supersized turbines.

Offshore wind energy report 2021 edition US Dept of Energy

Existing land based wind farms are repowering This activity creates potential port bottlenecks for new OSW projects

"There's a huge demand right now for turbines, for blades, and so they're sourcing all over the world right now to deliver the energy projects that we're building for our customers by the end of 2020," said Timothy Henstreet, managing director at PacifiCorp June 2019

Port of Vancouver BC: Offloading a shipment of Italian made turbine blades
Bound for PacifiCorp's 12 yr. old 117-turbine Marengo wind farm in Dayton WA
351 blades are part of a repower upgrade.

https://www.clarkcountytoday.com/news/largest-ever-shipment-of-wind-turbine-blades-arrives-at-the-port-of-vancouver/

Is the solution to keep making *More* Energy? What if we invested in using *Less* Energy?

Manifest destiny got us to this point. Should we keep going?

Energy producers have no fiscal reason to support using less energy
Their purpose is to produce more not to decrease “demand”

“You can’t get to net zero without insulation...”

Jan Rosenow, director of European programmes the Regulatory Assistance Project.

“For decarbonisation, we want to be the pilots, not the passengers.”

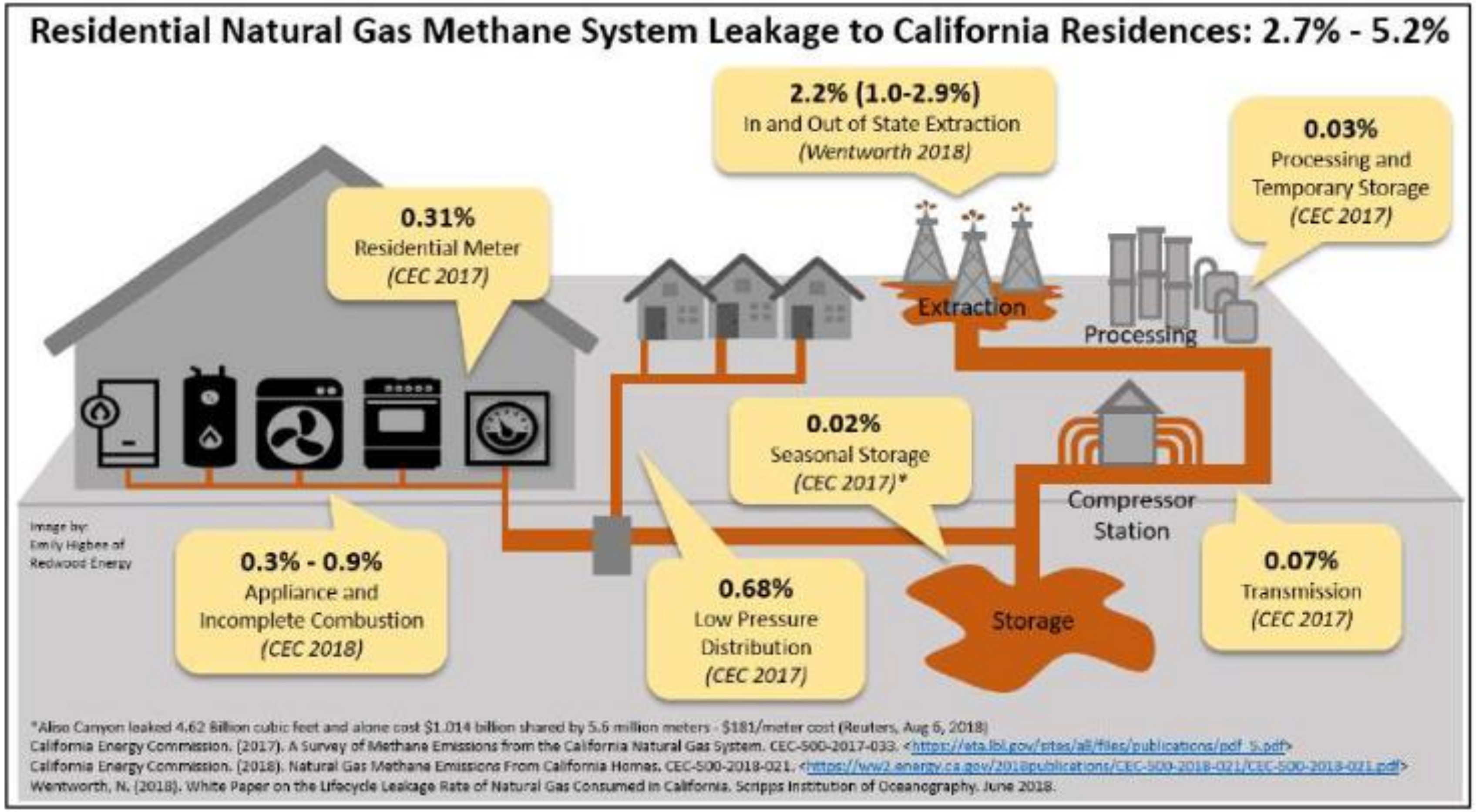
Grant Shapps, UK transport secretary,

Decarbonization
Use less solution
Replace your gas appliances!

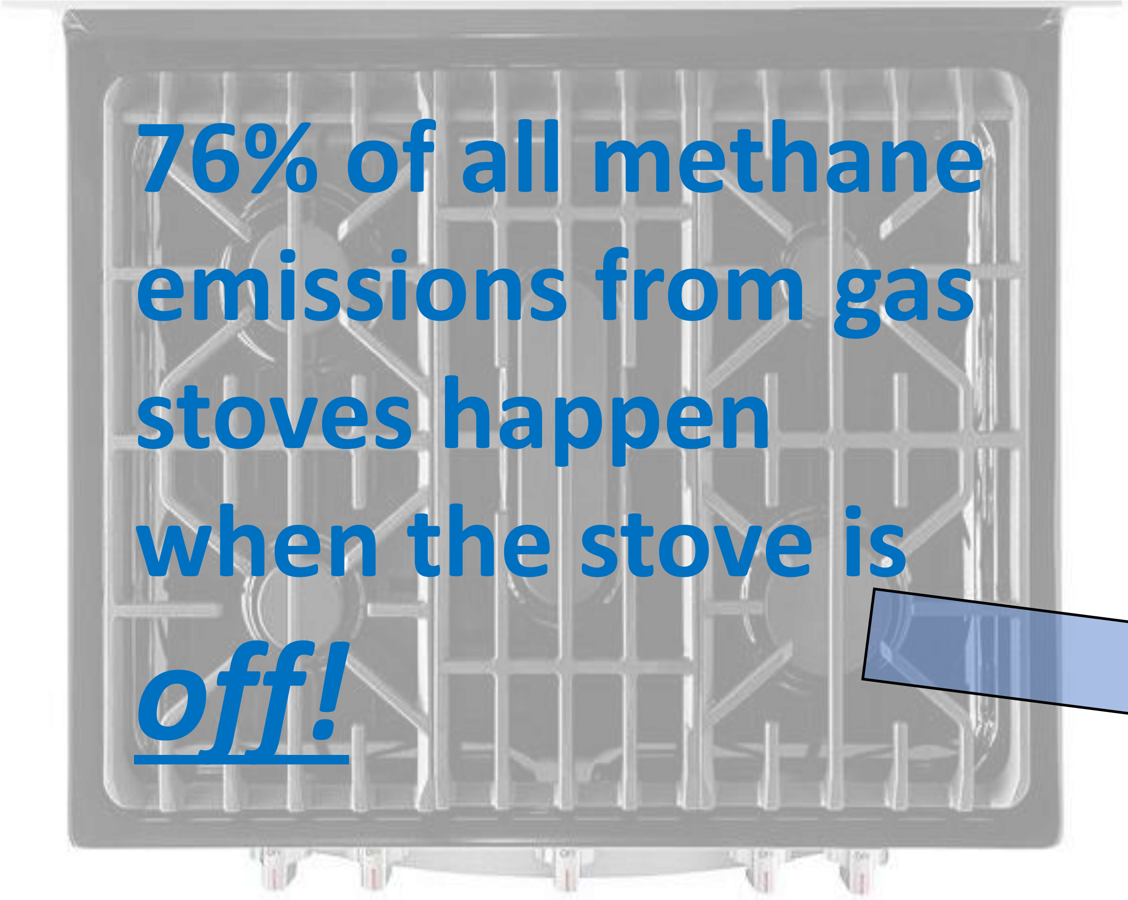
Methane (Natural Gas)
Potent climate disrupting gas
80X more than Carbon Dioxide

A lot of gas leaks before even it gets burned.

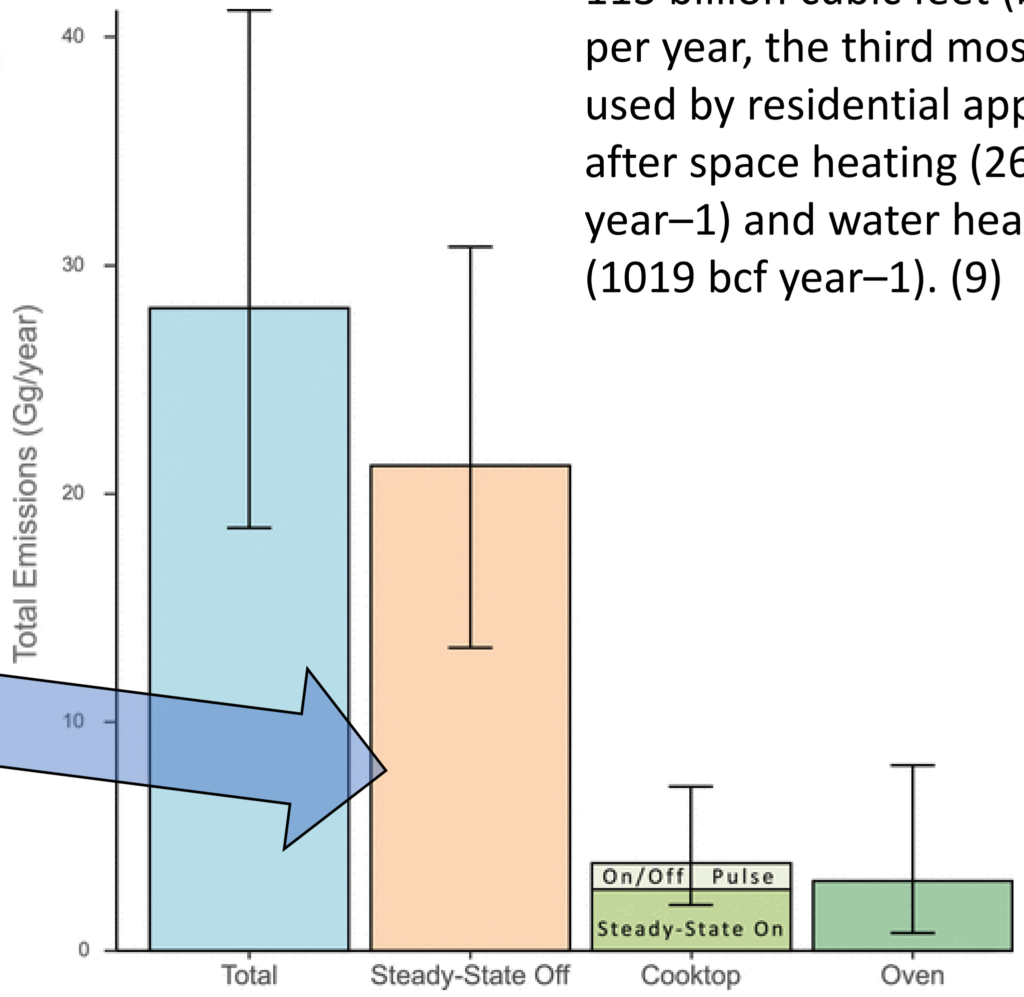
Gas utilities probably aren't too excited about that option…



Decarbonization solution: Replace your gas stove!



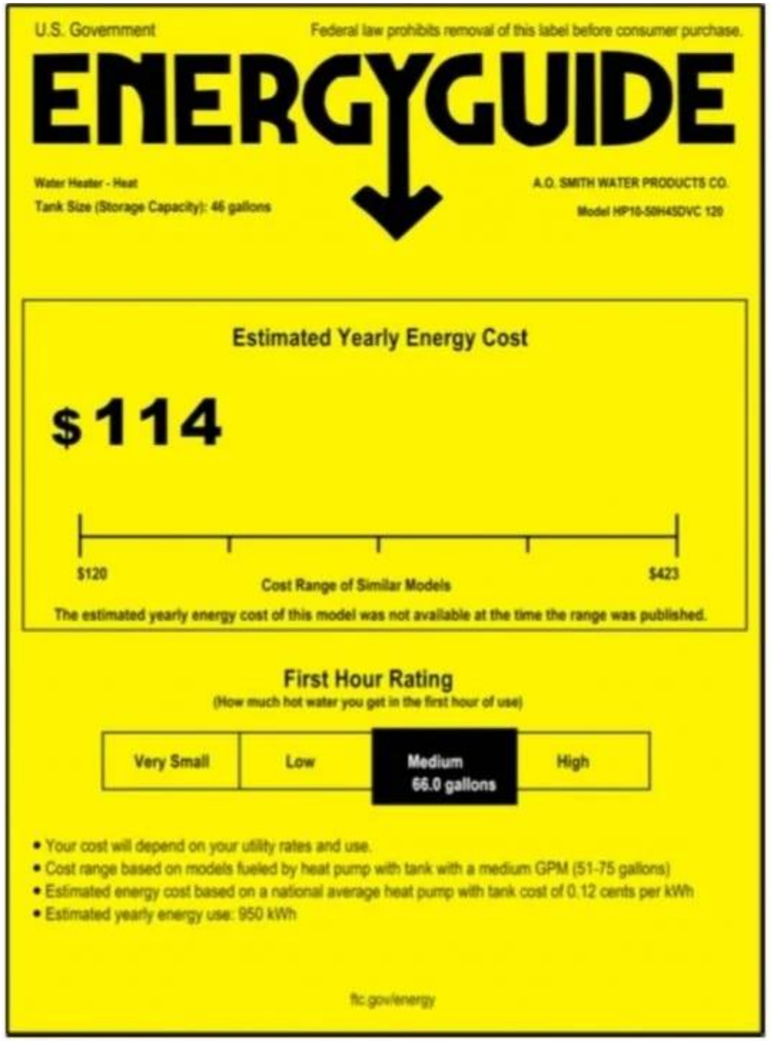
76% of all methane emissions from gas stoves happen when the stove is *<u>off!</u>*



In the US, natural gas residential indoor cooking appliances use 113 billion cubic feet (bcf) of gas per year, the third most gas used by residential appliances, after space heating (2677 bcf year–1) and water heating (1019 bcf year–1). (9)

https://pubs.acs.org/doi/10.1021/acs.est.1c04707

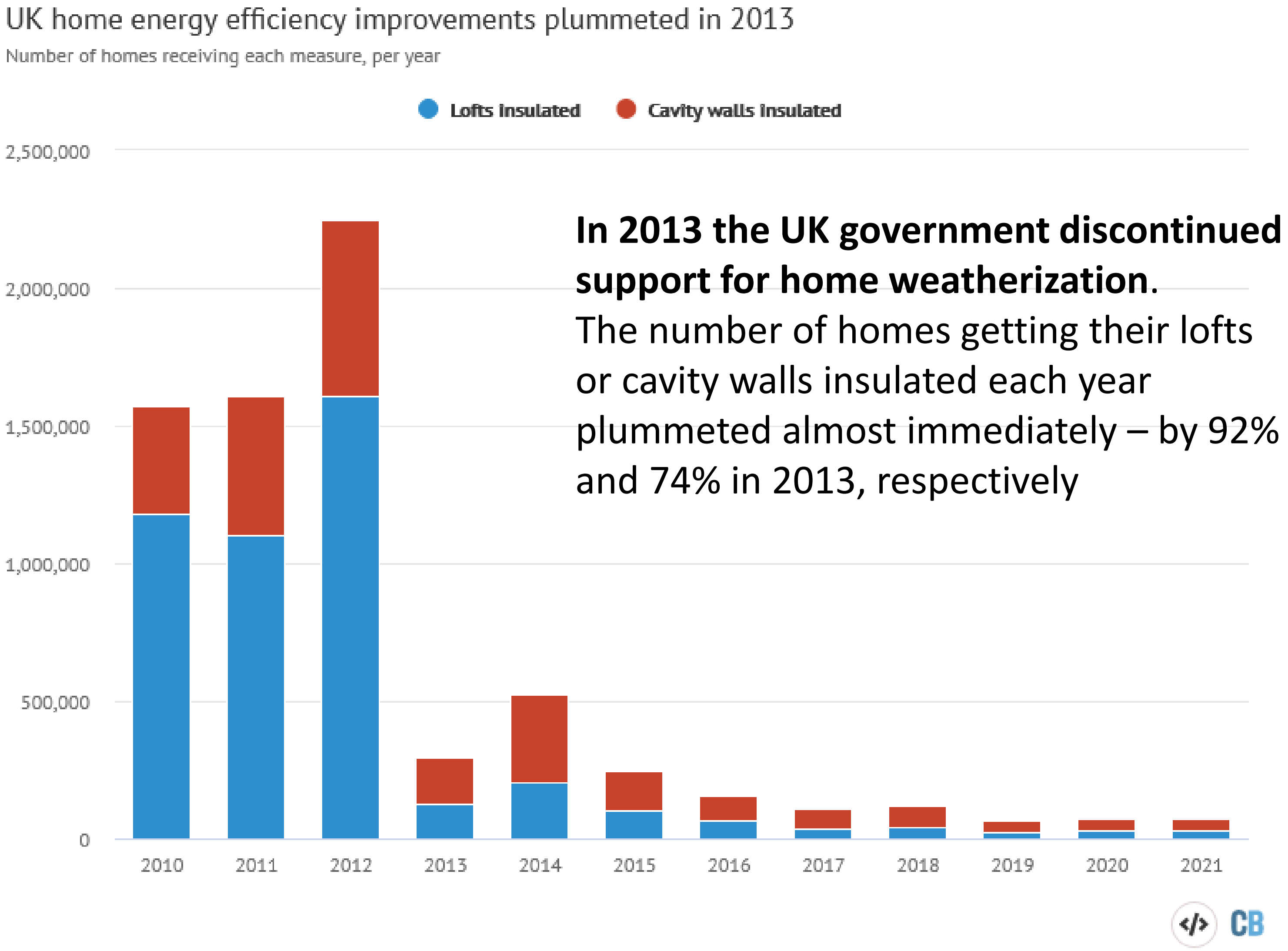
Decarbonization solution using less: Replace your electric water heater



Heat pump water heater

Conventional electric

Conservation Incentive programs work! Encourage use reduction polices



In 2013 the UK government discontinued support for home weatherization.
The number of homes getting their lofts or cavity walls insulated each year plummeted almost immediately – by 92% and 74% in 2013, respectively

https://www.carbonbrief.org/analysis-cutting-the-green-crap-has-added-2-5bn-to-uk-energy-bills

Frequently asked questions about offshore wind energy

"Yes, but what about all those cars and oil furnaces?
they need to be converted to electricity that'll take a LOT!"

Shouldn't it be "yes to all the above?"

"Well, how about nuclear then? It makes a LOT of electricity!"

- Hmmm…. But nuclear has big downsides
  - Remember 3 Mile Island? 28 March 1978
  - Nuclear power is really expensive too.
  - It'll take forever to permit a nuke plant
  - What about radioactive waste?

"Are there any other options?"

What about Solar panels?

It costs ***6 x*** more to install Floating OSW generating capacity than the same amount of land based solar photovoltaic

Using NERL's 2019 estimated installed cost of $5,350/kW for Floating Offshore Wind

The estimated installation cost for **3 GW of floating offshore wind generating capacity in CA is $16.05 *Billion* dollars**

Here's the math….

$5,350/kW installed

x 1,000 kW/MW (= $5,350,000/MW)

x 1,000 MW/GW (= $5,350,000,000/GW)

x **3 GW = $16,050,000,000**

Using IREA's 2020 global average installed cost of $883/kW for land based photovoltaic solar

The estimated installation cost for **3 GW of solar photovoltaic generating capacity is $2.65 Billion**

Here's the math

$883/kW installed

x 1,000 kW/MW (= $883,000/MW)

x 1,000 MW/GW (= $883,000,000/GW)

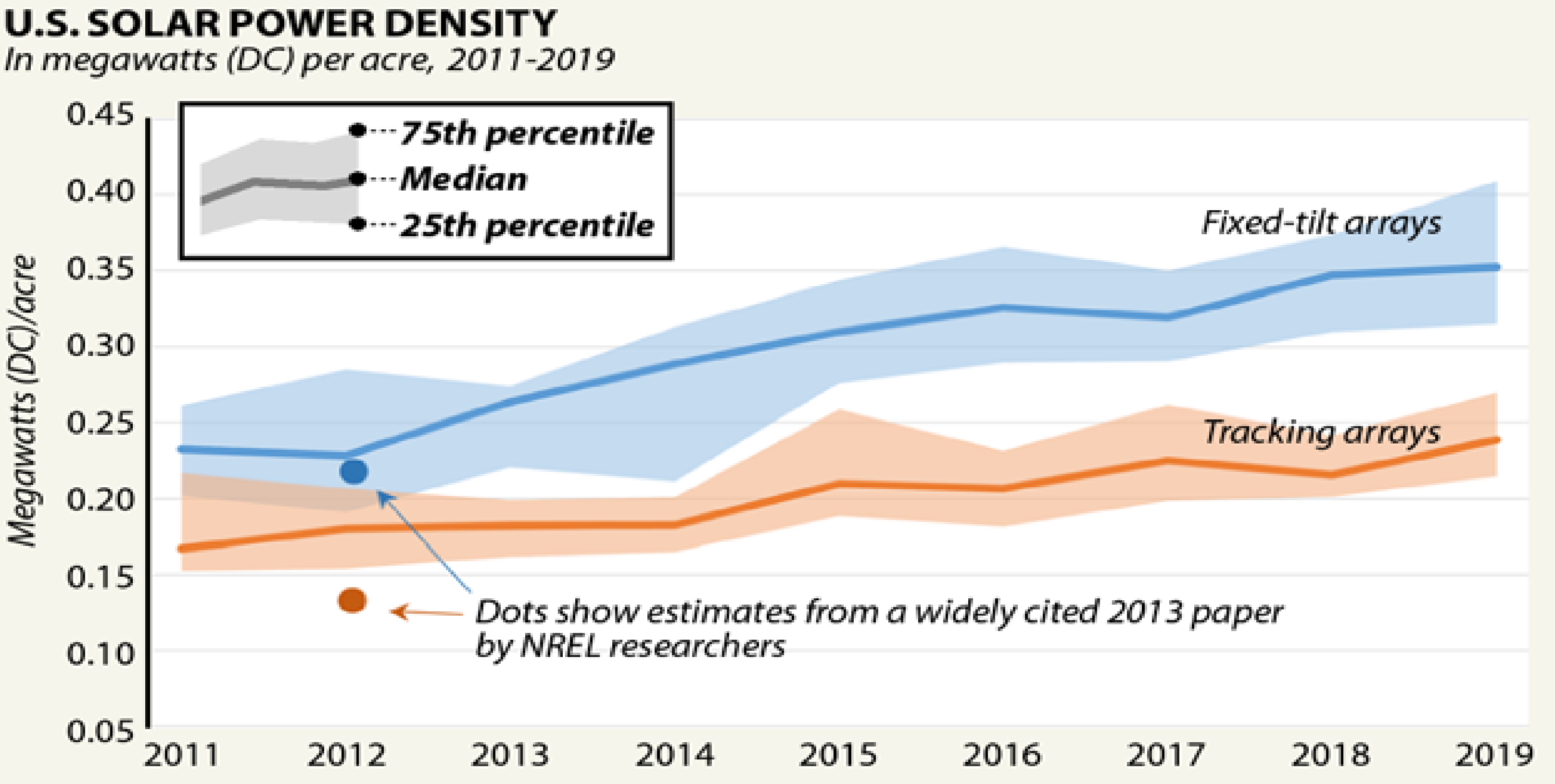
x **3 GW = $2,648,000,000**

https://www.nrel.gov/docs/fy21osti/77384data.xlsx https://www.irena.org/Statistics/View-Data-by-Topic/Costs/Global-Trends

https://www.energy.gov/sites/default/files/2021-08/Offshore Wind Market Report 2021 Edition_Final.pdf

Utility-Scale Solar photovoltaic energy uses *less space* than offshore wind

New research shows that rising efficiency of solar panels means that developers can get much more electricity generating capacity per acre than before. This chart shows the shift in megawatts per acre for "tracking" solar arrays, with panels that shift throughout the day, and "fixed-tilt" arrays, which are stationary.



SOURCE: IEEE Journal of Photovoltaics

Inside Climate News

In 2019, median power densities were 52% higher for fixed-tilt plants and 43% higher for tracking plants than in 2011

a 100MW tracking solar array needed about 600 acres in 2011, but only needed about 420 acres in 2019

https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=9676427

Solar PV lease areas compared to Oregon offshore wind call areas

Desert Sunlight Solar Farm;
USBLM lease area in Riverside County, California
550MW capacity; Second largest solar farm in US.
6 Square miles (3,900 acres).

Topaz Solar Farm;
USBLM lease area San Luis Obispo Co., CA
550MW capacity; Second largest solar farm in US.
7.3 Square miles (4,700 acres).

The 1.1 GW nameplate capacity of these two photovoltaic plants occupy 13.3 Square Miles
Thus, the *land area* encompassed by a 3 GW land-based PV solar plant = **40 square miles**

The o*cean area* encompassed by BOEM's Oregon Floating offshore wind call areas = **2,181 square miles**

If covering up the desert with solar panels is not for you

Consider Agrivoltaics:

A win for renewable energy

Changing just 1% of American farmland to agrivoltaics could meet 100% of US national renewable energy targets

And a win for agriculture
while also saving water and
creating a sustainable long-term food system.
It also creates new revenue opportunities for
family farms currently facing increasing economic challenges

In Arizona, shading of crops using solar panels
reduced plant drought stress,
increased food production and reduced PV panel heat stress

https://www.nature.com/articles/s41893-019-0364-5
https://www.nature.com/articles/s41598-019-47803-3
https://agsci.oregonstate.edu/newsroom/sustainable-farm-agrivoltaic

To sum all this up;
In the search for effective decarbonization solutions

Floating offshore wind should be considered the "Caviar" of Renewable Energy

In 2020 the global average *installed cost* of solar PV was $883/kW ($8,830/MW)
The *cost per kWH* was $0.057/KWh ($57/MWh)
https://www.irena.org/Statistics/View-Data-by-Topic/Costs/Global-Trends

The 2019 *estimated installed cost* of floating offshore wind in California was between $3,850/kW ($3,850,000/MW) to $5,350/kW ($5,350,000/MW) ***this estimate does not include the cost to construct transport and operations vessels or port related facilities development costs.

NREL Estimated the cost per kWh for a 1 GW FOSW plant across five California study areas: Estimates ranged between $114/MWh and $95/MWh for plants starting in 2019, declining to $53–64/MWh by 2032
https://www.nrel.gov/docs/fy21osti/77384data.xlsx
https://www.energy.gov/sites/default/files/2021-08/Offshore%20Wind%20Market%20Report%202021%20Edition_Final.pdf

My decarbonization options evaluation put another way:

Land-based wind or solar

- Delivers far more decarbonization “bang for the buck” than FOSW
  - The amount of money needed to install *3GW* of floating offshore wind could be used to install *18 GW* of land based photovoltaic electricity
- I far more than adequate to replace all carbon-based electric generation
- Is faster and simpler to build, operate, maintain, and decommission
- Does not necessitate development of dedicated port infrastructure
- Is not constrained by the provisions of the Jones Act
- Does not displace existing uses like navigation and fisheries
- Can be co-located with existing uses such as agriculture and housing
- Can *increase* the productivity and value of agricultural land
- Does not degrade or industrialize the ocean “frontier”
- Is less resource intensive all around.
  - Less space, copper, steel, plastic, vessel fuel
  - Easier construction no special ships, no special anchors, simpler cable,
  - Simpler operations, maintenance refit and demobilization.

So why all the buzz about Floating Offshore wind?

Because pursuing offshore will stimulate economic growth

Who likes Floating offshore wind?

- The steel industry
- The copper industry
- The offshore industry
- The undersea cable industry
- The marine transportation industry
- The crane industry
- Trade unions
- Politicians
- Port development authorities
- The US treasury
- The Bureau of Ocean Energy Management

Are any of these interests obliged to choose the most effective way to decarbonize the planet?

Should we reasonably expect these interests to advocate for any decarbonization strategy other than offshore wind even if other options are more effective?

Whose responsibility is it to advocate for the most effective approach to decarbonization if not these interests?

Pursuing floating offshore wind is more of an economic development initiative with a green patina than a rational decarbonization strategy.

In a statement, U.S. Interior Secretary Deb Haaland said, "The Biden-Harris administration is committed to supporting a robust clean energy economy, and the upcoming Carolina Long Bay offshore wind energy auction provides yet another excellent opportunity to strengthen our offshore wind industry while creating good-paying union jobs."

CA - California Now Close to Offshore Wind Development for Renewable Energy / The National Law Review

USA - Government Moves to Dismiss Case Challenging New York Bight Wind Energy Area Designations / JD Supra

NY - Investor Consortium Backs Invenergy's New York Bight Project / Offshore WIND

https://www.irena.org/newsroom/pressreleases/2022/Mar/Energy-Transition-Holds-Key-to-Tackle-Global-Energy-and-Climate-Crisis

USA - Energy & Environment — Biden, EU leaders announce energy plan | TheHill / The Hill

https://www.heraldsun.com/news/politics-government/article259725390.html#storylink=cpy

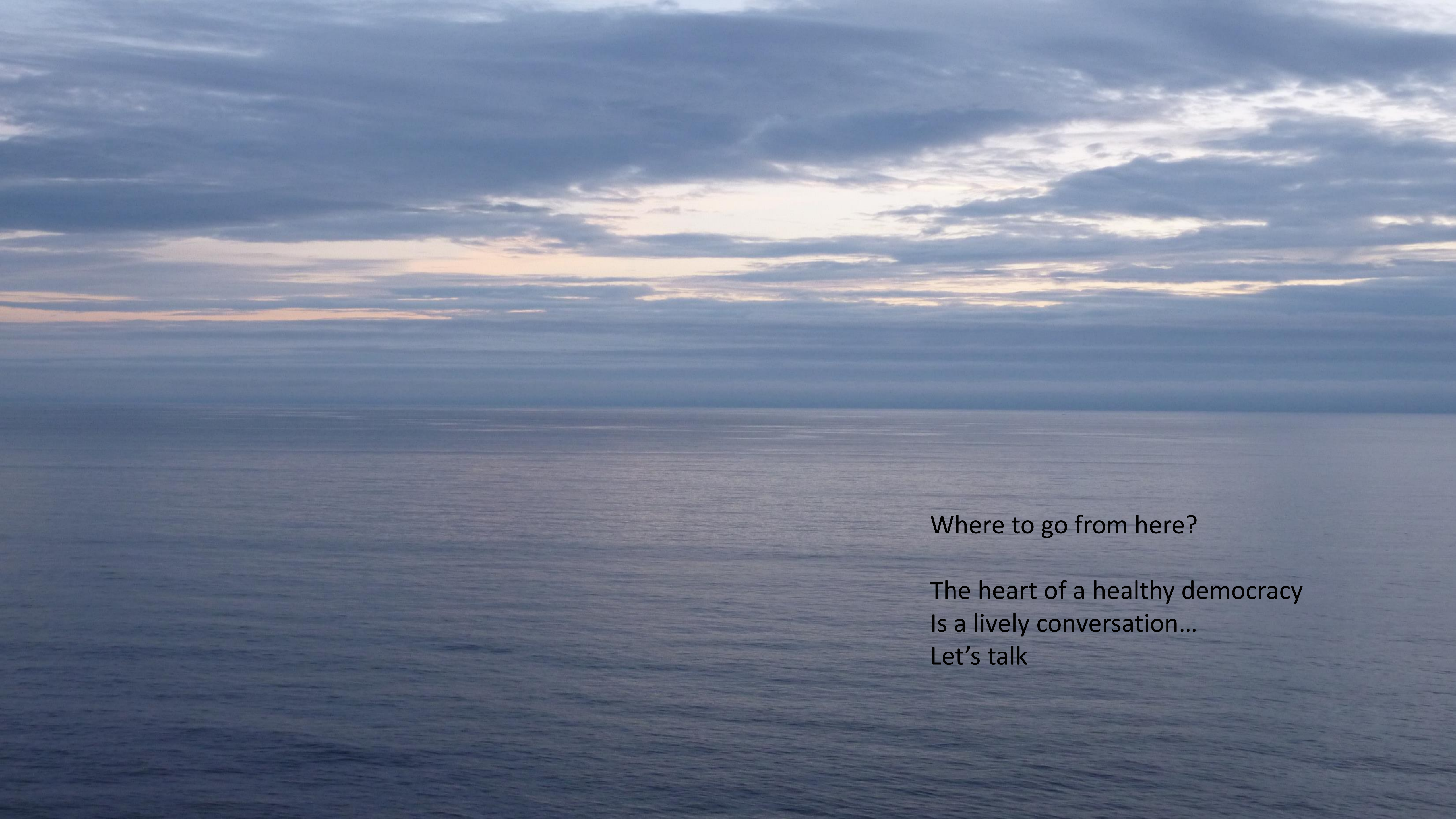

Where to go from here?
The heart of a healthy democracy
Is a lively conversation…
Let's talk

Image courtesy RL Pitman