Learning from the Experts Webinar Series

U.S. and European Research to Transform Our Energy Systems

Dr. Eric Hines
Professor of the Practice and Kentaro Tsutsumi Faculty Fellow
Civil and Environmental Engineering
Tufts University

Dr. Simon Watson
Professor of Wind Energy Systems
Director of the TU Delft Wind Energy Institute
TU Delft

May 16, 2024

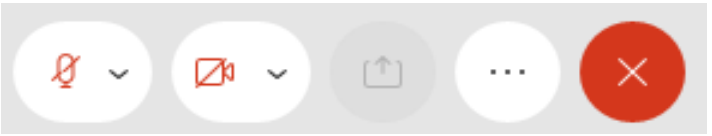
Meeting Procedures

Webinar recordings and presentations will be available at:

www.nyserda.ny.gov/osw-webinar-series

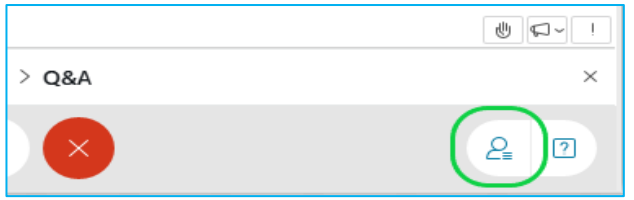
Participation for Members of the Public:

> Members of the public will be muted upon entry.



You'll see  **when your microphone is muted**

> Questions and comments may be submitted in writing through the Q&A feature at any time during the event. Please submit to **All Panelists**.



> If technical problems arise, please contact Sal.Graven@nyserda.ny.gov

Learning from the Experts

This webinar series is hosted by NYSERDA's offshore wind team and features experts in offshore wind technologies, development practices, and related research.

DISCLAIMER:
The views and opinions expressed in this presentation are those of the presenter and do not represent the views or opinions of NYSERDA or New York State.

NEW YORK STATE | NYSERDA

NYSERDA
Learning from Experts Series

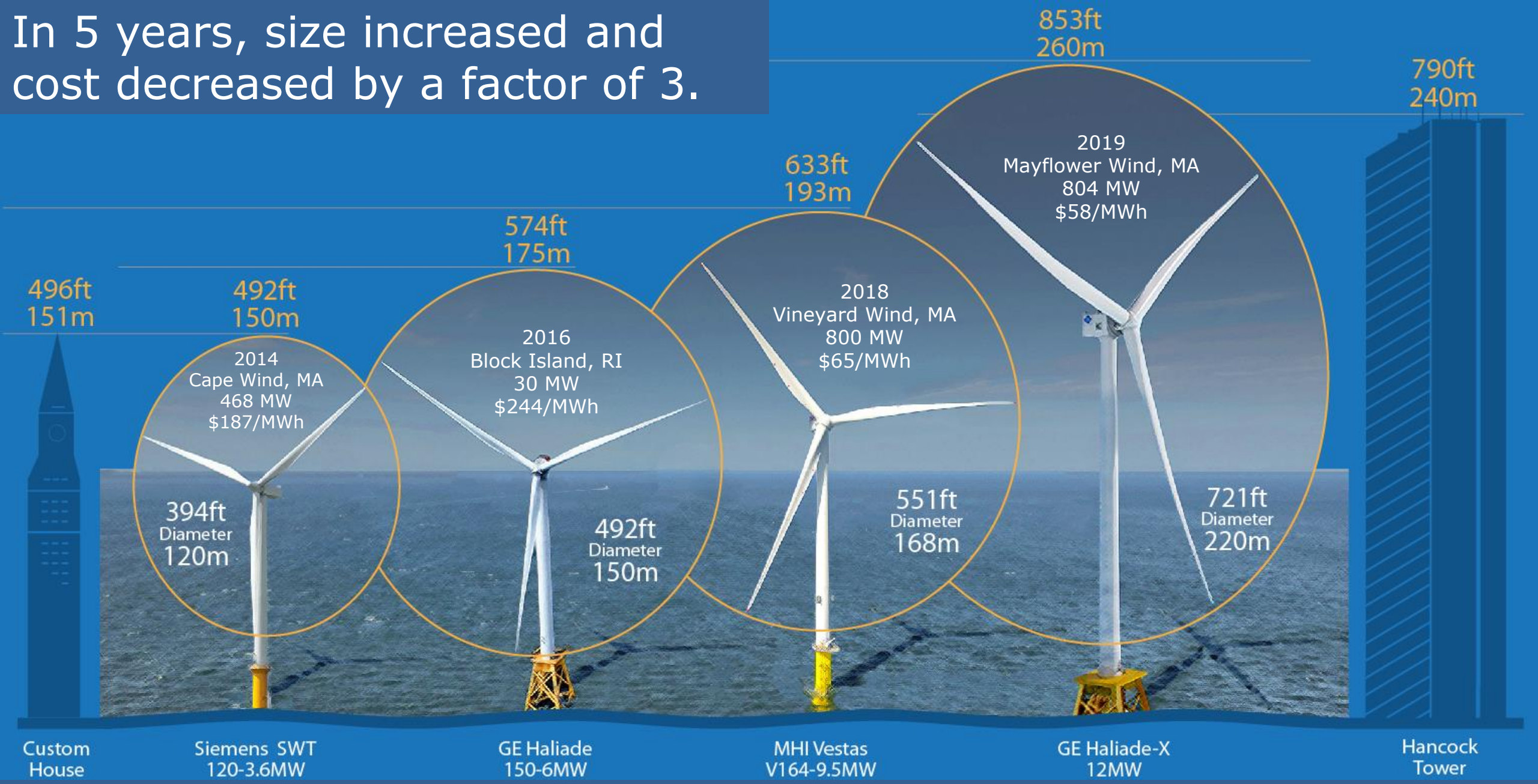
U.S. Offshore Wind R&D

May 16, 2024

Eric Hines

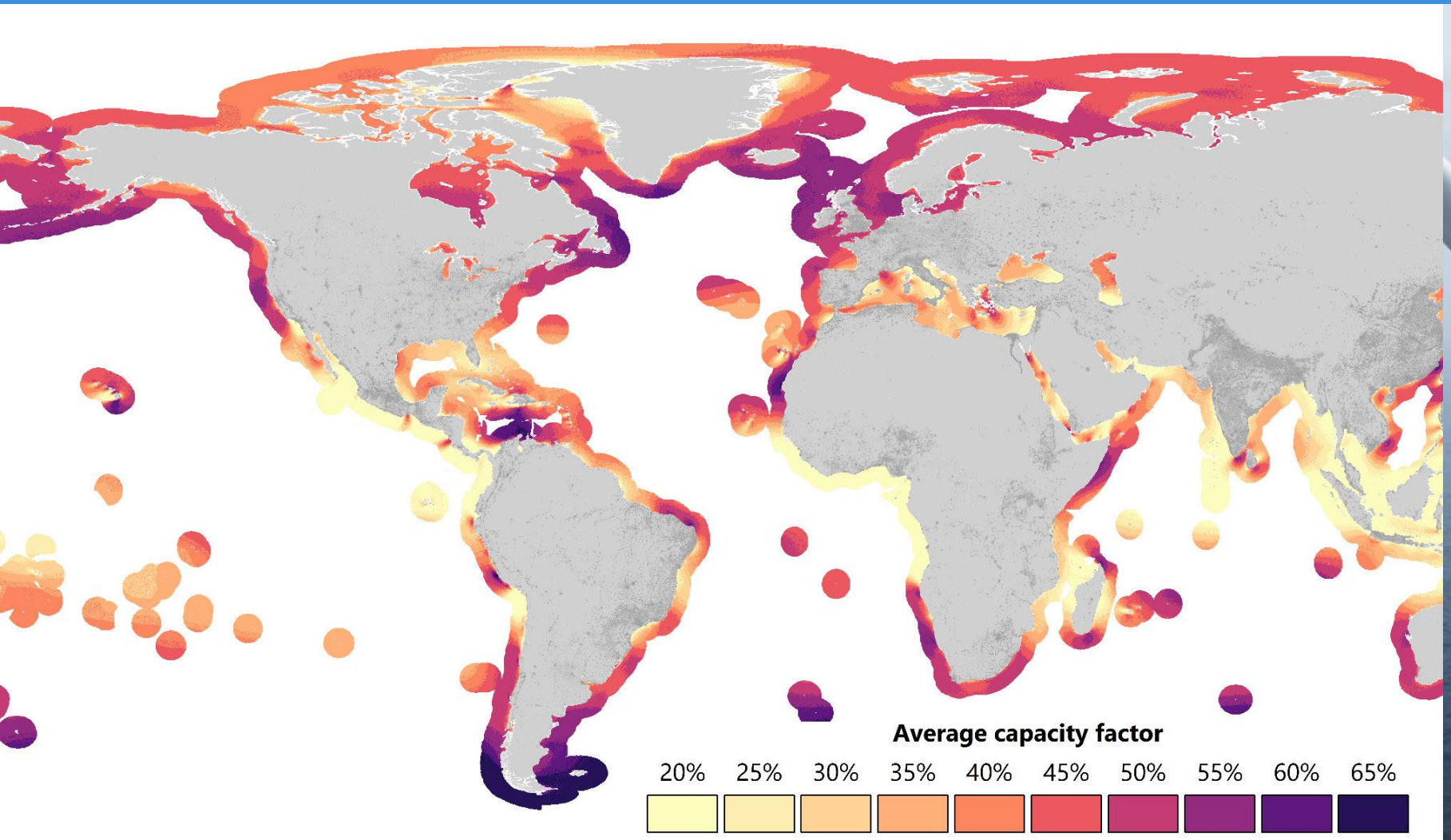
Tufts UNIVERSITY

In 5 years, size increased and cost decreased by a factor of 3.



Tufts UNIVERSITY

Enough to power the entire world 11 times over in 2040



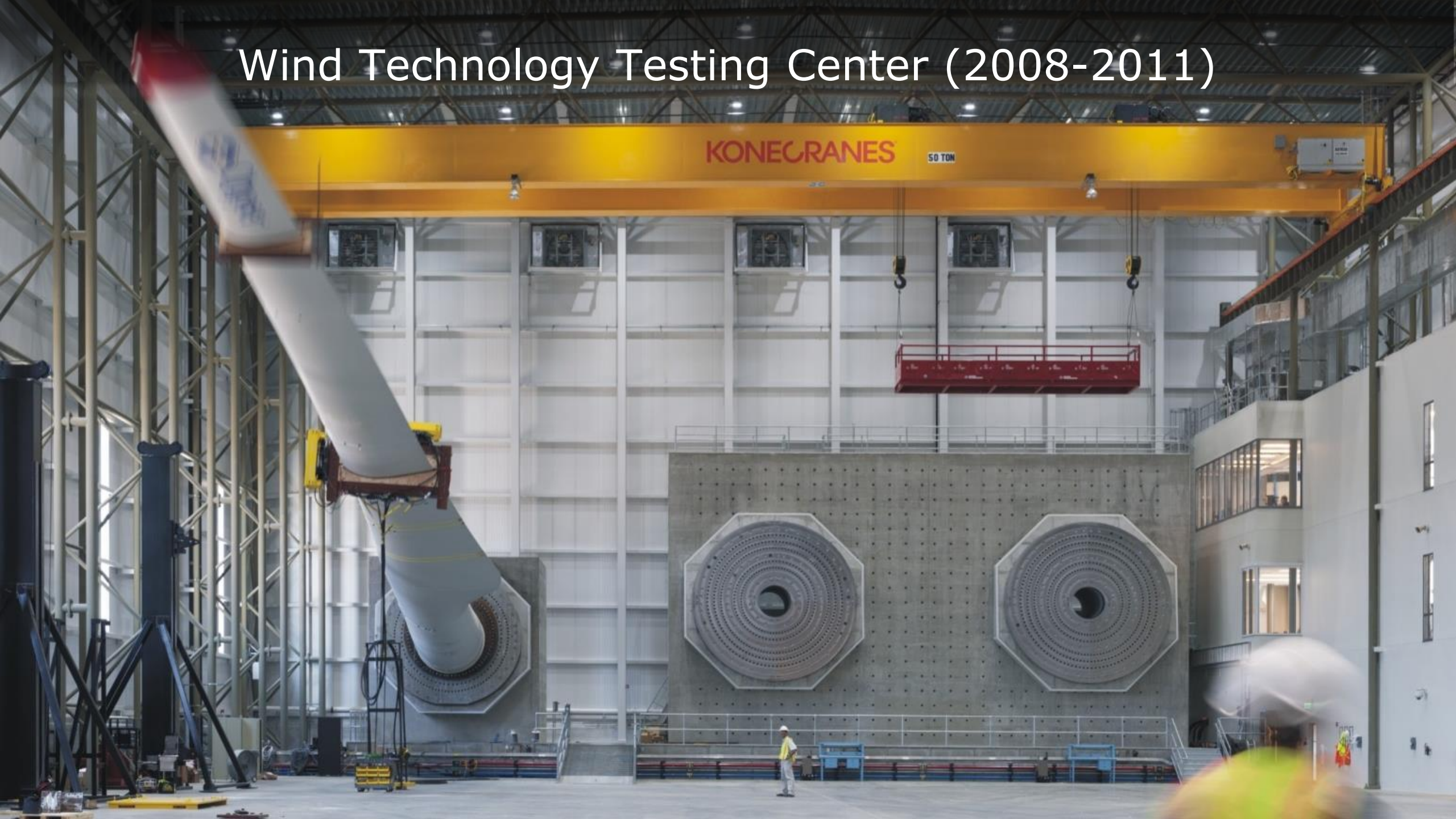
Global Technical Potential = 120,000 GW

Tufts UNIVERSITY

The U.S. Energy Transition

Offshore Wind:	30 GW by 2030 300 GW by 2050
U.S. Wind + Solar:	3000 GW by 2050

Wind Technology Testing Center (2008-2011)



New Bedford Marine Commerce Terminal (2011-2016)

Designed to facilitate the use of mobile cranes, the 21-acre facility forming the main storage area for the New Bedford Marine Commerce Terminal will be able to sustain uniform loads of 4,100 psf and concentrated loads nearly five times that amount.

POWERFUL UPGRADE

The first port facility in North America expressly built to serve as a logistics hub for offshore wind farms, the New Bedford Marine Commerce Terminal, in New Bedford, Massachusetts, required a bulkhead capable of handling loads significantly greater than those imposed on other wharves in the United States. Designed to accommodate large crawler cranes that will lift turbine components weighing hundreds of metric tons, the bulkhead features a system of cellular sheet-pile cofferdams capable of providing the support and flexibility required. By combining port construction with significant efforts to remediate existing contamination in New Bedford Harbor, the project boosts local economic prospects while helping to foster the nascent U.S. offshore wind industry.

By Eric M. Hines, Ph.D., P.E., M.ASCE, Jay A. Borkland, P.G., Chester H. Myers, P.E., Susan E. Nilson, P.E., M.ASCE, and John A. DeRugeris, P.E.

RECOGNIZING THE BENEFITS that offshore wind energy could bring to New England, the Commonwealth of Massachusetts has been preparing for this industry for many years. Among these preparations has been the development of the New Bedford Marine Commerce Terminal, in New Bedford, Massachusetts. An ambitious, challenging effort, the terminal project entailed the creation of the first purpose-built marine terminal in North America having

to deliver reliable, competitive, and clean power to metropolitan areas along U.S. coastlines, provide a measure of energy independence and security to regions that currently import

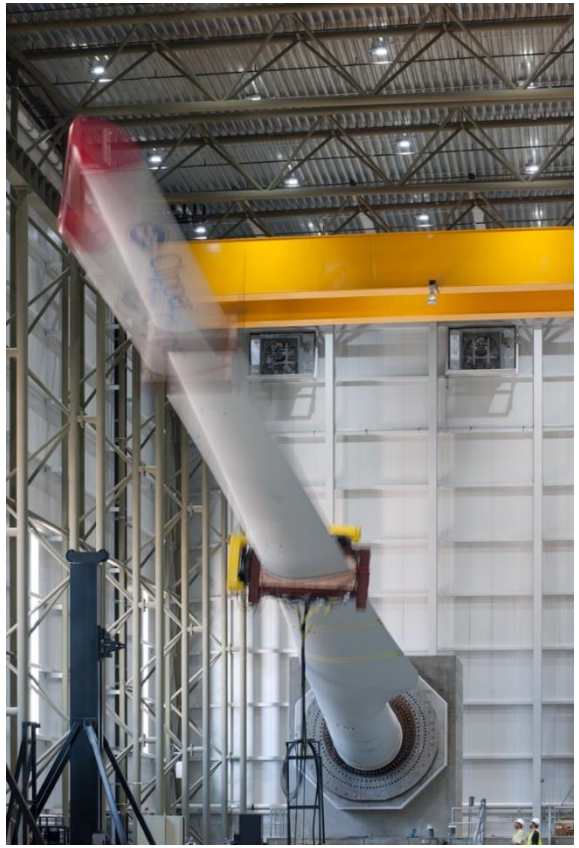
Marine Commerce Terminal, MassCEC completed work on the Wind Technology Testing Center, a massive facility in Charlestown for testing wind turbines (see "Testing Tomor-

legislature passed the Global Warming Solutions Act in 2008. The law commits the commonwealth to a 25 percent reduction of greenhouse gases from 1990 levels by 2020 and an 80 percent

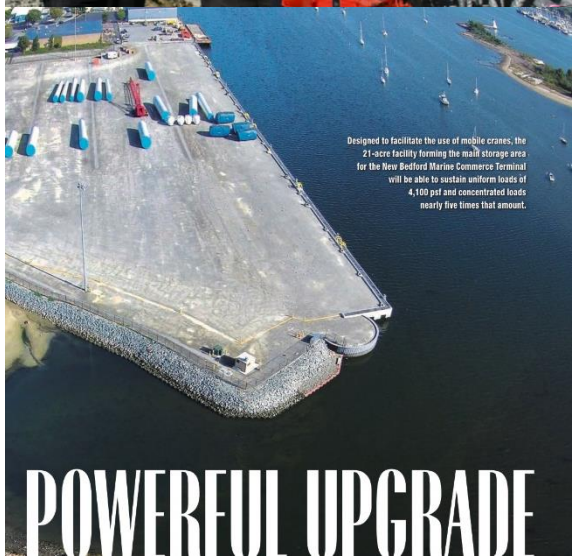
Tufts UNIVERSITY

16-Years of Offshore Wind Innovation and Research

2008



2011



2016

Advancing American Offshore Wind Research

September 20, 2016
Hyatt Regency Washington on Capitol Hill
Washington, DC

Tufts University

Interagency Workshop
MassCEC
DOE
BOEM
NASA
NOAA
NSF
BNOW
Fraunhofer (Germany)
ORE Catapult (UK)

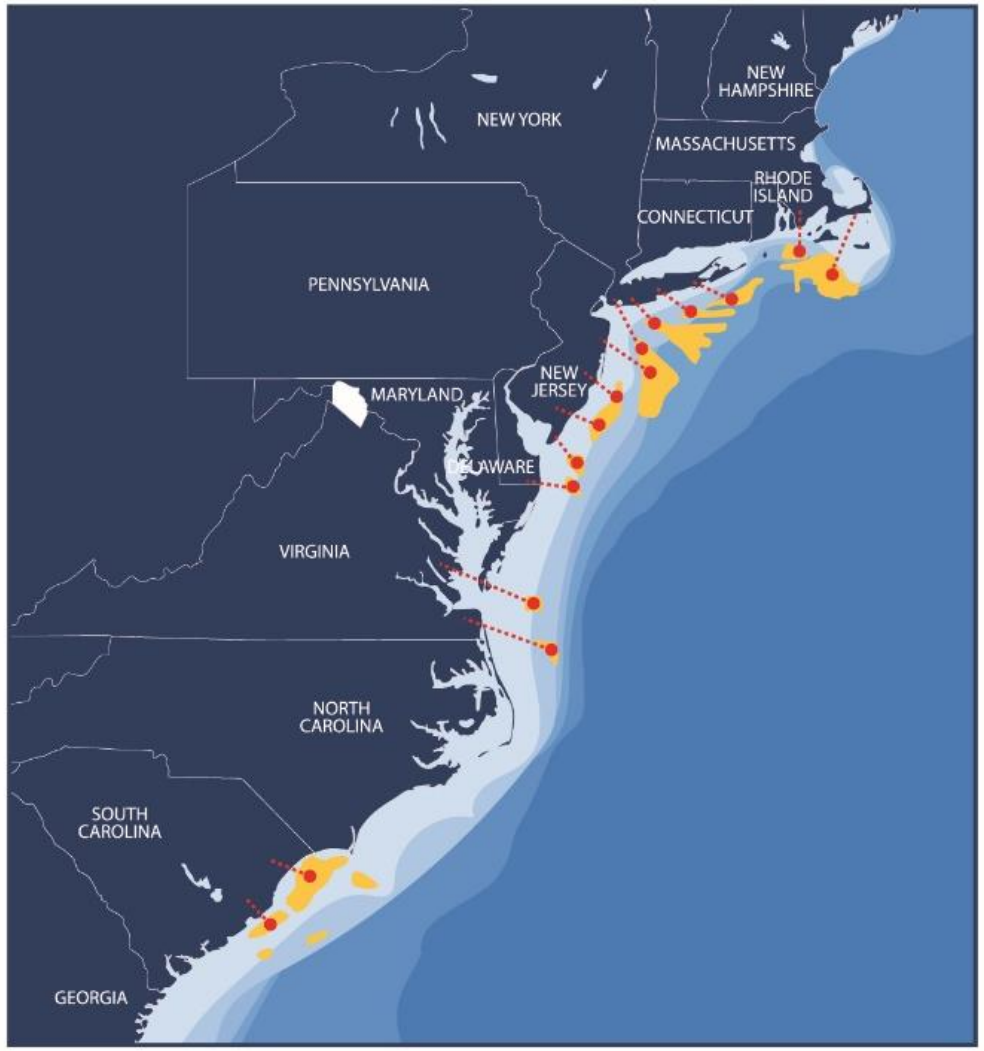
2019-2024

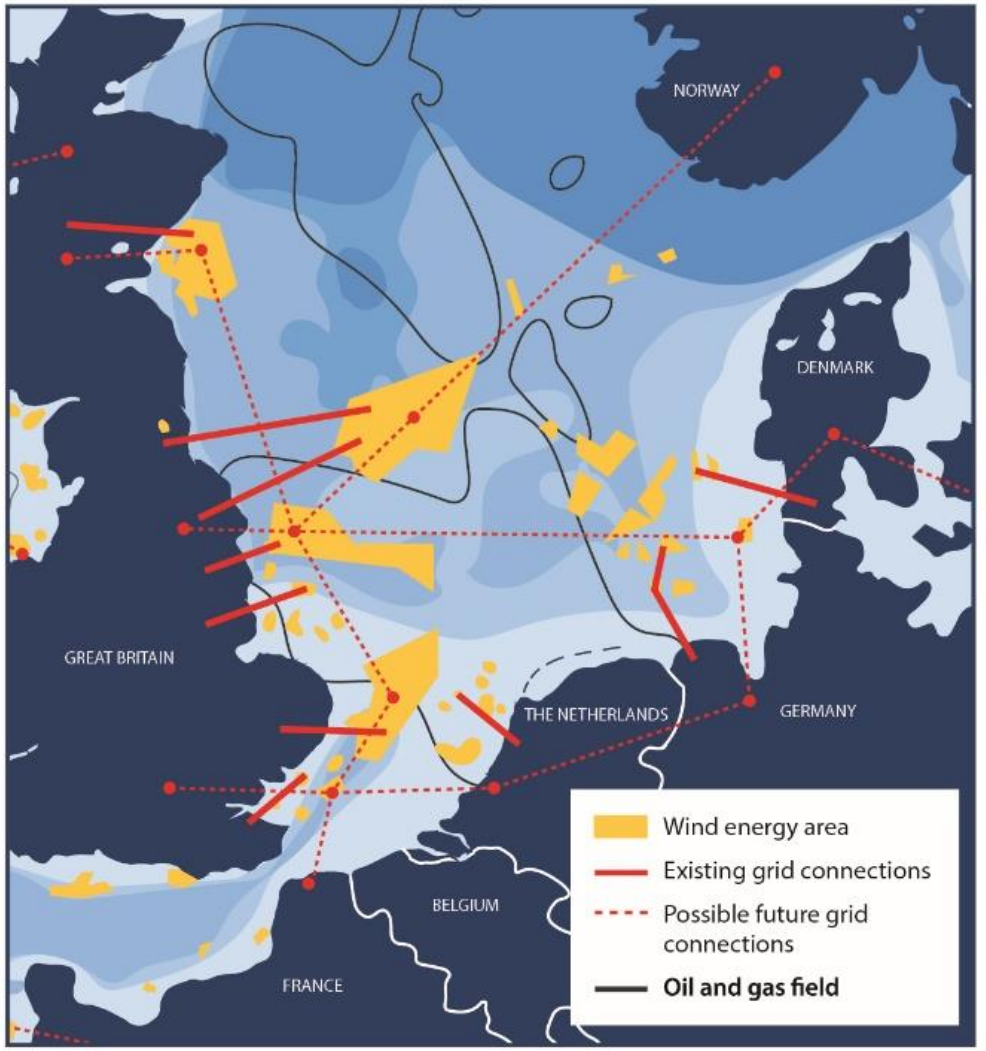
Building the early infrastructure

Educating decision makers on the need

Tufts UNIVERSITY

Reliance on European Expertise | Project-by-Project Approach





- Water depth
- Fishing & recreation
- Oil & gas
- Hurricanes
- Right whales
- Network capacity

Tufts UNIVERSITY

We need a systems-level approach

- Infrastructure
  - 100+ Year Service Life
  - Social + Environmental Justice
- Supply Chain
  - Global WTIV and Supply Chain shortage
  - Leverage U.S. assets + create U.S. jobs
- Transmission
  - Integrate 300 GW of offshore wind along Atlantic Coast by 2050
  - North American Macrogrid

Infrastructure

- Design Verification
- Predictive Maintenance
- Service Life Extension

ELSEVIER

Renewable Energy

Volume 202, January 2023, Pages 1032-1045

Structural instrumentation and monitoring of the Block Island Offshore Wind Farm

Eric M. Hines [a], Christopher D.P. Baxter [b], David Ciochetto [c], Mingming Song [a f], Per Sparrevik [d], Henrik J. Meland [d], James M. Strout [d], Aaron Bradshaw [b], Sau-Lon Hu [b], Jorge R. Basurto [e], Babak Moaveni [a]

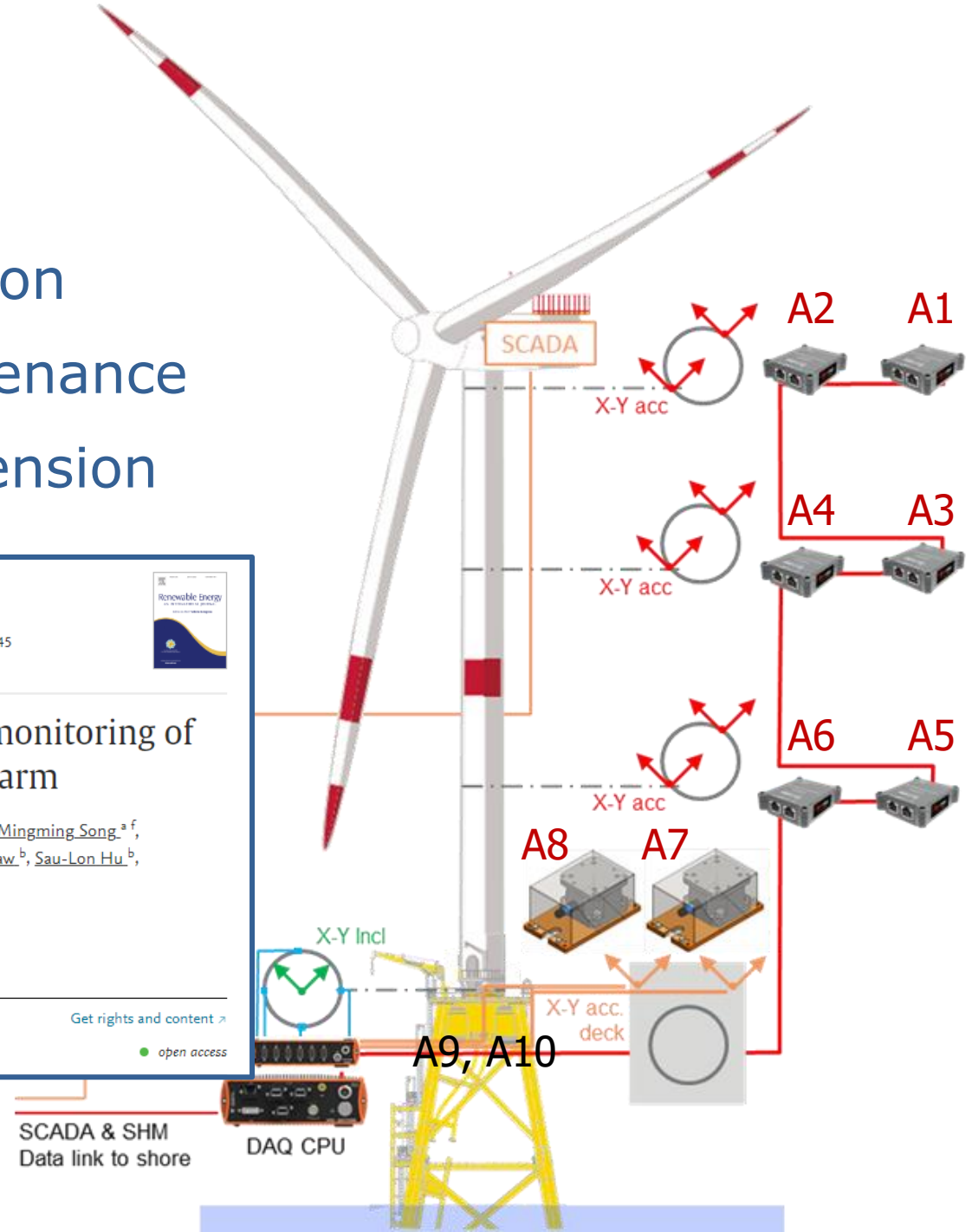
Show more

+ Add to Mendeley Share Cite

https://doi.org/10.1016/j.renene.2022.11.115

Get rights and content

open access



CRMC Coastal Resources Management Council

The University of Rhode Island

Tufts University

NGI

150 Year
Design Life

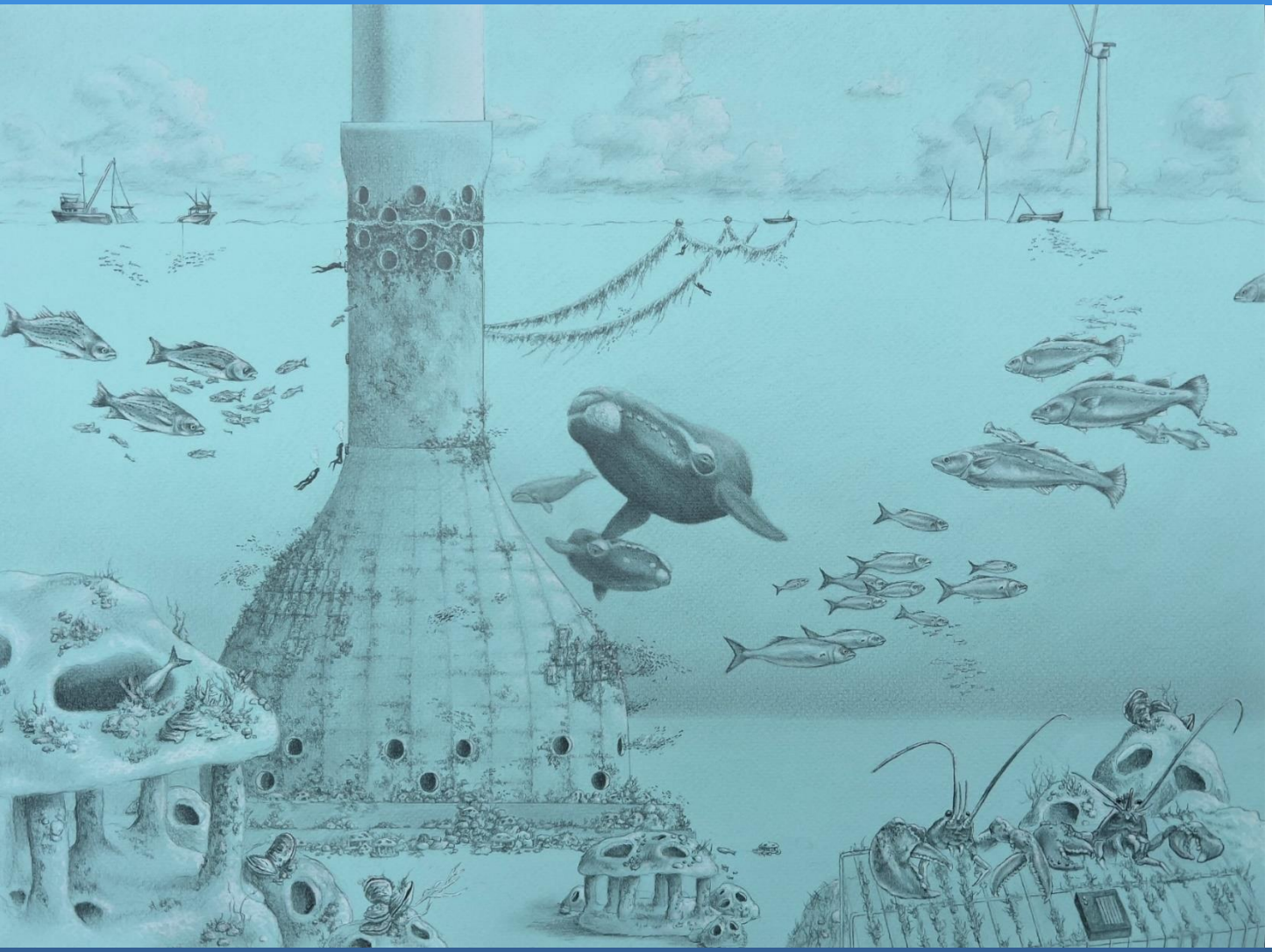
1500 Year
Earthquake

San Francisco—Oakland Bay Bridge

UC San Diego

Tufts UNIVERSITY

Nature-Inclusive, Low-Carbon, 100-Year Infrastructure



MOCEAN

Federal, State and Local Agencies and Regulators
State Energy Departments
Standards Organizations

Economic Development Organizations
Certified Verification Agents (CVAs)
Environmental and Conservation Organizations

Responsible Bodies

Bluetech Community
Marine Construction
Fisheries and Aquaculture
OW Developers
OW Supply Chain
Startups and SME
Entrepreneurs
VCs and Finance

Industry

Growing the Blue Economy

Nature Inclusive OW Farms

Stake-holders

Coastal Communities
Other Ocean Users
Unions and Workforce Development Organizations

Healthy Oceans

Universities
Community Colleges
Training Institutes
Vocational HS
K-12 Education
Museums/Aquariums

Educators

Researchers and Assets

US Researchers
European Researchers
Labs and Sensors
Databases
US OW Projects
Field Research Assets

WOODS HOLE OCEANOGRAPHIC INSTITUTION

THE UNIVERSITY OF CHICAGO MARINE BIOLOGICAL LABORATORY

Tufts UNIVERSITY

Supply Chain

2021

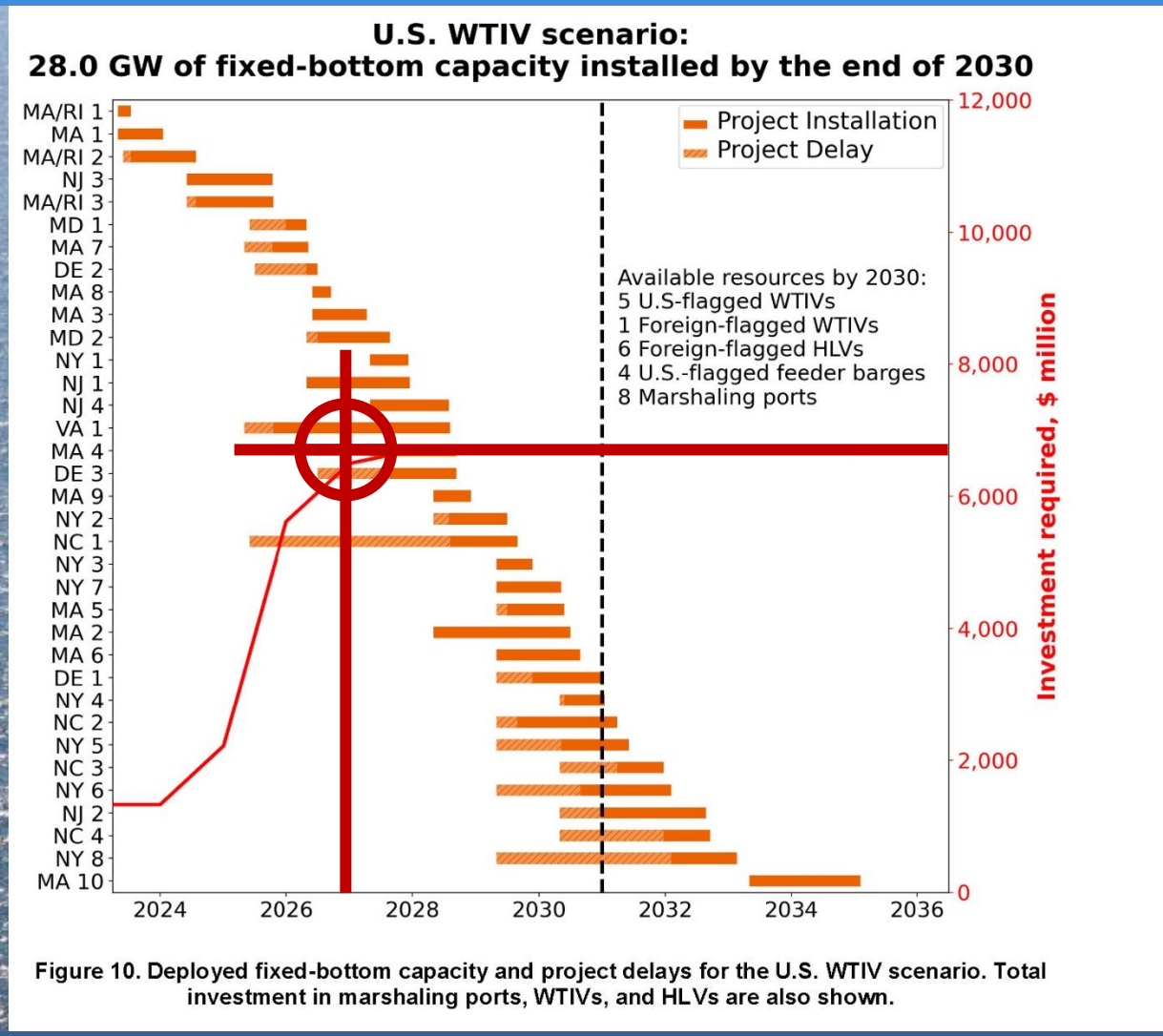
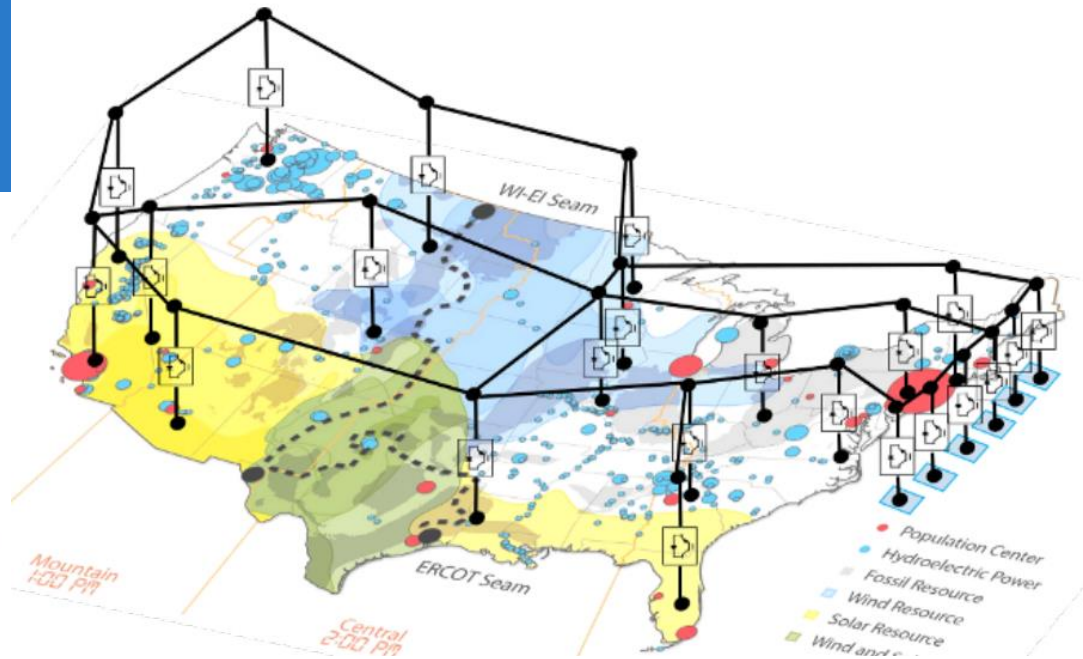


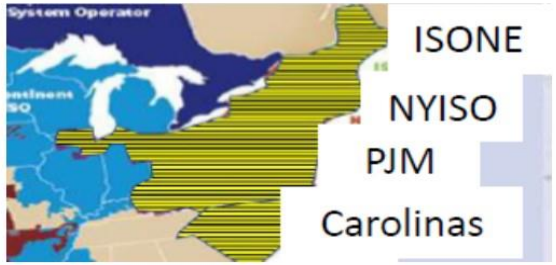
Figure 10. Deployed fixed-bottom capacity and project delays for the U.S. WTIV scenario. Total investment in marshaling ports, WTIVs, and HLVs are also shown.

2023

OSW Transmission and the U.S. macrogrid



Model 2: CEP, 1161 buses



Model 1: TARA/POIA, 93,520 buses

POI Identification

OSG Design

Relation to Macrogrid

Model 3: CEP, 176 buses

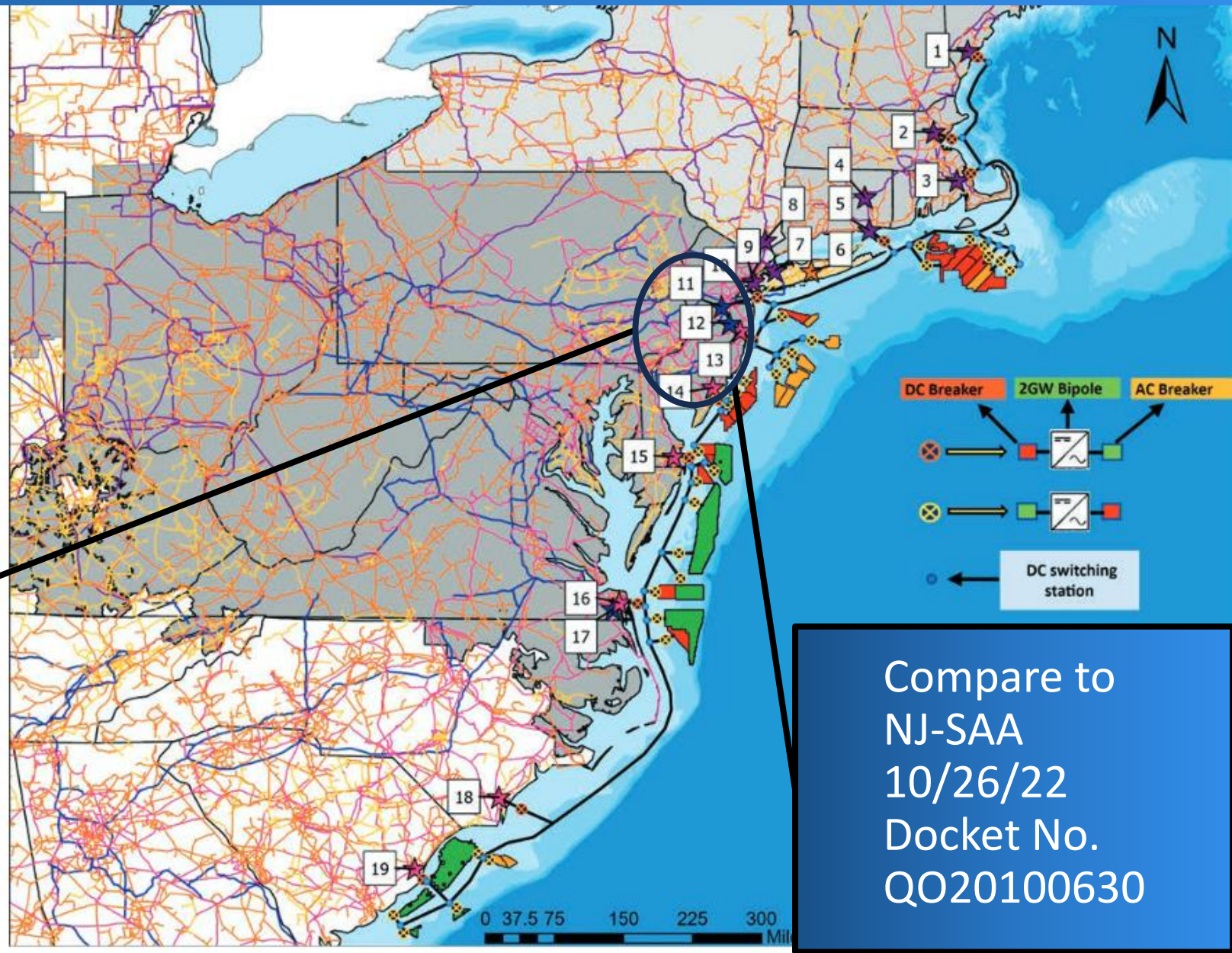
J. McCalley and Q. Zhang, "Macrogrids in the Mainstream: An International Survey of Plans and Progress." Americans for a Clean Energy Grid. November 2020. https://cleanenergygrid.org/resources/publications/.

Model 1—POI Capacities

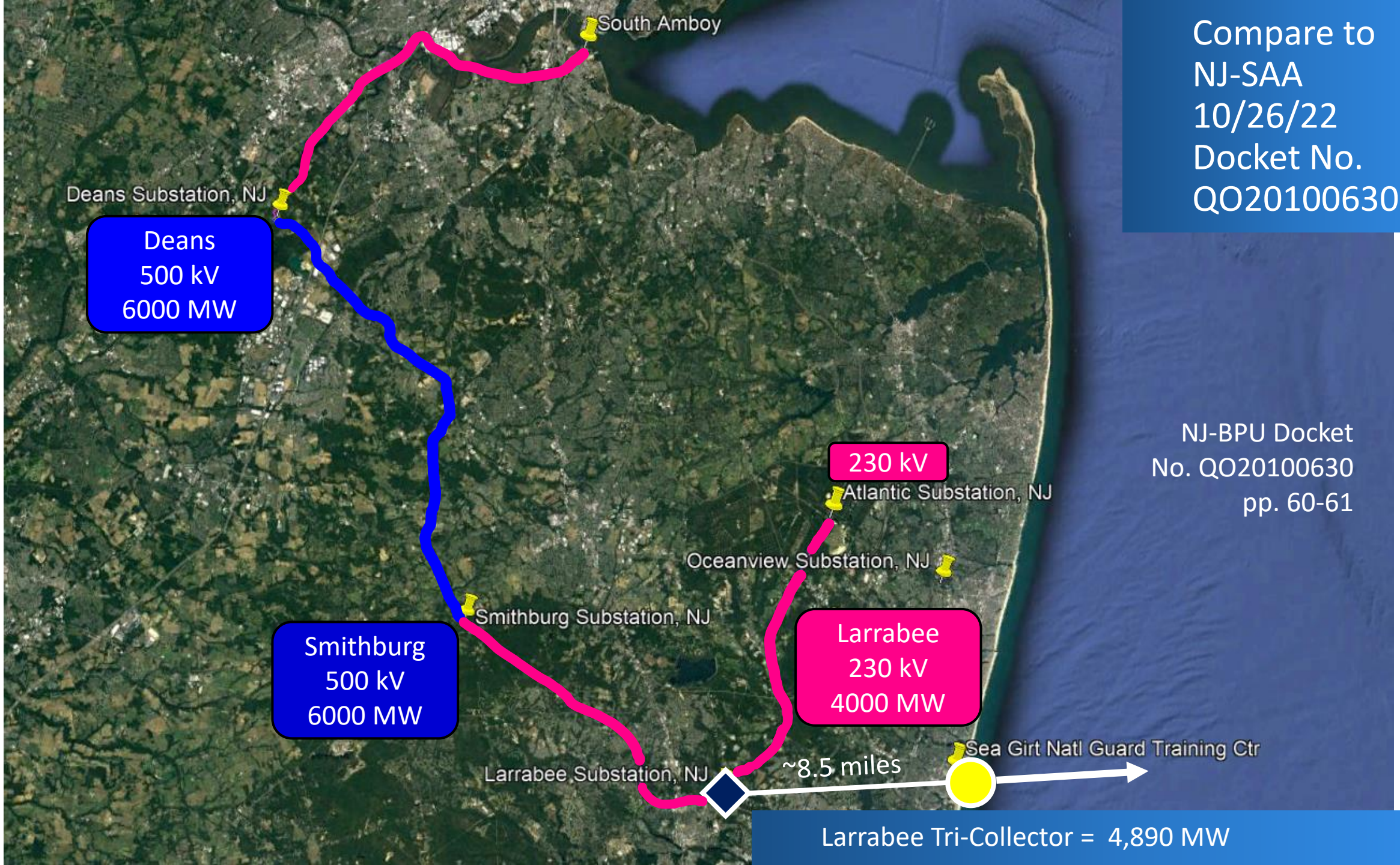
(93,520 buses, Summer Peak 2031, AC+DC, N-1)

	POI	kV	State	Capacity (MW)
	ISO-NE			
1	Maguire Road	345	ME	4000
2	Woburn	345	MA	4000
3	Carver	345	MA	4000
4	Card Street	345	CT	4000
5	Millstone	345	CT	4000
	Total			**20000**
	NYISO			
6	Holbrook	138	NY	2000
7	Shore Road	345	NY	4000
8	Millwood	345	NY	6000
9	Farragut East	345	NY	4000
10	Farragut West	345	NY	4000
	Total			**20000**
	PJM			
11	Deans	500	NJ	6000
12	Smithburg	500	NJ	6000
13	Larrabee	230	NJ	4000
14	Cardiff	230	NJ	4000
15	Indian River	230	DE	2000
16	Landstown	230	VA	4000
17	Fentress	500	VA	4000
	Total			**30000**
	South			
18	Sutton	230	NC	2000
19	Winyah	230	SC	4000
	Total			**6000**

PRELIMINARY 76 GW OFFSHORE HVDC BACKBONE



Compare to NJ-SAA 10/26/22 Docket No. QO20100630



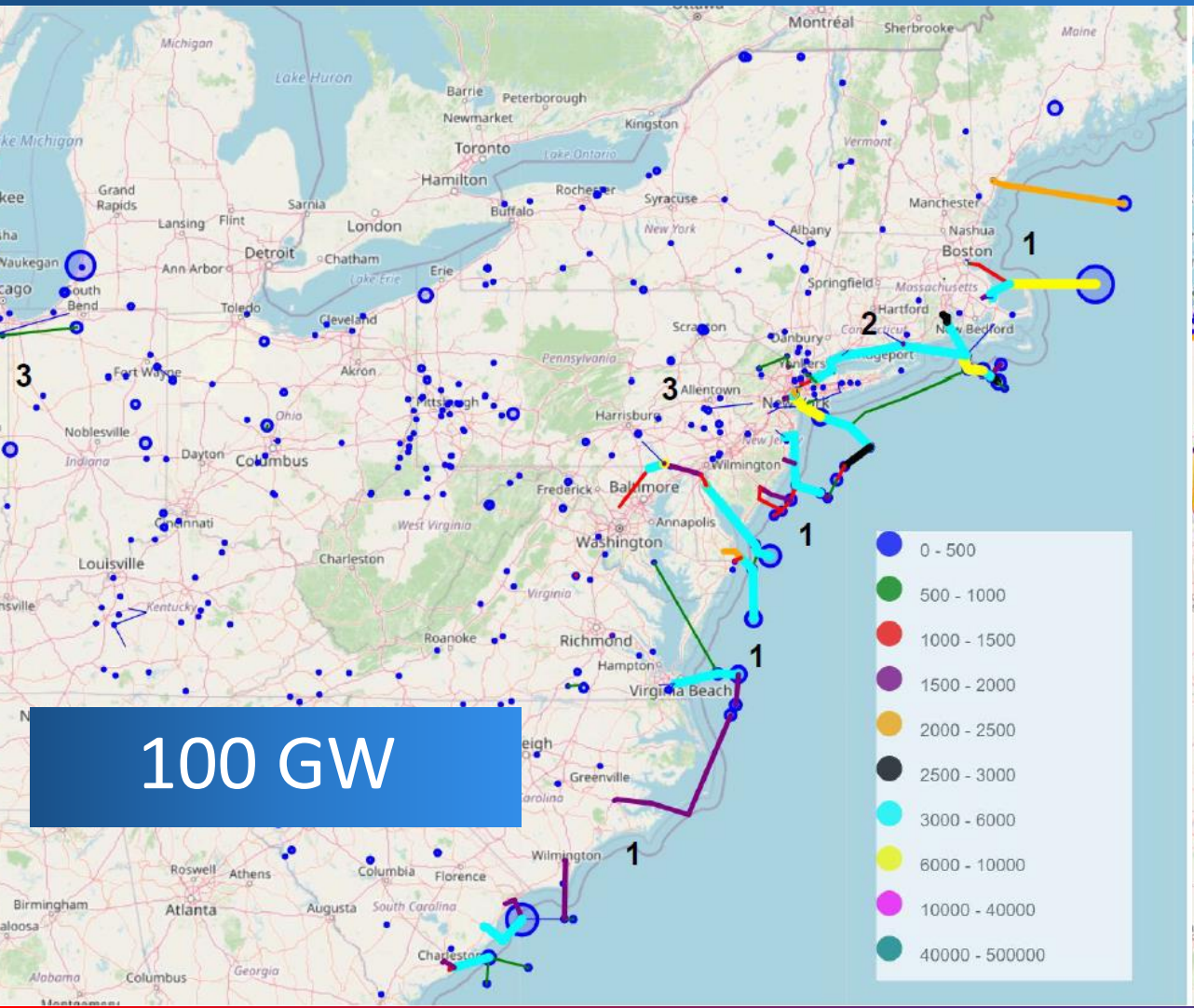
Compare to NJ-SAA 10/26/22 Docket No. QO20100630

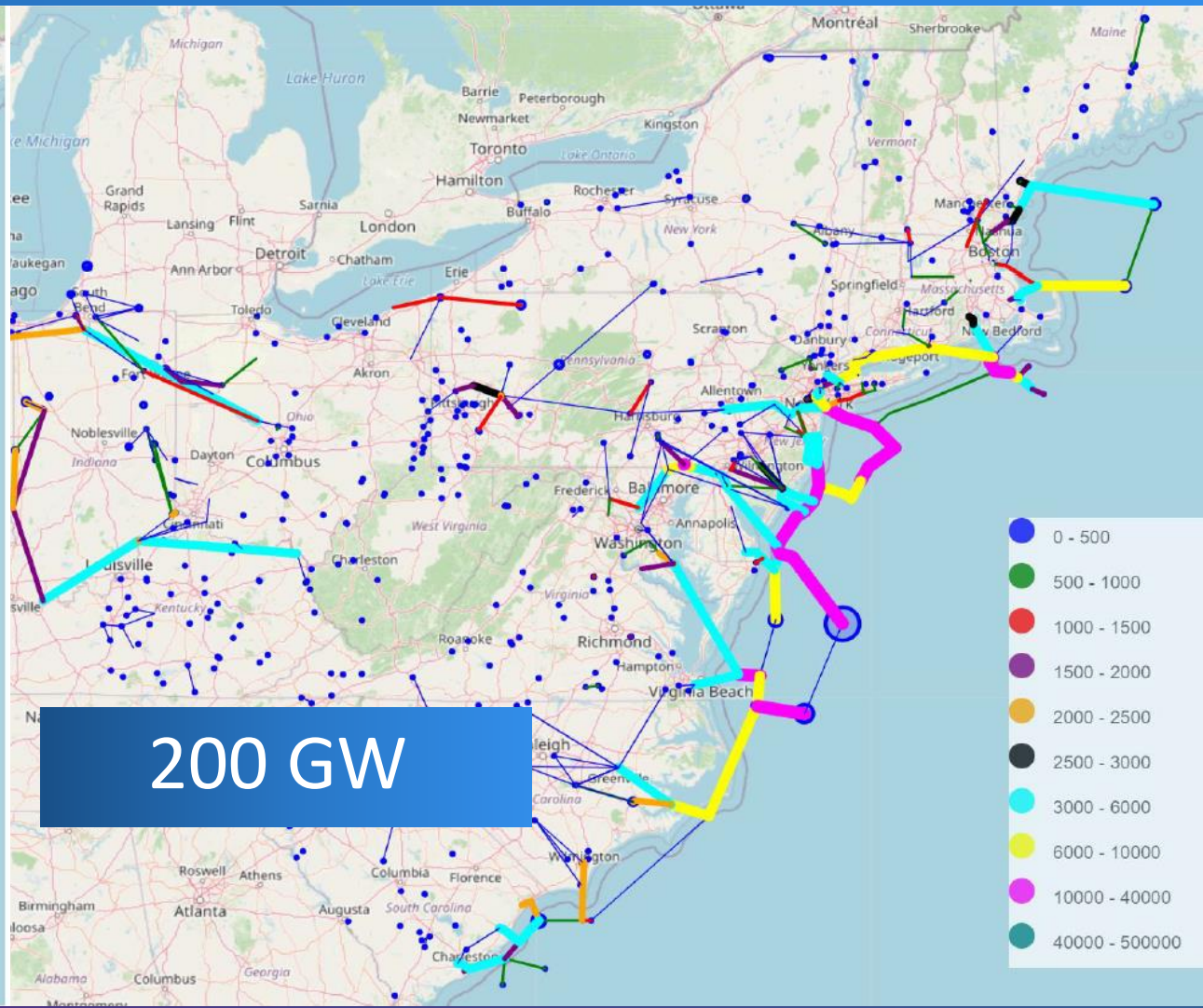
NJ-BPU Docket No. QO20100630 pp. 60-61

Larrabee Tri-Collector = 4,890 MW

Model 2—Responsive Analysis

(1161 buses, 340 LCs from 2031-2051, DC, no N-1)





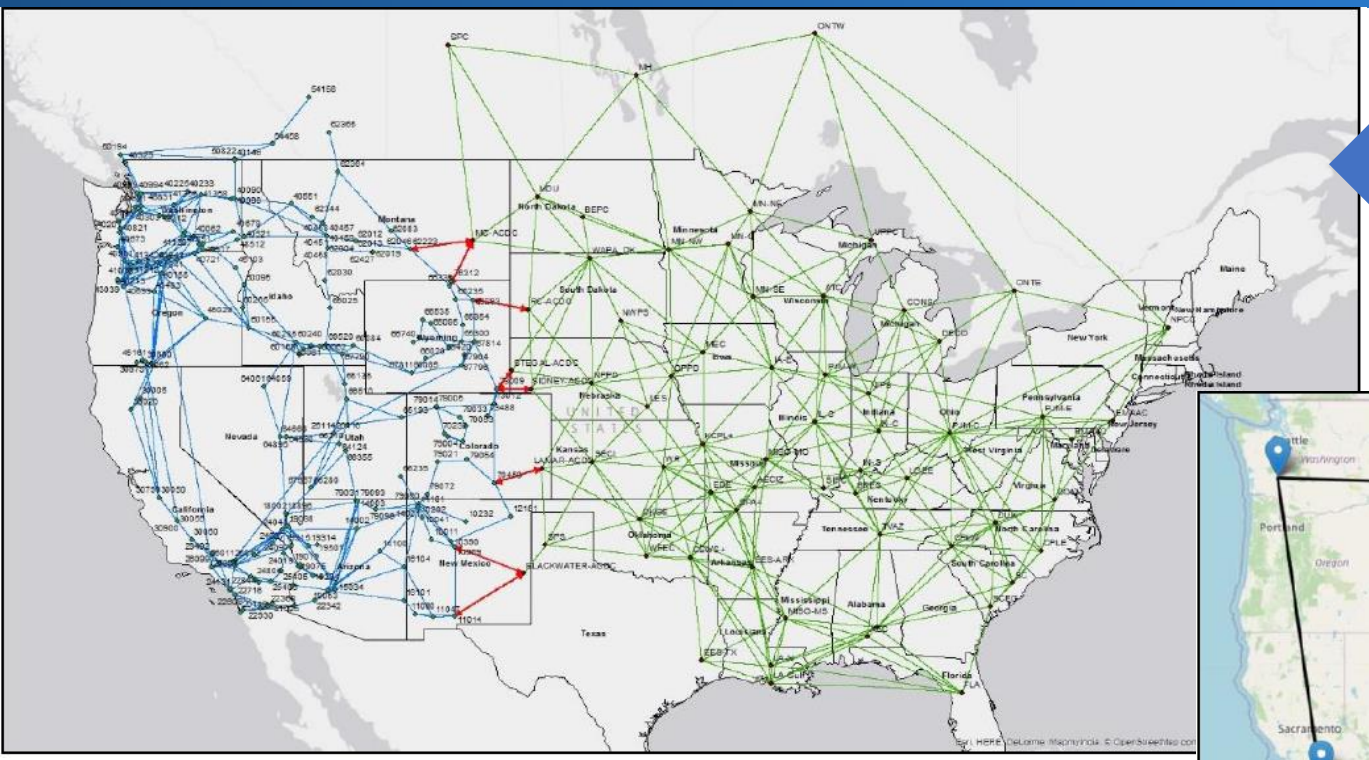
IOWA STATE UNIVERSITY

CLEMSON CHARLESTON

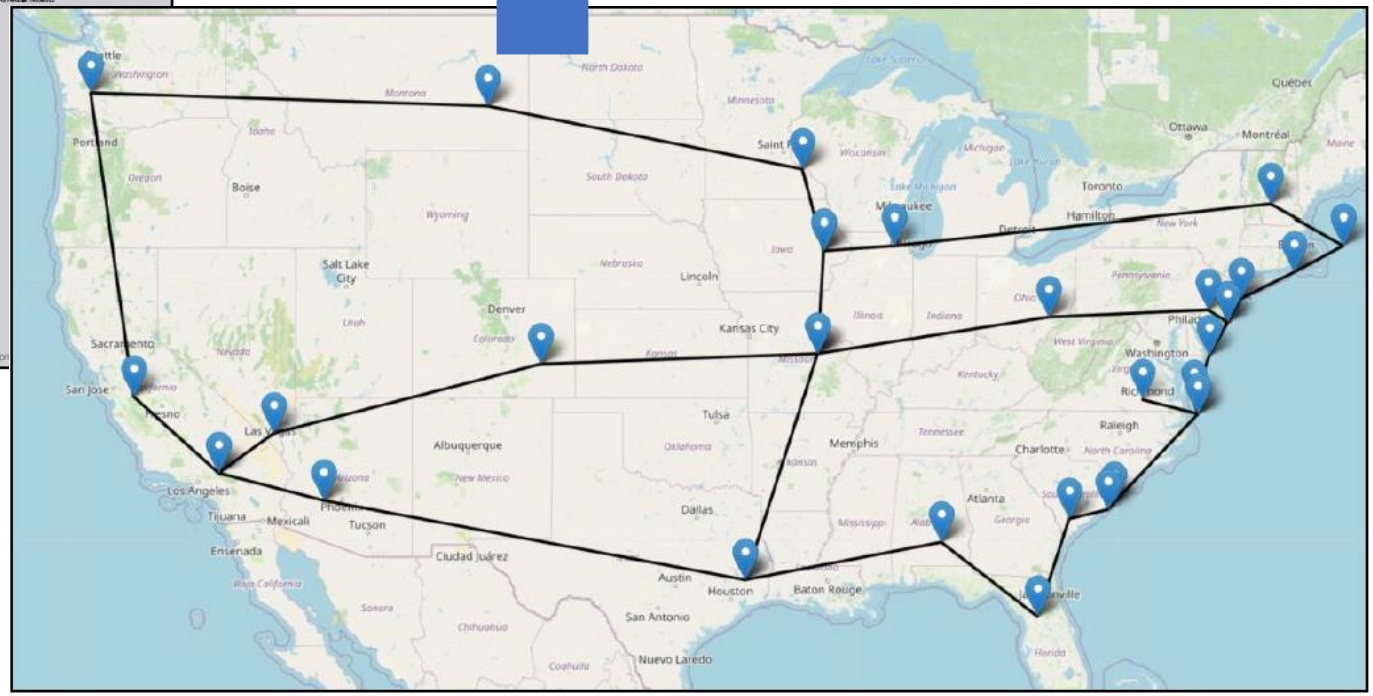
Tufts UNIVERSITY

Model 3—Macrogrid Overlay

(176 buses, 513 LCs from 2024-2051, DC, N-1 MG)



Overlaid



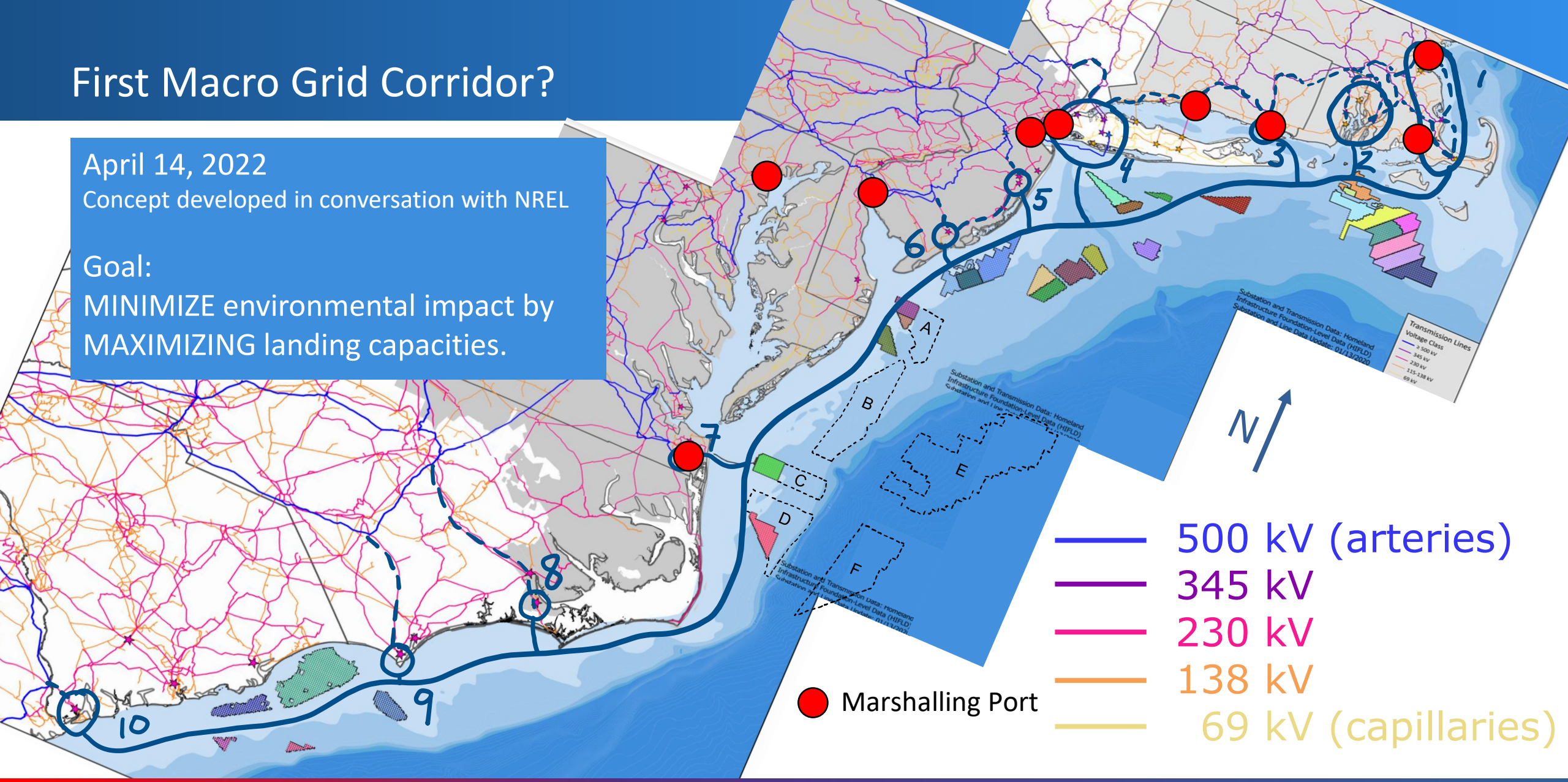
First Macro Grid Corridor?

April 14, 2022

Concept developed in conversation with NREL

Goal:

MINIMIZE environmental impact by MAXIMIZING landing capacities.



SCALING UP OFFSHORE WIND IN EUROPE – R&D MEETS THE CHALLENGE

Simon Watson

Professor of Wind Energy Systems

Director of TU Delft Wind Energy Institute

OVERVIEW

- Scale of the challenge
- Impact on local wind climate
- Environment
- Circularity
- Operations and maintenance
- Turbine technology
- Grid

Figures from WindEurope

Offshore wind in Europe*

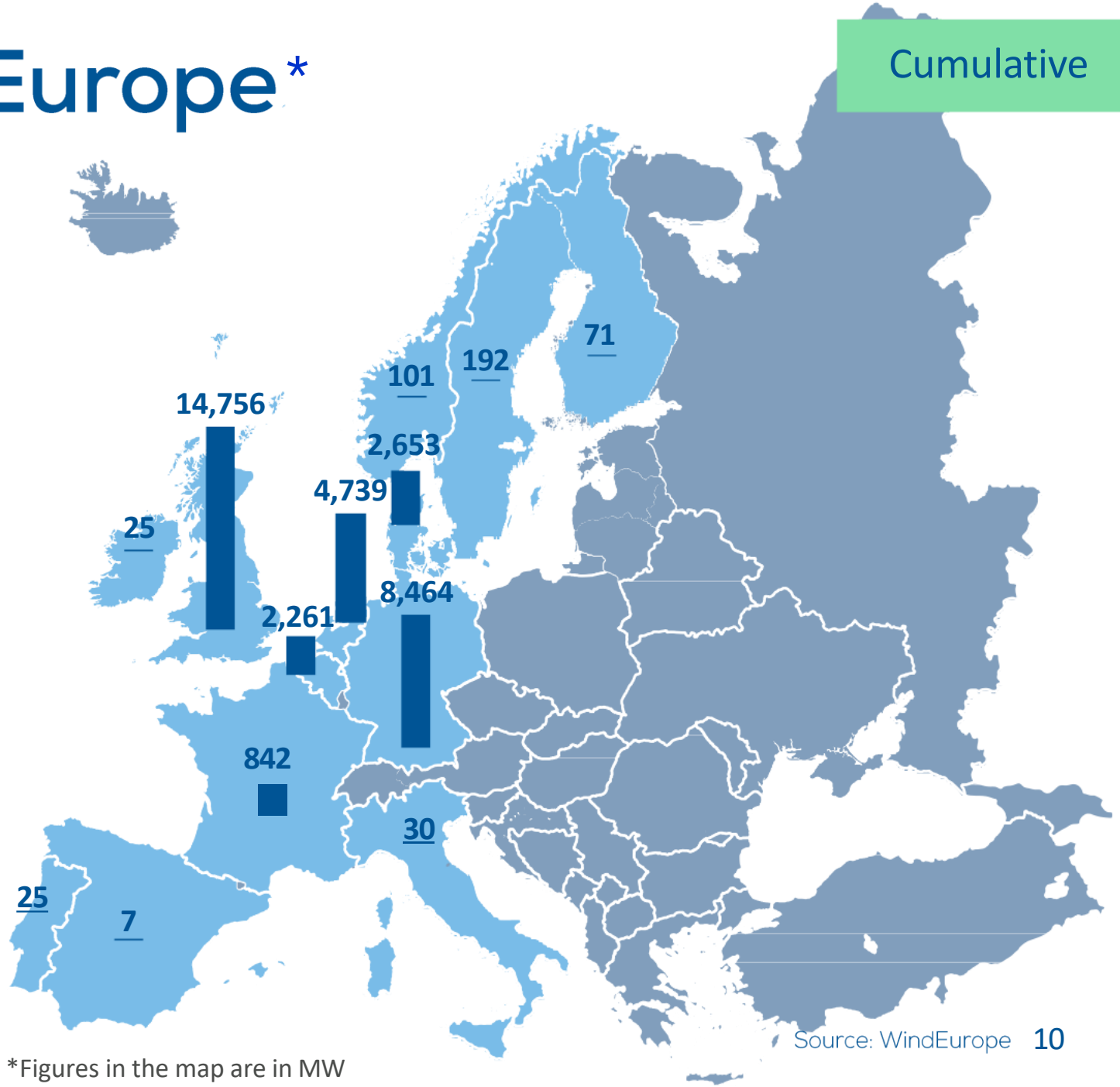
Cumulative

34,166 MW
connected to the grid

13 countries

6,340 turbines

135 wind farms
connected to the grid



*Figures in the map are in MW

*As of end 2023

Source: WindEurope

Targets

OFFSHORE WIND TARGETS: NORTH SEA

- 2030 - 120GW
- 2050 - 300GW

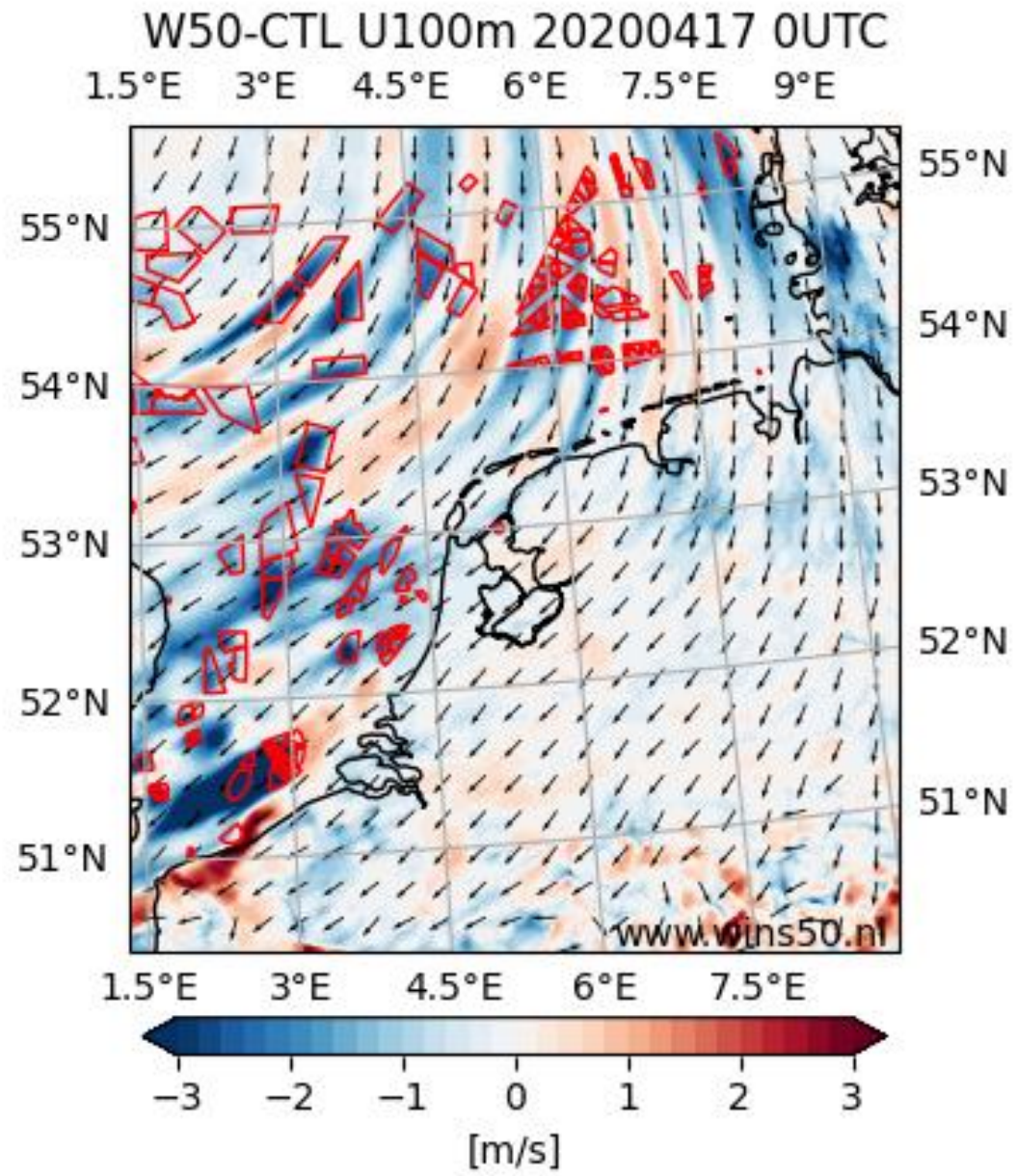
Today we are at around 30GW in the North Sea…

Impacts on wind climate

WINS50 SCENARIO FOR 2050 BUILD-OUT

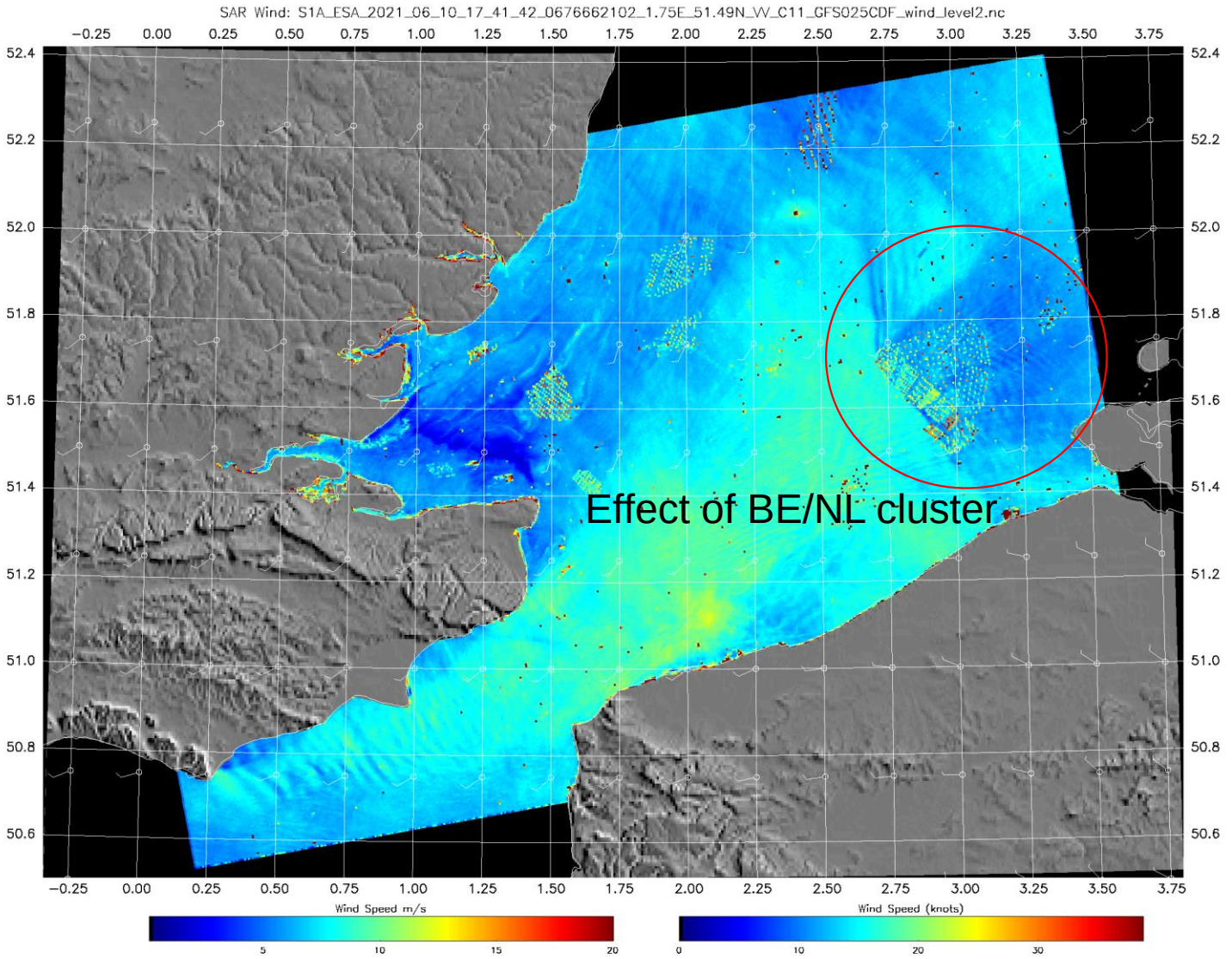
- Project to assess impact of wind farm clusters in the North Sea

WAKE EFFECTS BECOME SIGNIFICANT



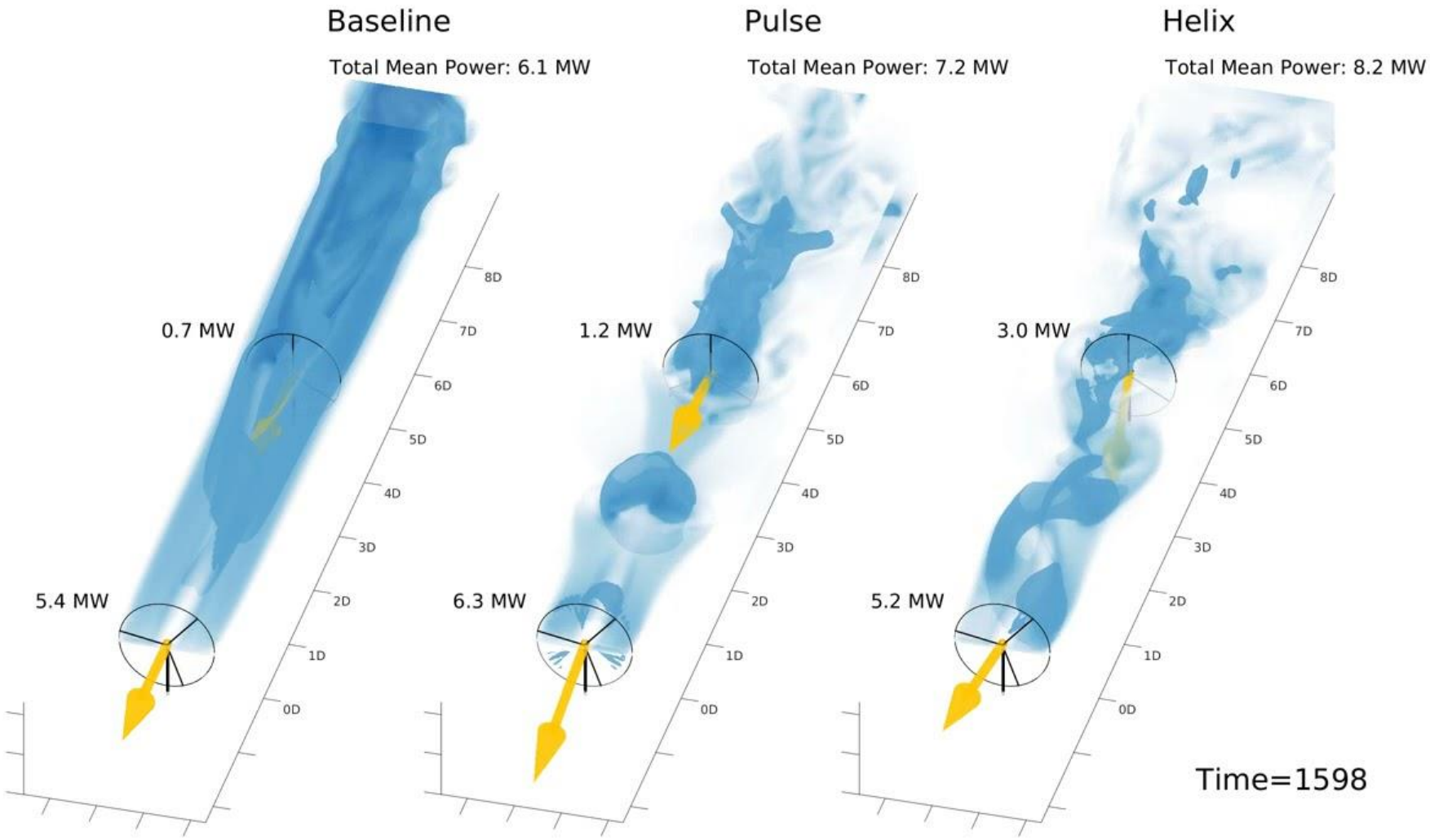
- Snapshot: change in 100m wind speed of 2050 build-out compared to no wind farms
- By 2050, a typical offshore wind farm could see ~5% reduction in output due to cluster effects
- WINS50.nl
- Whiffle, TU Delft, KNMI

THE EFFECTS ARE REAL!



- Satellite image showing inferred 10m wind speeds

REDUCING WAKE LOSSES



See YouTube video for animation

Environment

FOUNDATION INSTALLATION

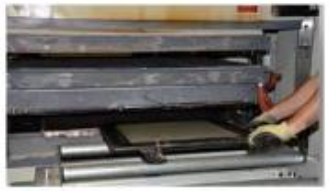
- Hammering in piles creates damaging noise levels and excessively disturbs soil
- By twisting pile back and forth, process is less obtrusive and more efficient
- Gentle Driving of Piles (GDP)

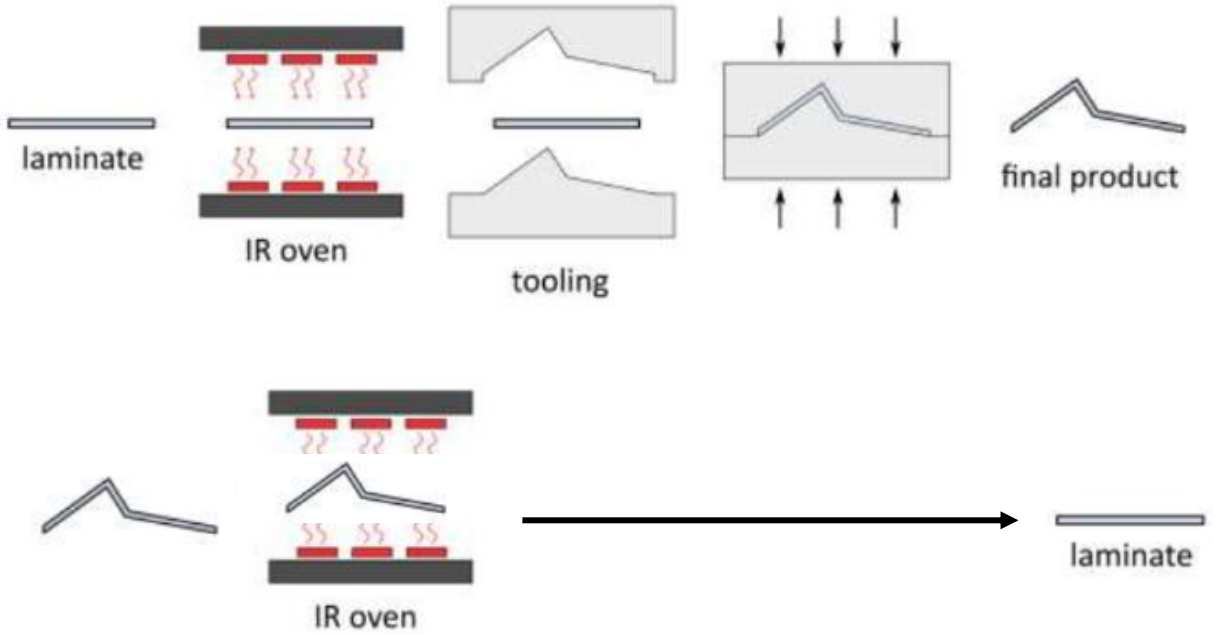
See YouTube video for details

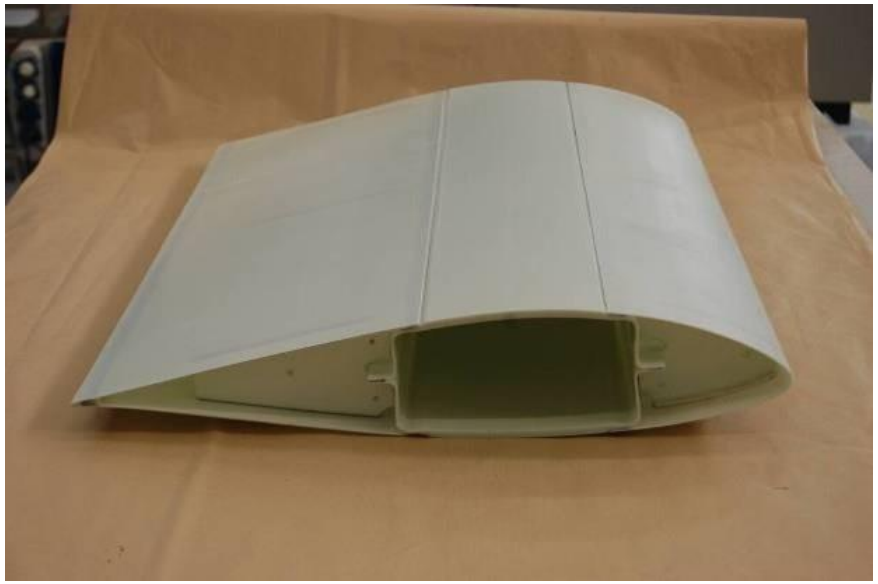
Circularity (esp. blades)

RETHINK BLADES – NATURAL FIBRES

RE-MANUFACTURING OF THERMOPLASTIC COMPOSITES & INFUSION OF THERMOPLASTIC COMPOSITES



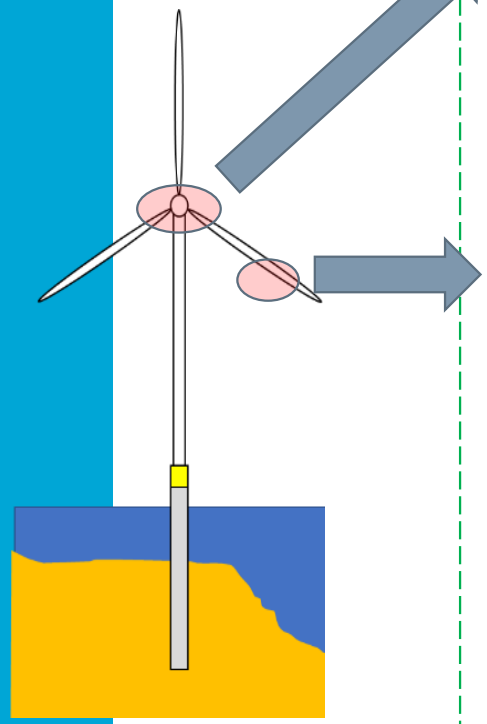




Operations and Maintenance

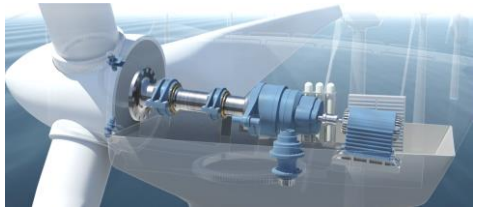
Holi-DOCTOR: Holistic framework for DiagnOstiCs and moniTORing of wind turbine blades

Wind Turbine



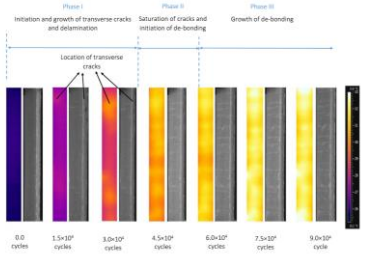
Simulation

Drive train model

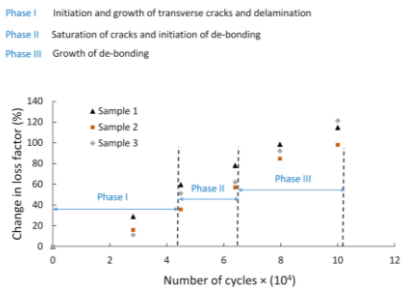


Measurement

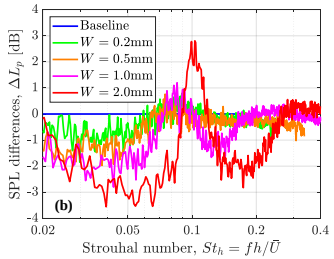
Infrared



Vibrometry



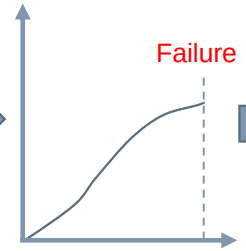
Aeroacoustics



Supporting data

Machine Learning

Fault Detection, Diagnosis and Prognosis



O&M Model

Circularity, Environment, Social Impact

LCoE
Availability
O&M
Schedules

TU Delft

WAGENINGEN UNIVERSITY & RESEARCH

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

LM WIND POWER
a GE Renewable Energy business

NWO

Turbine technology

DIFFERENT OFFSHORE TECHNOLOGIES

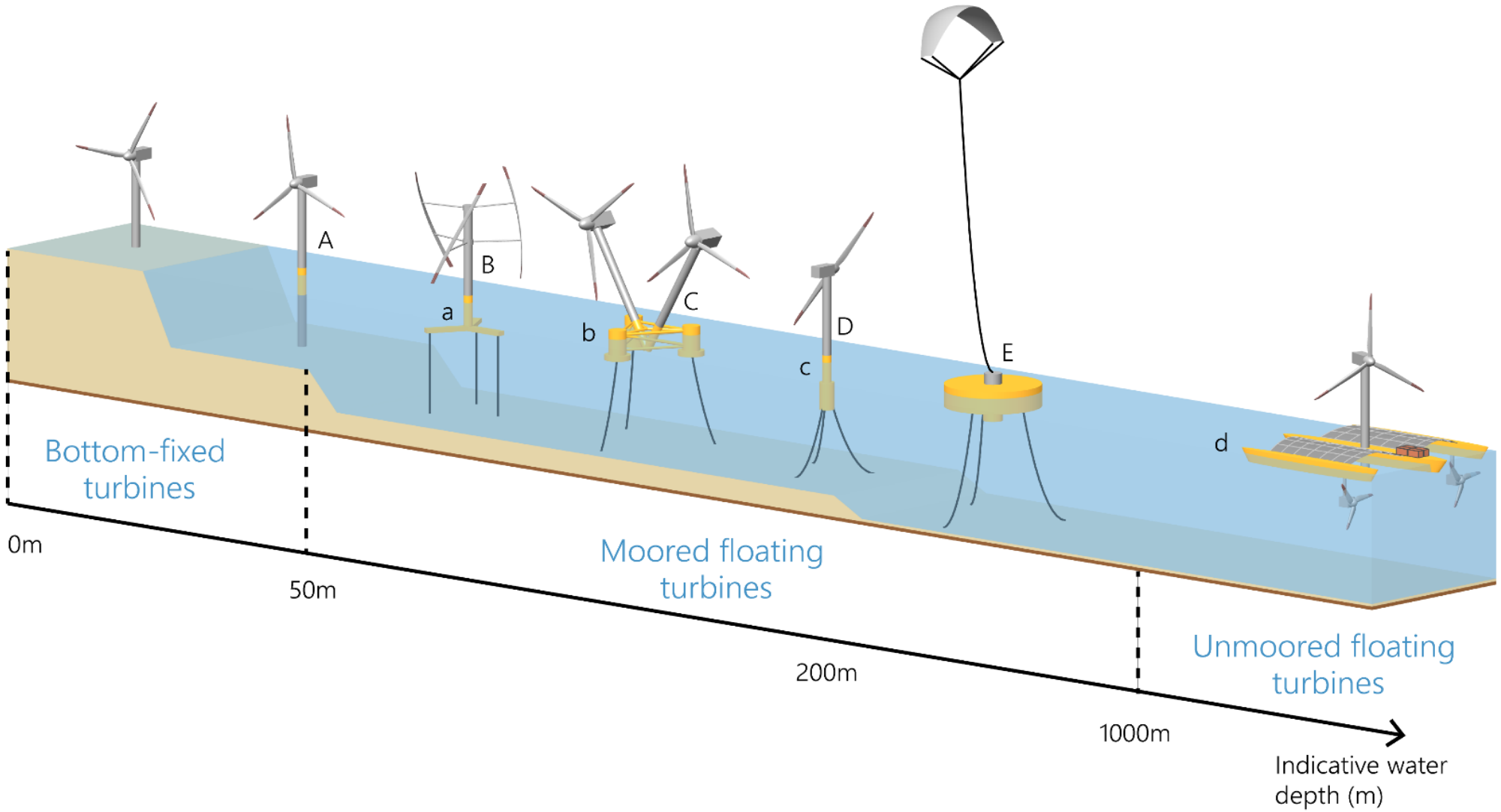
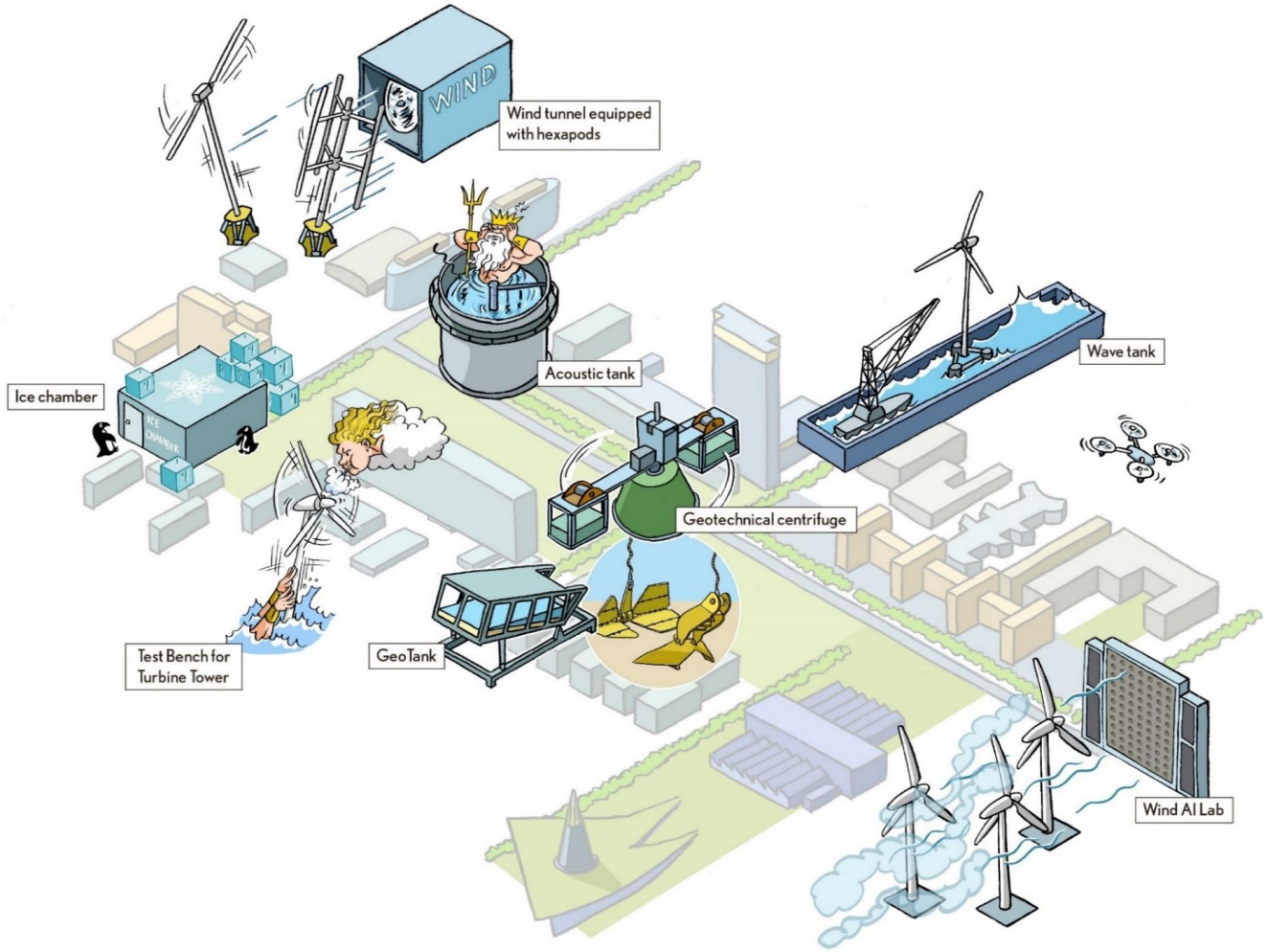


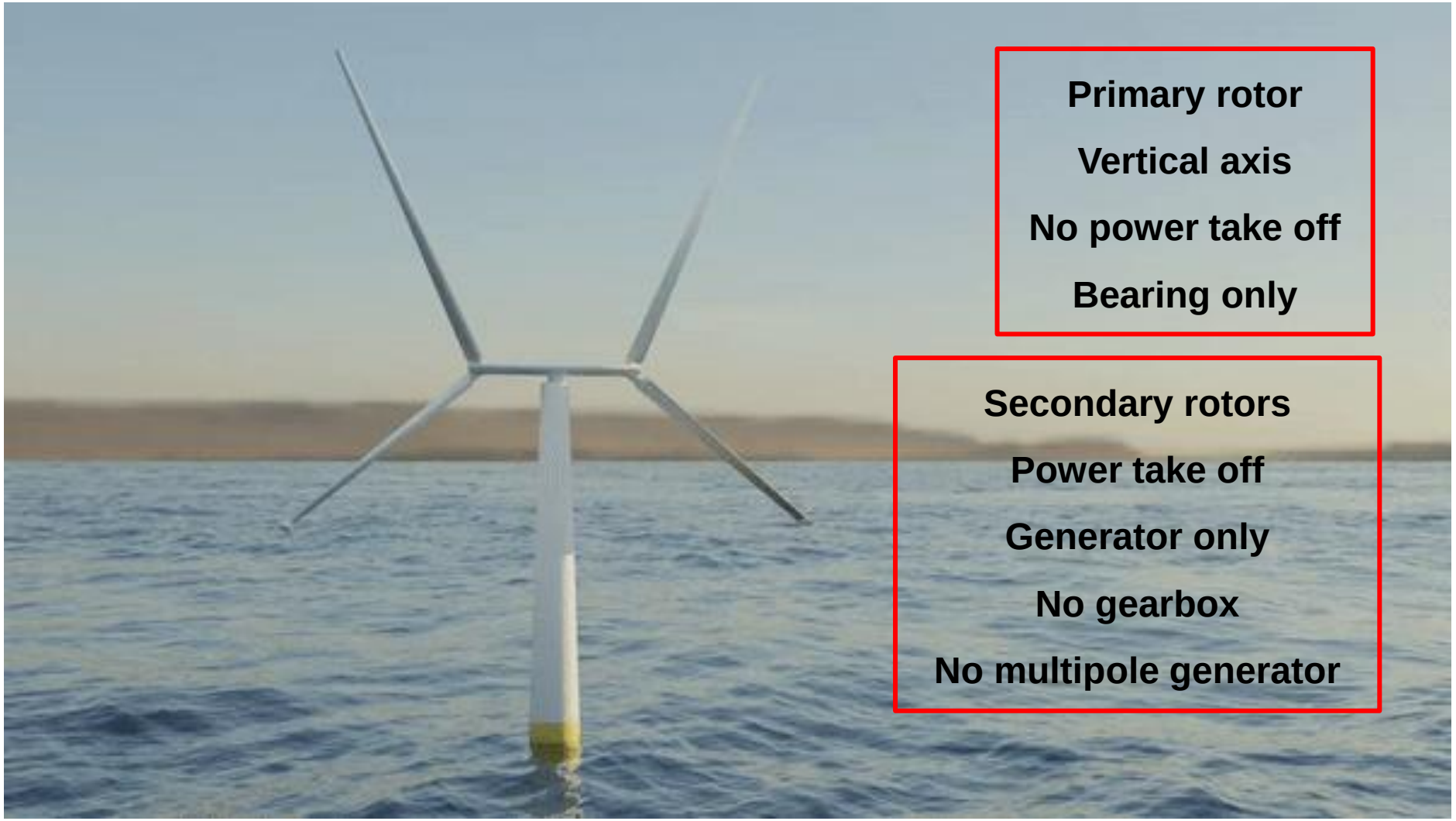
Diagram courtesy of Delphine De Tavernier

FLOATING RENEWABLES LABORATORY



- Multi-faculty testing facilities
- Hybrid testing
- Better floating platforms and turbines

X-Rotor Concept



Primary rotor

Vertical axis

No power take off

Bearing only

Secondary rotors

Power take off

Generator only

No gearbox

No multipole generator

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no. 101007135

https://xrotor-project.eu

Grid

ELECTRICAL SUSTAINABLE POWER (ESP) LAB

- Research into transmission, distribution, conversion and use
- Fundamental material research, through devices, components and microgrids towards system of systems
- Combine crucial elements from the electricity grid, such as high-voltage facilities, wind and solar energy, energy storage and distribution networks, into one functioning whole

Next Webinars

May 29, 1:00 p.m. ET

Innovations and Emerging Technologies in Offshore Wind

National Offshore Wind Research and Development Consortium

June 12, 1:00 p.m. ET

How Offshore Wind Connects to New York's Electric Grid

New York Independent System Operator (NYISO)

Visit wind.ny.gov to register

Check out over 40 past webinars, including:

- How Offshore Wind Farms are Installed
- Research and Regulations for Marine Mammal Interactions with Offshore Wind
- In-Air Acoustic Assessments for Offshore Wind
- Assessing and Advancing Transmission Upgrades for Offshore Wind
- Environmental Data Management and Offshore Wind

www.nyserda.ny.gov/osw-webinar-series

We want your feedback! Send suggestions for future webinar topics to offshorewind@nyserda.ny.gov

NEW YORK STATE | NYSERDA