DOCKETED	
Docket Number:	20-EPIC-01
Project Title:	Development of the California Energy Commission Electric Program Investment Charge Investment Plans 2021-2025
TN #:	238928
Document Title:	Presentation + Offshore Wind Energy R&D Opportunities for Epic 4 - July 14, 2021
Description:	Presentation slides for Electric Program Investment Charge 2021-2025 Investment Plan Scoping Workshop - Offshore Wind Energy R&D Opportunities for EPIC 4
Filer:	Kaycee Chang
Organization:	California Energy Commission
Submitter Role:	Commission Staff
Submission Date:	7/16/2021 11:31:45 AM
Docketed Date:	7/16/2021

Electric Program Investment Charge: 2021-2025 (EPIC 4) Investment Plan Scoping Workshop

Title: **Offshore Wind Energy R&D Opportunities for EPIC 4**

Date: July 14, 2021

Workshop Agenda

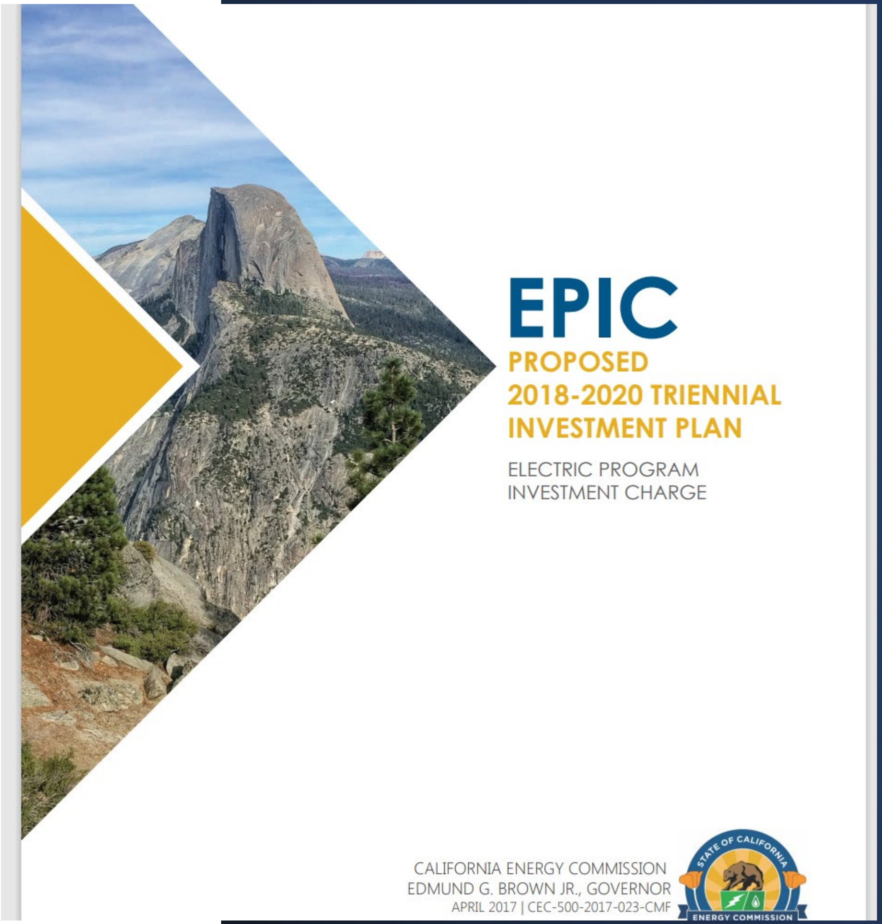
Time	Item
1:00 PM	Welcome and EPIC 4 Introduction
1:10 PM	**Session I** Research and Development Opportunities for Floating Offshore Wind
2:10 PM	**Session II** Facilitating Early Floating Offshore Wind Deployments in California
3:10 PM	**Session III** Floating Offshore Wind Environmental Impact Assessment and Minimization
4:10 PM	Public Comment
4:30 PM	Adjourn

EPIC 4 Investment Plan Process, Timeline, and Public Participation

Jonah Steinbuck, CEC

EPIC Investment Planning Background

- The CPUC requires each EPIC administrator to submit an Investment Plan.
- Investment Plans lay out the proposed research investments for the funding period.
- The EPIC 4 Plan will describe the CEC's proposed investments for funding collected from **2021-2025**.
- CEC develops its plan through an open and transparent stakeholder process.
- The previous CEC EPIC Investment Plan can be found at: https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M185/K575/185575884.PDF
- The Draft Proposed EPIC Interim Investment Plan 2021 can be found at: https://efiling.energy.ca.gov/getdocument.aspx?tn=236221



EPIC 4 Investment Plan Research Themes

Decarbonization

Reduce GHG emissions and use of fossil fuels.

Resilience and Reliability

Manage through and recover from *large-area or long-duration outages.*

Reduce the frequency or impact of *small-scale or short-duration disruptions* in electric service.

Entrepreneurship

Support clean energy entrepreneurs developing breakthrough technology solutions from idea to market.

Affordability

Improve the affordability of energy services for all electric ratepayers.

EQUITY is an overarching theme for EPIC investment planning. Initiatives will include funding set-asides for projects in under-resourced communities and other equity-targeting elements.

EPIC 4 Plan Schedule

Task / Event	Date(s)
Public workshops to solicit stakeholder input on specific topic gaps	May – July 2021
Public workshop to get input and feedback on the CEC’s draft research initiatives being considered for the EPIC 4 Investment Plan	August 4, 2021
EPIC 4 Investment Plan considered at CEC Business Meeting for approval	September 2021 (tentative)
EPIC 4 Investment Plan submitted to CPUC	October 1, 2021 (tentative)
CPUC Decision on EPIC 4 Plan expected	Spring-2022 (tentative)
The first EPIC 4 solicitations released	Summer-Fall 2022

EPIC 4 Workshops

Workshop Title and Description	Date
Offshore Wind Energy R&D Opportunities for EPIC 4	Wednesday, July 14, 2021 1:00 p.m.
Industrial Decarbonization	Friday, July 16, 2021 9:30 a.m.
Technology Advancements for Energy Storage	Tuesday, July 20, 2021 9:30 a.m.
Improving the Bankability of New Clean Energy Technologies	Thursday, July 22, 2021 10:00 a.m.
Draft Initiatives for EPIC 4	Wednesday, August 4, 2021 9:00 a.m.

Empower Innovation

EMPOWER INNOVATION

empowerinnovation.net

To stay involved in EPIC 4:

Visit CEC's website for workshop info, presentations, docket, e-commenting, and EPIC listserv sign up: www.energy.ca.gov/epic4

Submitting Written Comments:

The Workshop Comments may be submitted using CEC's **e-commenting** system: https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01

See this event's **notice** for **e-mail and U.S. Mail** commenting instructions: https://efiling.energy.ca.gov/getdocument.aspx?tn=238093

For all comments, please include docket # **20-EPIC-01** and "EPIC 4 Investment Plan" in the subject line and on the cover page. Comments for this workshop are due **July 26, 2021**.

Workshop Agenda

Time	Item
1:00 PM	Welcome and EPIC 4 Introduction
1:10 PM	**Session I** Research and Development Opportunities for Floating Offshore Wind
2:10 PM	**Session II** Facilitating Early Floating Offshore Wind Deployments in California
3:10 PM	**Session III** Floating Offshore Wind Environmental Impact Assessment and Minimization
4:10 PM	Public Comment
4:30 PM	Adjourn

Session I: Research and Development Opportunities for Floating Offshore Wind

Moderator: Kaycee Chang, CEC

Panelists

A. Habib Dagher, Univ. of Maine Advanced Structures and Composites Center
B. Senu Sirnivas, National Renewable Energy Laboratory
C. Zachary Westgate, Norwegian Geotechnical Institute/University of Massachusetts Amherst

Lessons Learned:

New England
Aqua Ventus I

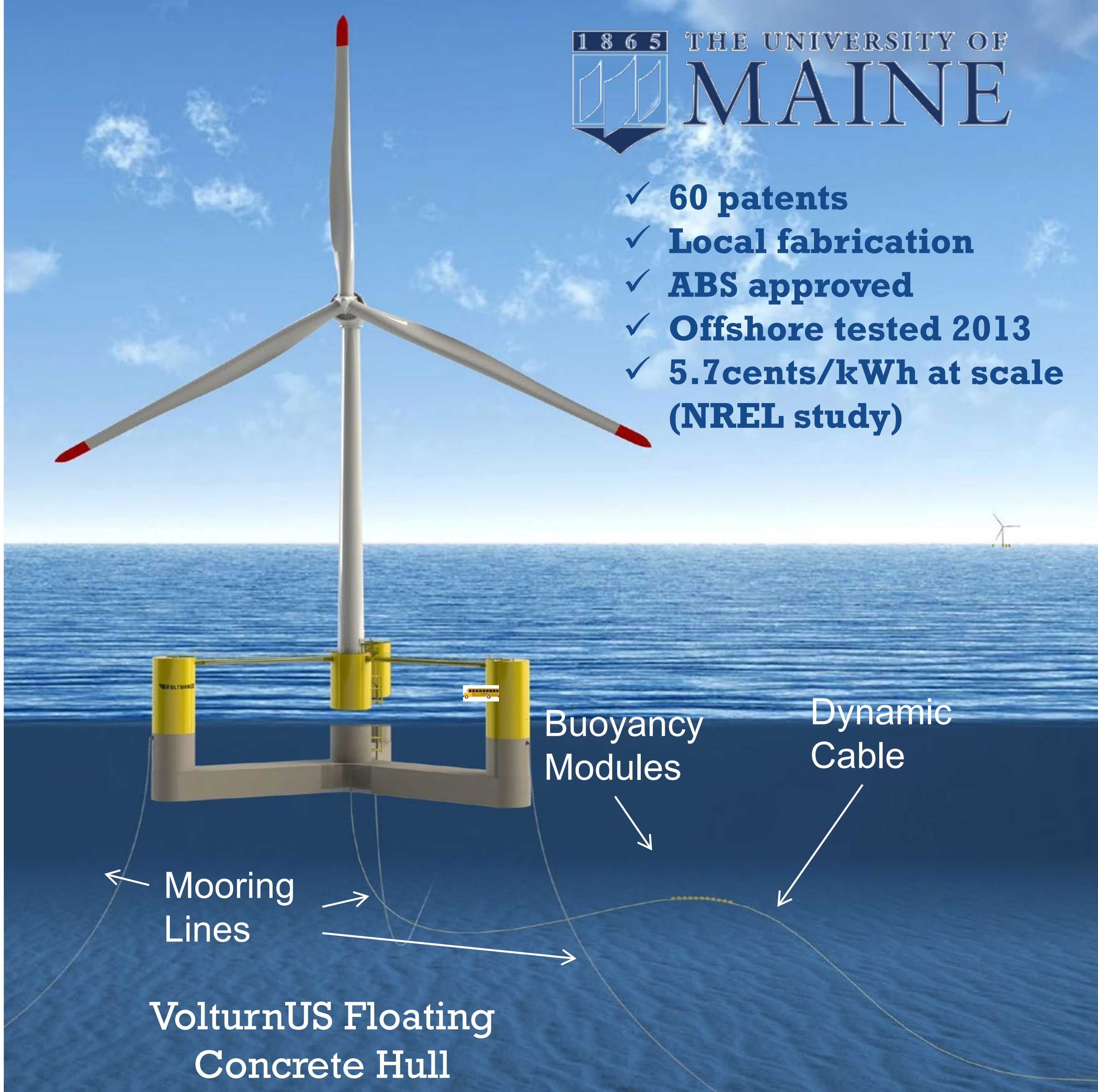
Floating
Offshore Wind

DOE Advanced Technology Demonstration Program for Offshore Wind

CEC Workshop
R&D Opportunities for EPIC 4

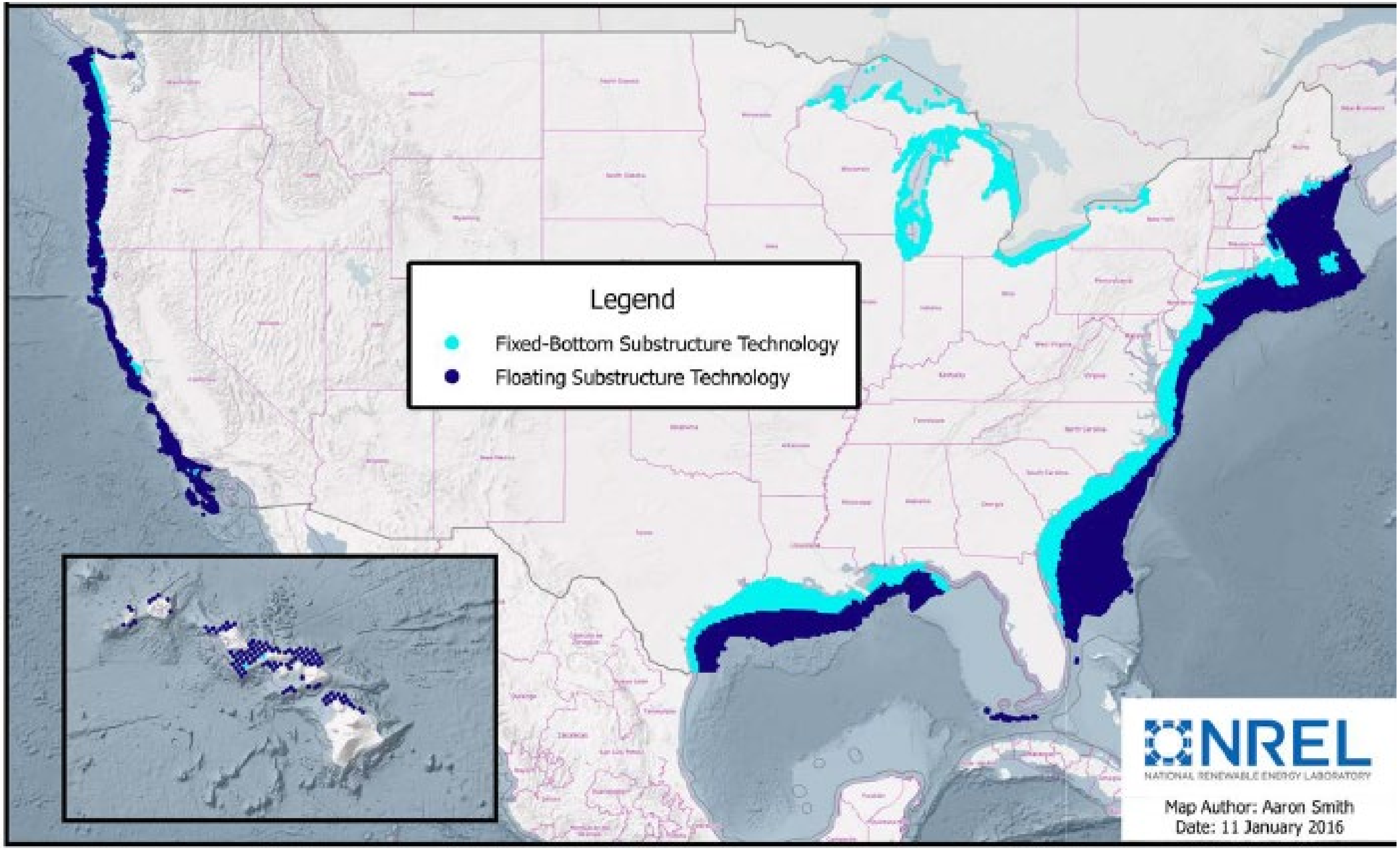
July 14, 2021

Presented by:
Prof. Habib Joseph Dagher, PhD, PE
Exec. Director, ASCC Center
DOE Aqua Ventus Project lead
hd@maine.edu +1 (207) 581-2138



US Potential for Floating Wind

60% of US offshore wind resource can be harnessed using floating technology

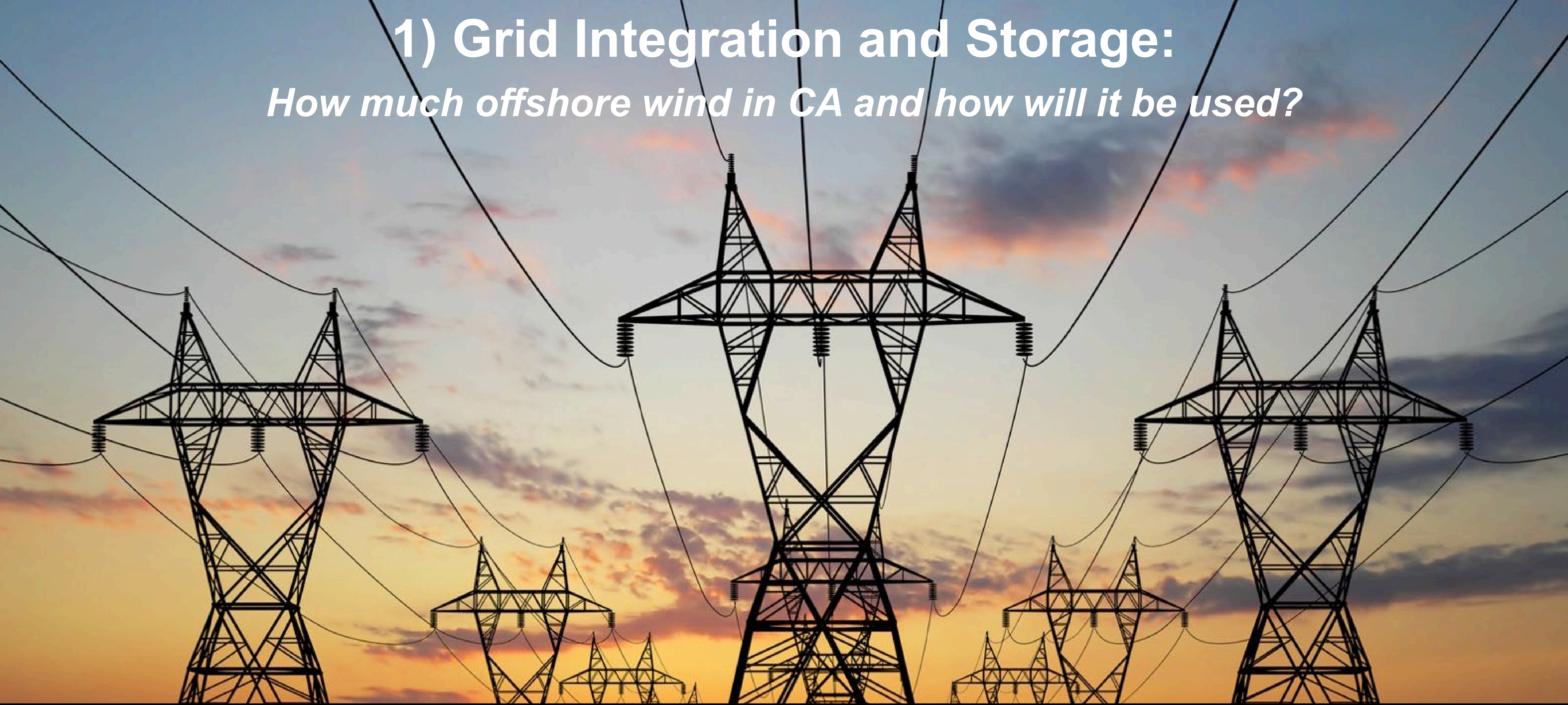


Outline: Research Opportunities

1. Grid Integration and Storage
2. Serial Fabrication and Port Facilities
3. Optimized Hull Designs for Local Conditions
4. Mooring Lines and Anchors for Deep Waters/ Use of Shared Anchors
5. Environmental, Ecological and Fisheries Impacts
6. Electrical Infrastructure: Dynamic/inter-array cables & substations
7. Farm Layout: Turbine and Anchor Spacing to minimize impacts

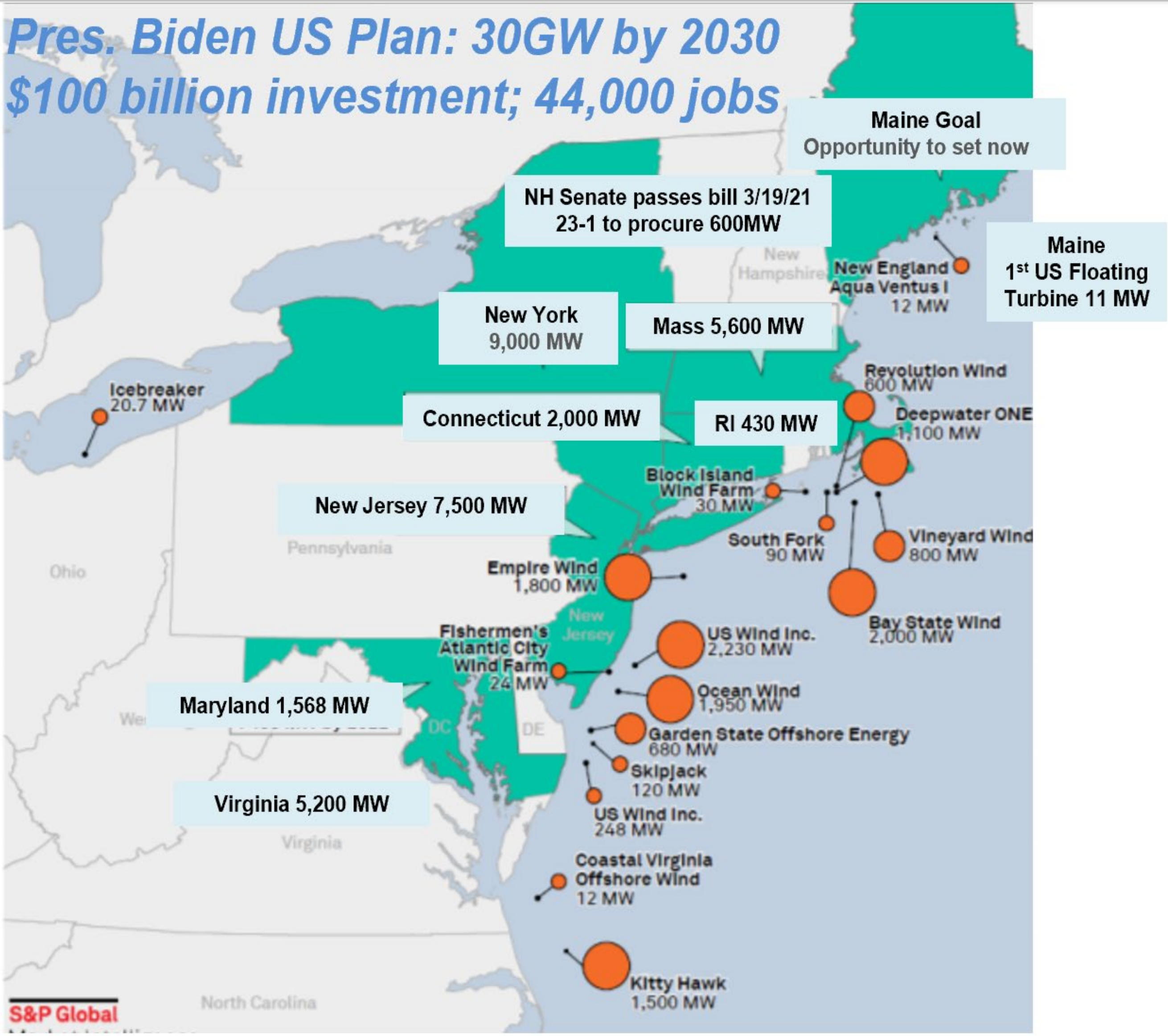
1) Grid Integration and Storage:

How much offshore wind in CA and how will it be used?



In Maine, 3% of Offshore Wind Resource Electrifies Heating and Transportation = 5 GW

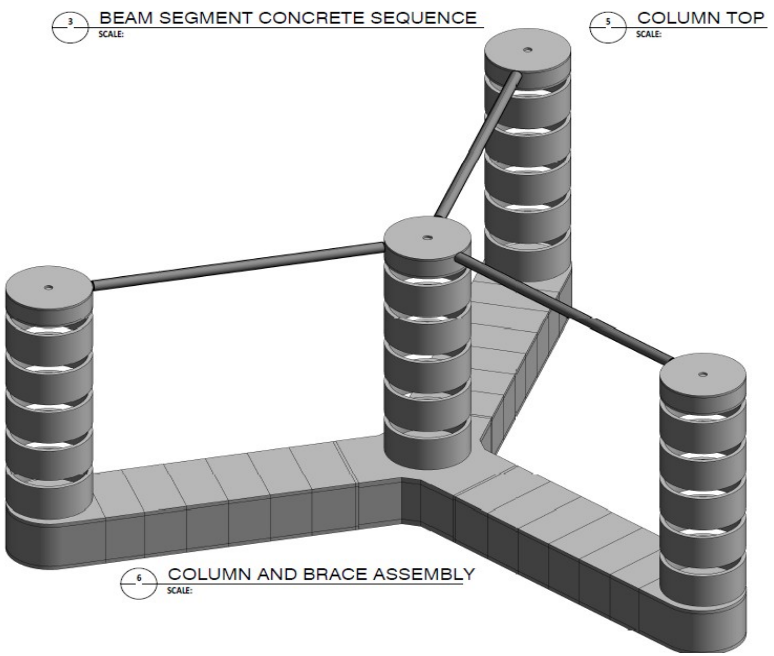
Grid Interconnection Planning



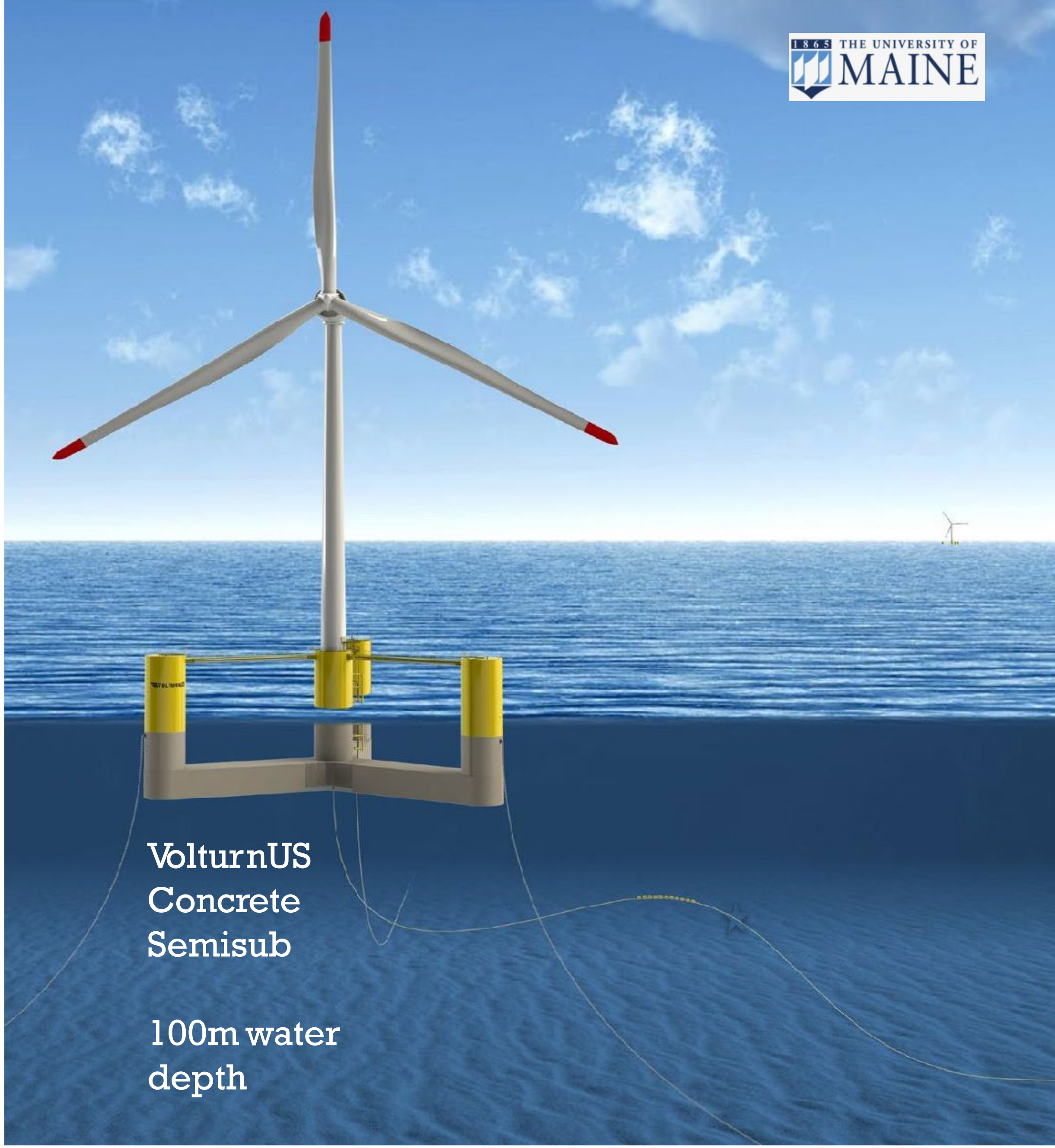
2) Serial Fabrication & Port Facilities

Illustration by Joshua Bauer, National Renewable Energy Laboratory (US Department of Energy)

Serial Production @ Local Ports: New England Aqua Ventus I



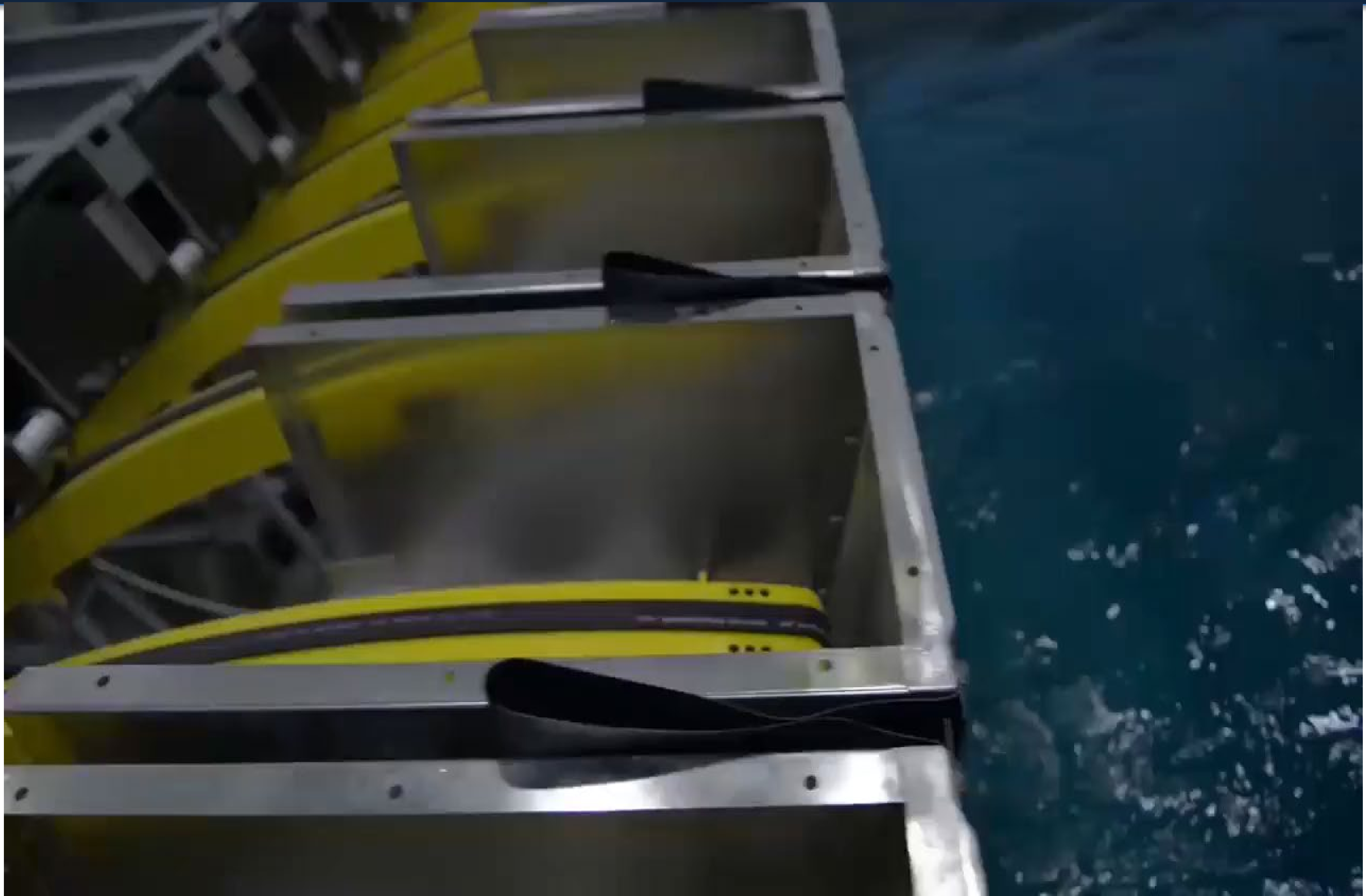
1. Designed for local serial production
2. Five concrete module types
3. Start construction 22/23, COD 24



VOLTURNUS TECHNOLOGY: BRIDGE BUILDERS BECOME HULL BUILDERS

1865 THE UNIVERSITY OF MAINE

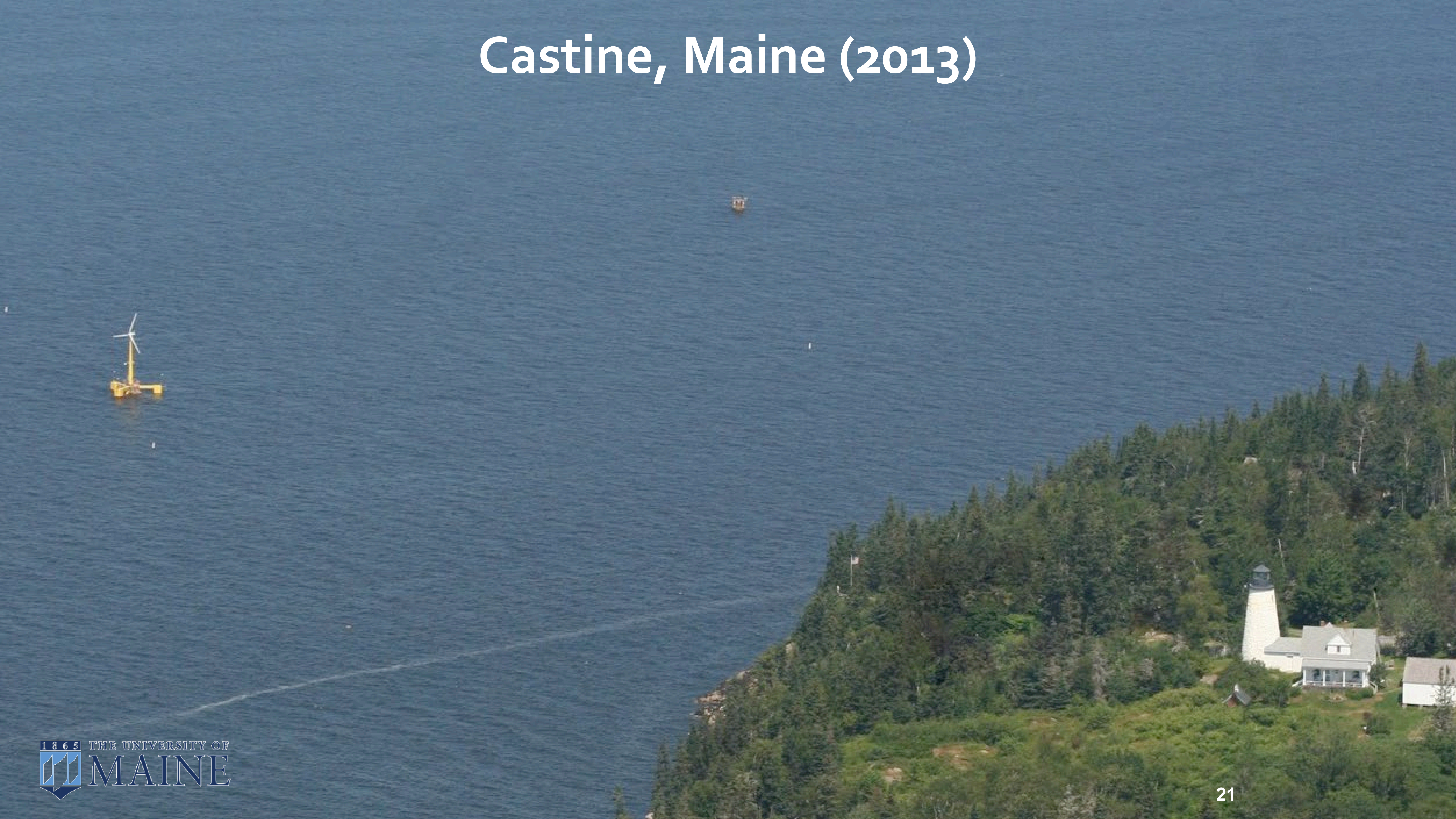
3) Optimize Designs for Local Conditions



May 31, 2013: VolturnUS

THE UNIVERSITY OF MAINE

Castine, Maine (2013)



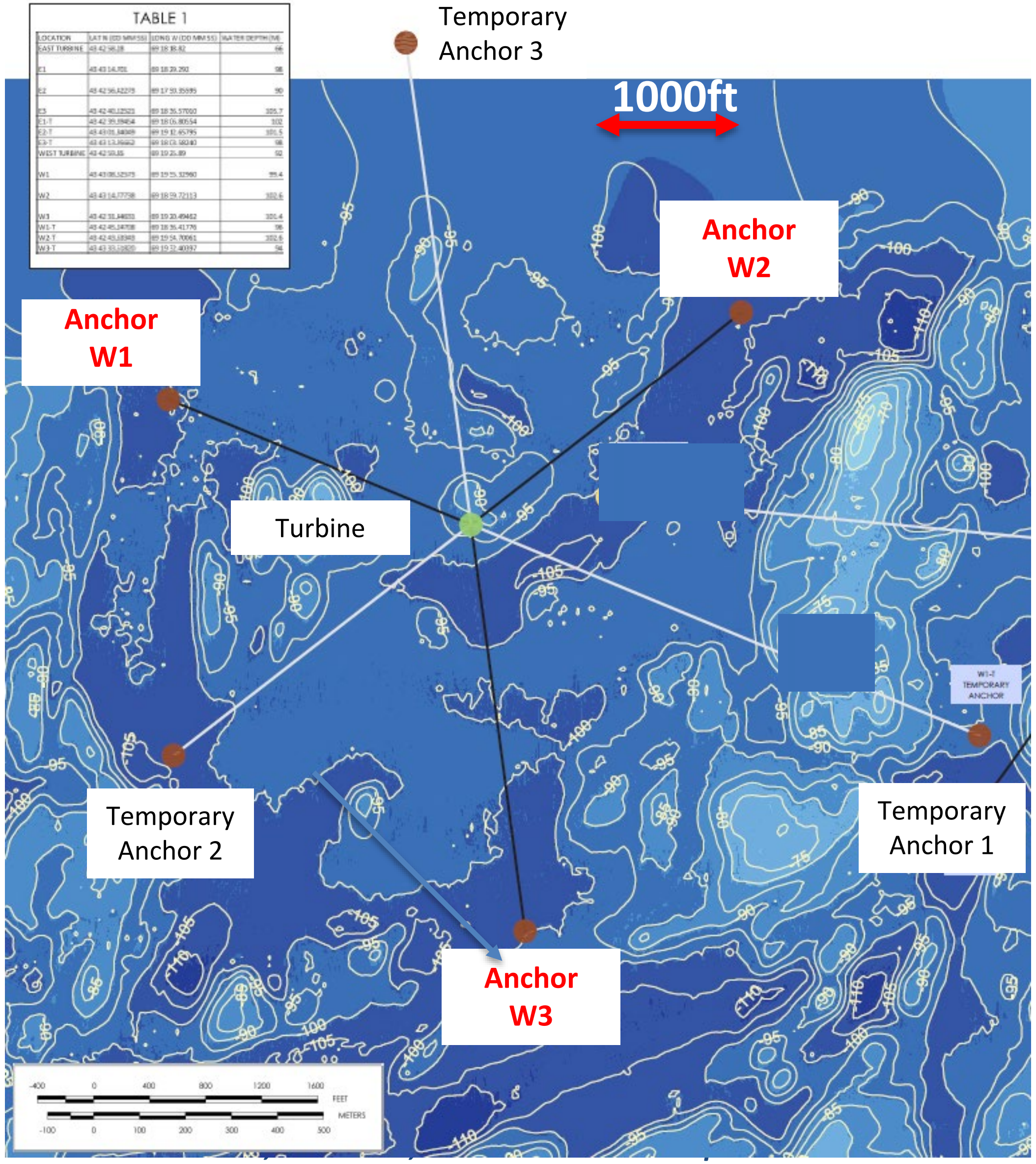
1865 THE UNIVERSITY OF MAINE

50-Year Return Period Storm

1865 THE UNIVERSITY OF MAINE

4) Mooring lines & Anchors for Deep Water

ADVANCED STRUCTURES & composites center

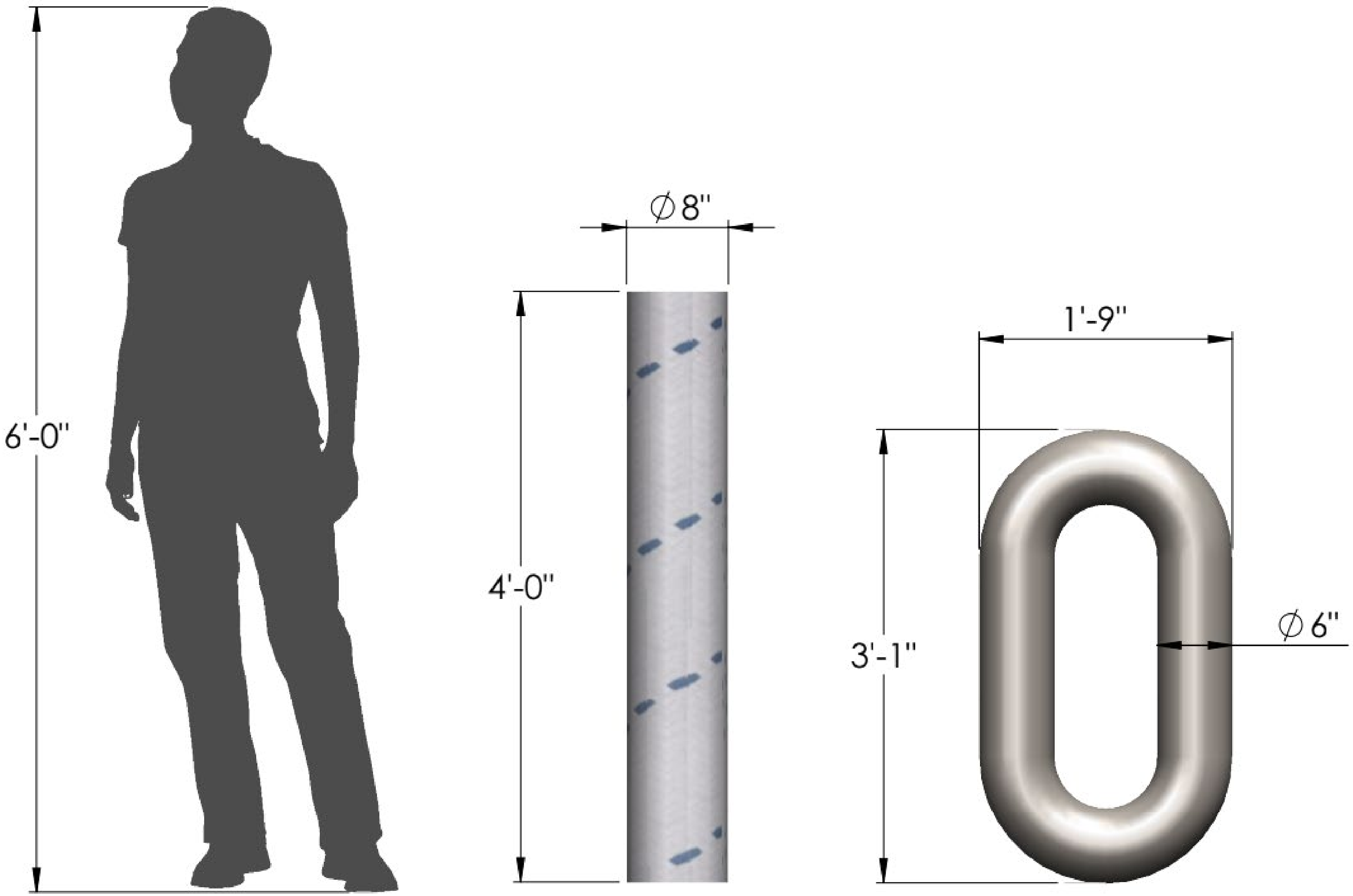


Drag or Suction Anchors or others?

Water Depth: 300-330ft (Maine)
>2,000 ft (CA)

Common anchors?

Mooring Lines: Synthetic vs Chain



5) Environmental Ecological Studies

Extensive ecological, geotechnical, and cultural studies have been completed and are planned:

- Benthos: 2010-13, 2015
- Fish: 2010-15
- Marine Mammals: 2010-15
- Birds: 2010-15
- Bats: 2010-13, 2015
- Noise and Vibration: 2011, 2013
- Electromagnetic Fields: 2011, 2013
- Geophysical: 2010, 2013, 2015
- Terrestrial: 2014
- Aesthetics/Visual: 2013
- Cultural/Historic: 2010, 2014, 2015

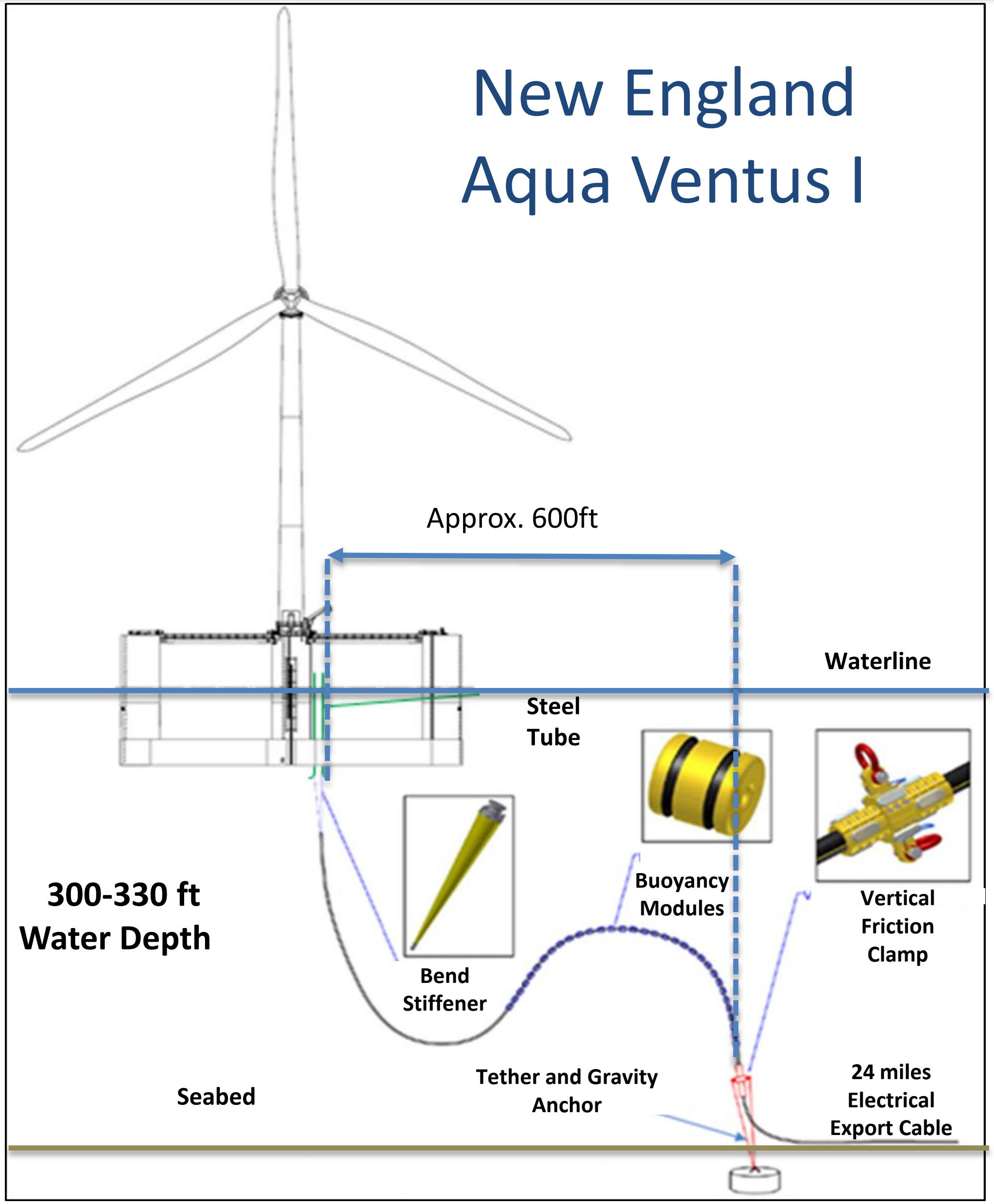
Additional questions for floating:

- Interaction of dynamic cables with fisheries

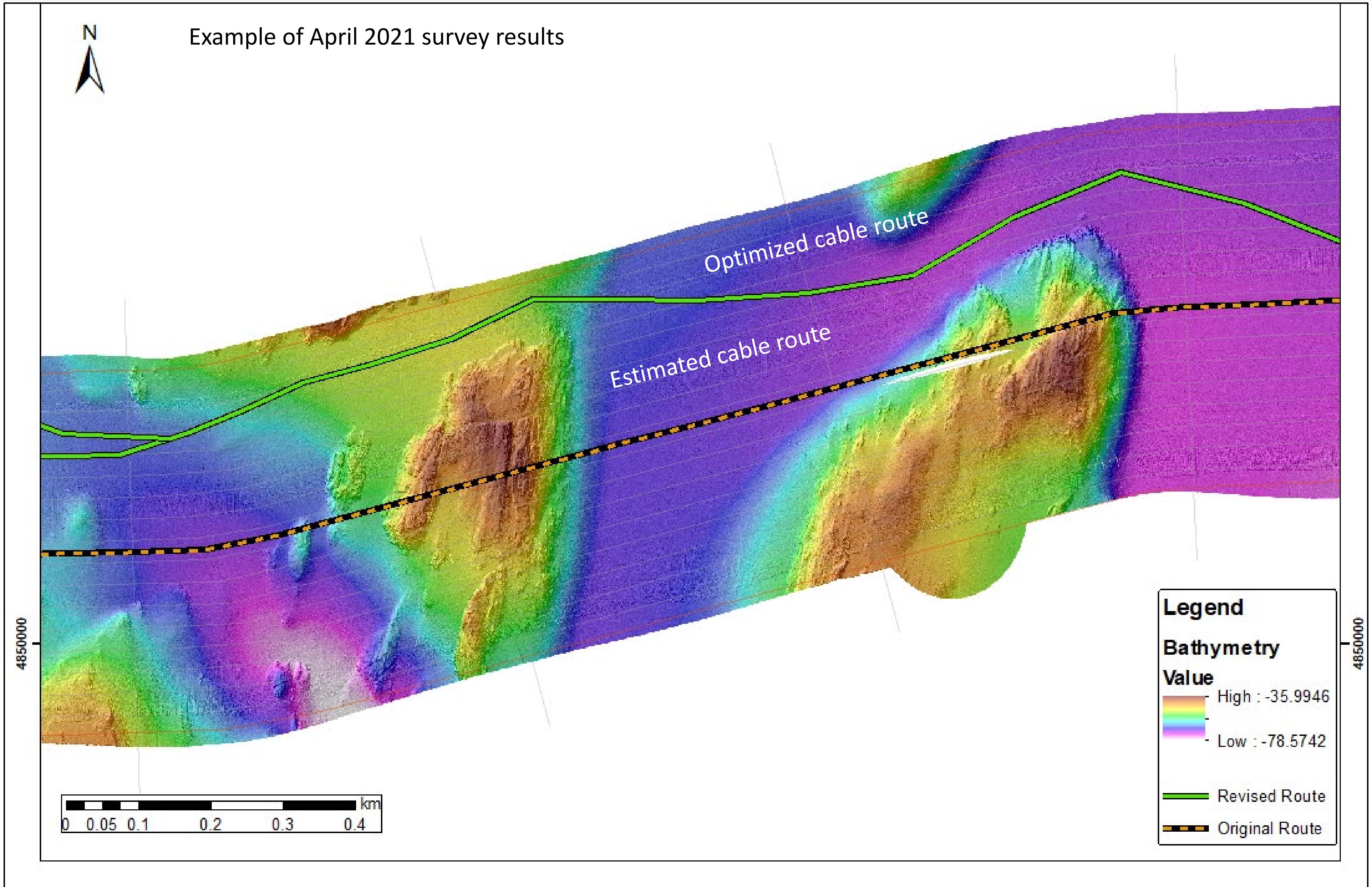
Ecological surveyor deploying equipment for surveys, 2012.

6) Electrical Infrastructure

1. Aqua Ventus 1 has relatively shallow water, with 300-330ft water depth.
2. California Waters will require optimization of **dynamic cables** designs: inter-array and export cables.
3. **Cable burial** and interactions with fisheries
4. **Substations:** Floating or on seabed?



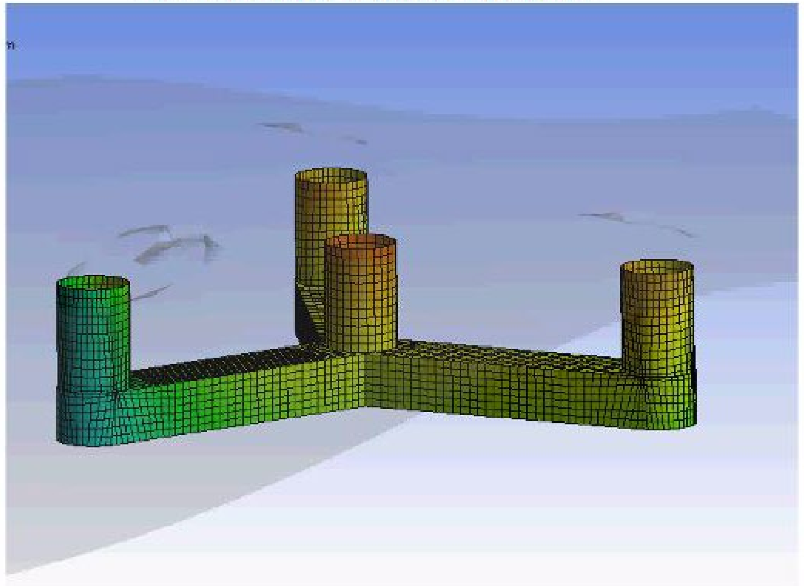
Geophysical Data:
Optimizing Anchors and Cables



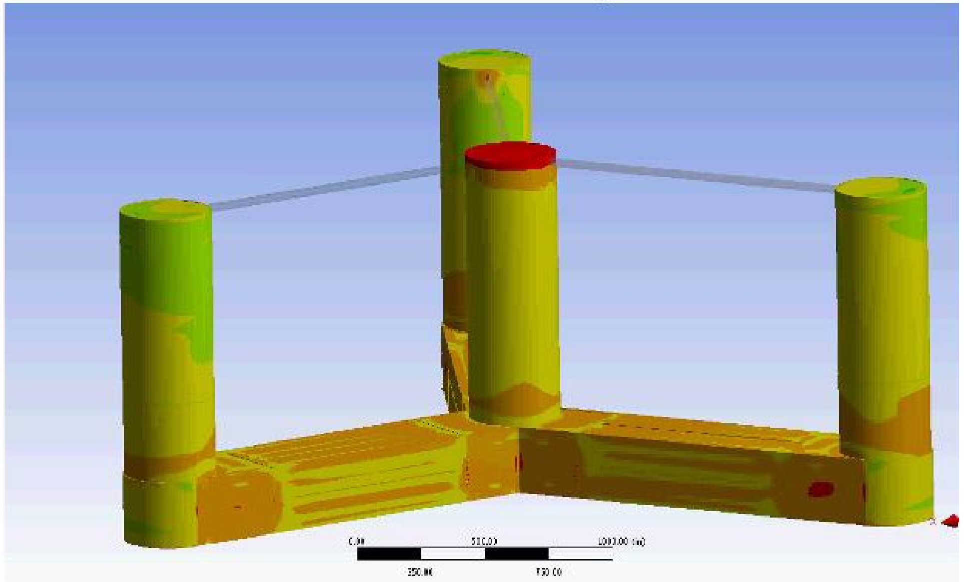
Hull Motions and Dynamic Cables

1. Designed hull using American Bureau of Shipping's *Guide For Building and Classing Floating Offshore Wind Turbines*.
2. Evaluated about 80,000 load cases
3. Dynamic cables need to follow hull motions, and resist fatigue loadings

DLC 6.1: 50-year Return Wave Event
Ansys AQWA Potential Flow Model

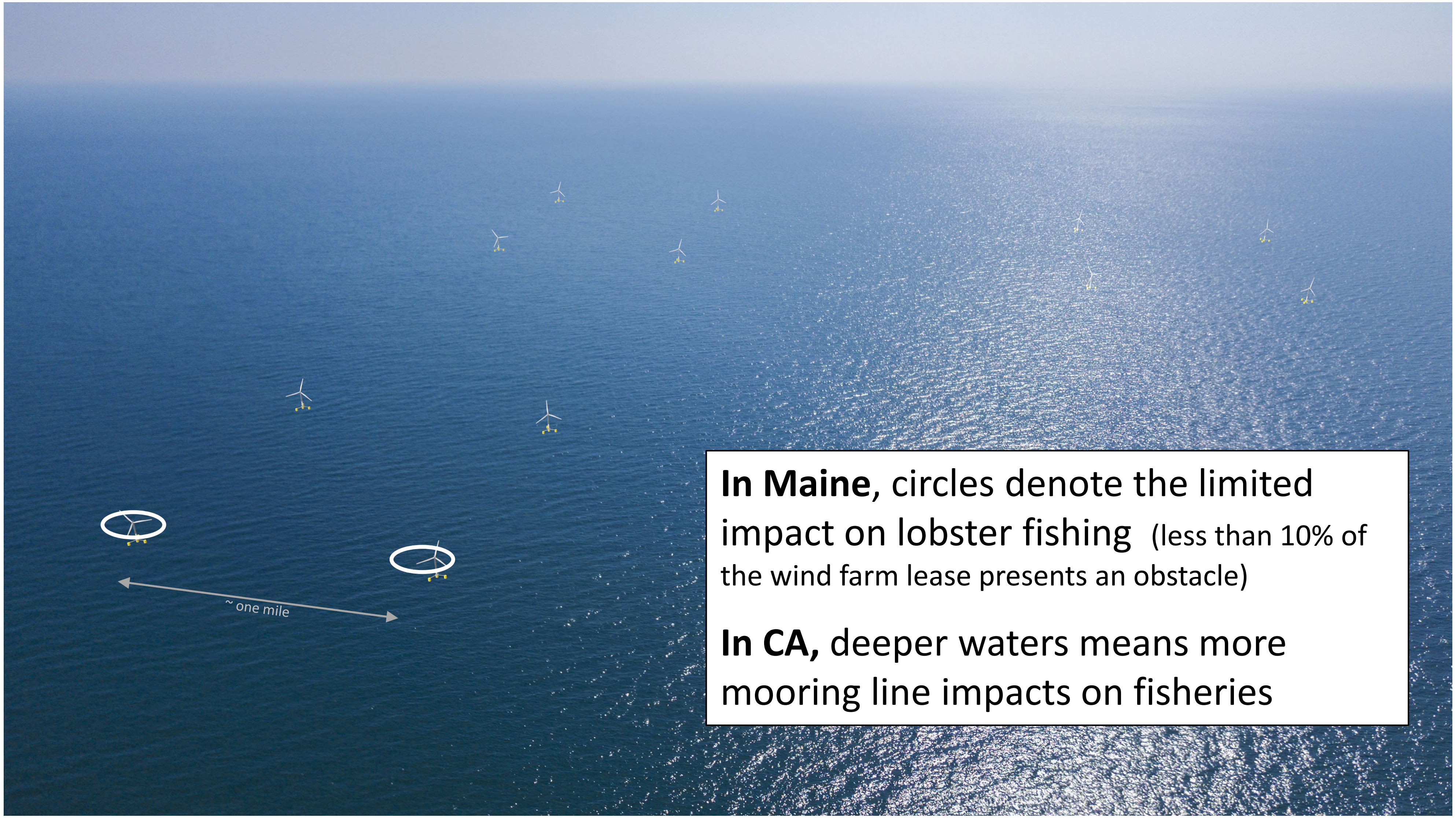


DLC 6.1: 50-year Return Wave Event
FEA Shell Model - von Mises Eq. Stress



THE UNIVERSITY OF MAINE 1865

7) Turbine & Anchor Spacing, Fisheries and Navigation



In Maine, circles denote the limited impact on lobster fishing (less than 10% of the wind farm lease presents an obstacle)

In CA, deeper waters means more mooring line impacts on fisheries

Summary: Research Needs

1. Grid Integration and Storage
2. Serial Fabrication and Port Facilities
3. Optimized Hull Designs for Local Conditions
4. Mooring Lines and Anchors for Deep Waters/ Use of Shared Anchors
5. Environmental, Ecological and Fisheries Impacts
6. Electrical Infrastructure: Dynamic/inter-array cables & substations
7. Farm Layout: Turbine and Anchor Spacing to minimize impacts

CEC Workshop
Offshore Wind Energy R&D Opportunities
EPIC 4 | Session 1

My Background / NREL / ARPAe USFLOWT / Research Needs

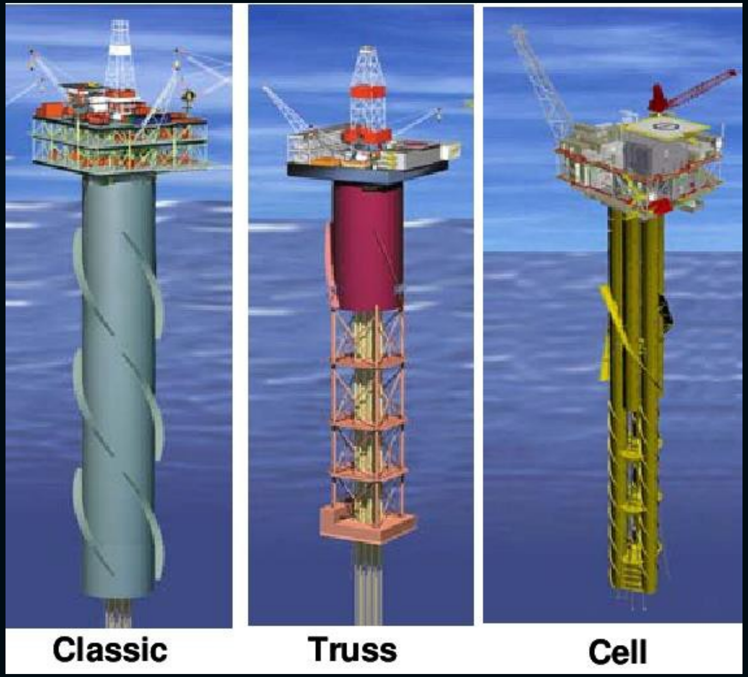
Senu Sirnivas
NREL

July 14, 2021

Senu Sirnivas
senu.sirnivas@nrel.gov

My Background

Oil & Gas
Spar Technology
Drilling and Production



20 Years

Wind
Floating Wind Technology
Energy Production

10 Years

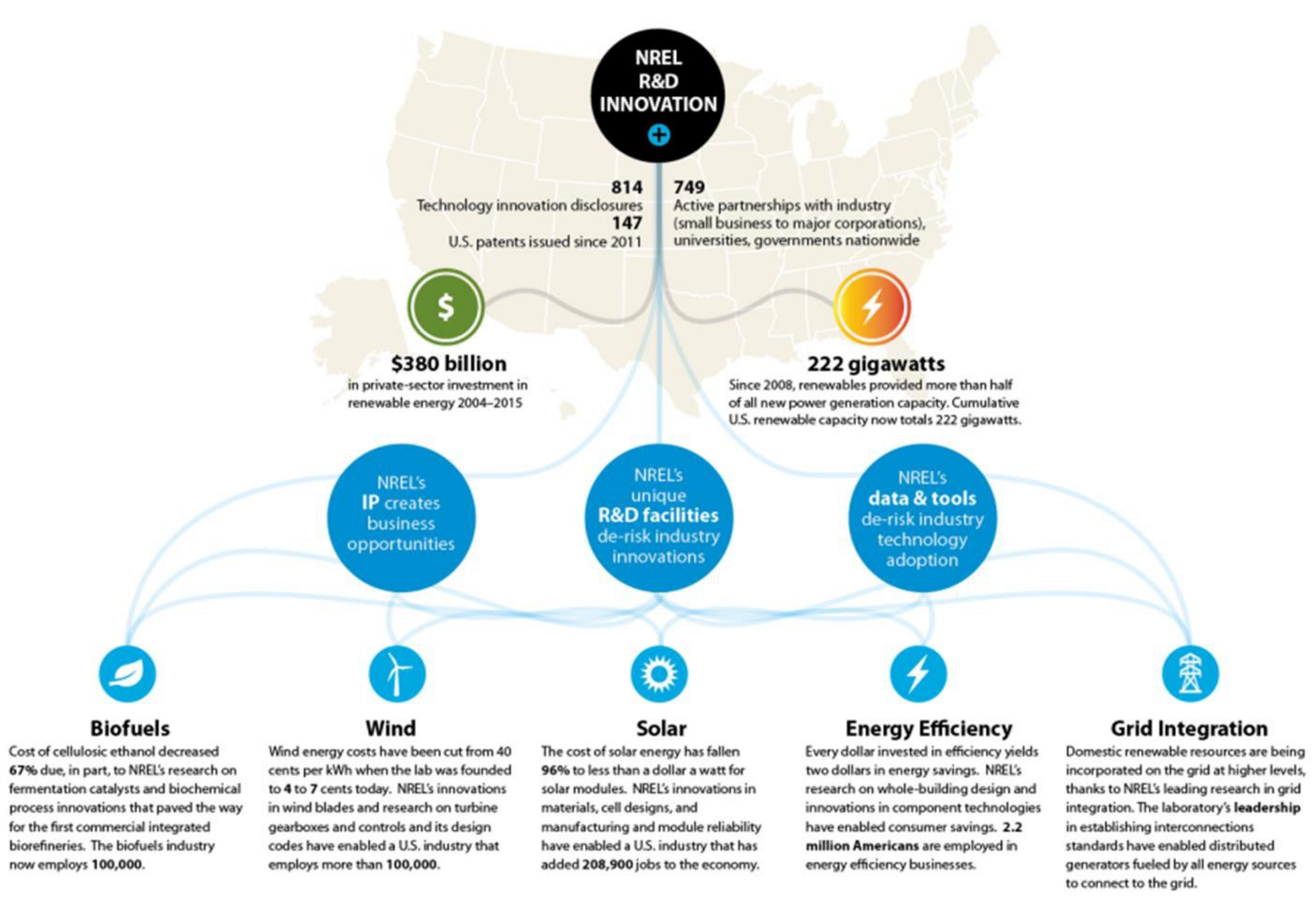
NREL - Background

40+ Years of Clean Energy Research

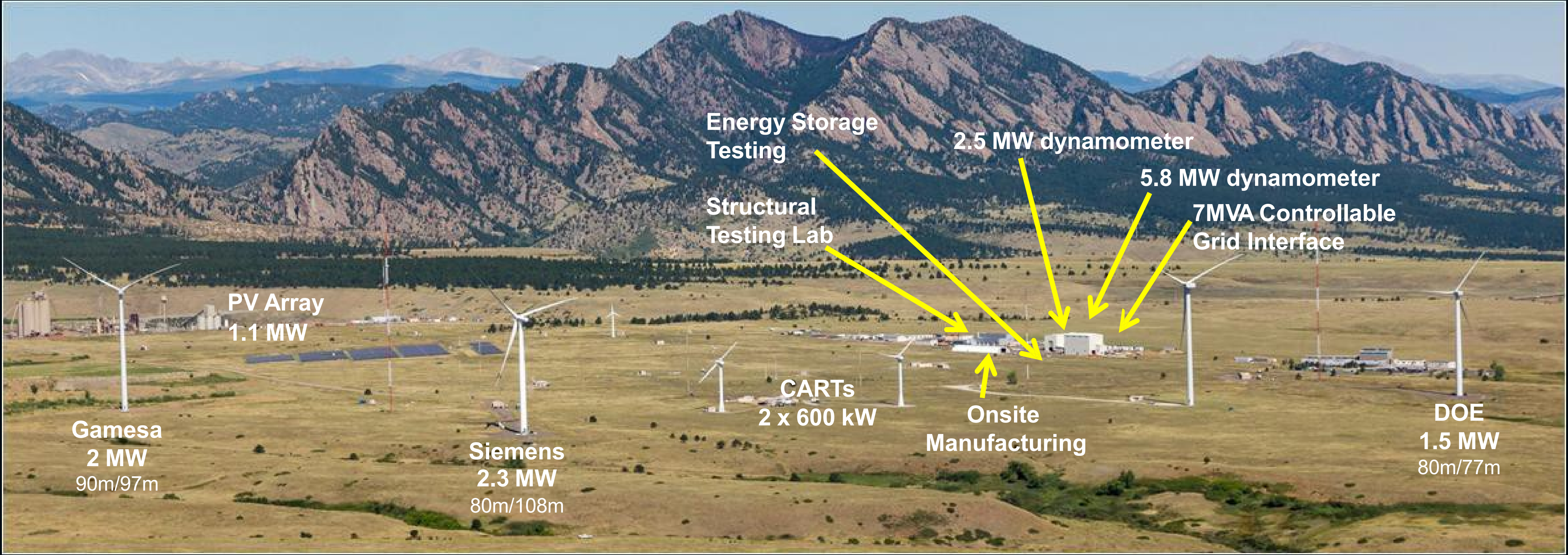
- ✓ Founded as Solar Energy Research Institute (SERI) in 1977
- ✓ Designated national laboratory in 1991 and renamed National Renewable Energy Laboratory
- ✓ Today managed by the Alliance for Sustainable Energy, LLC, for the U.S. Dept. of Energy

NREL - National Asset / Dedicated Mission

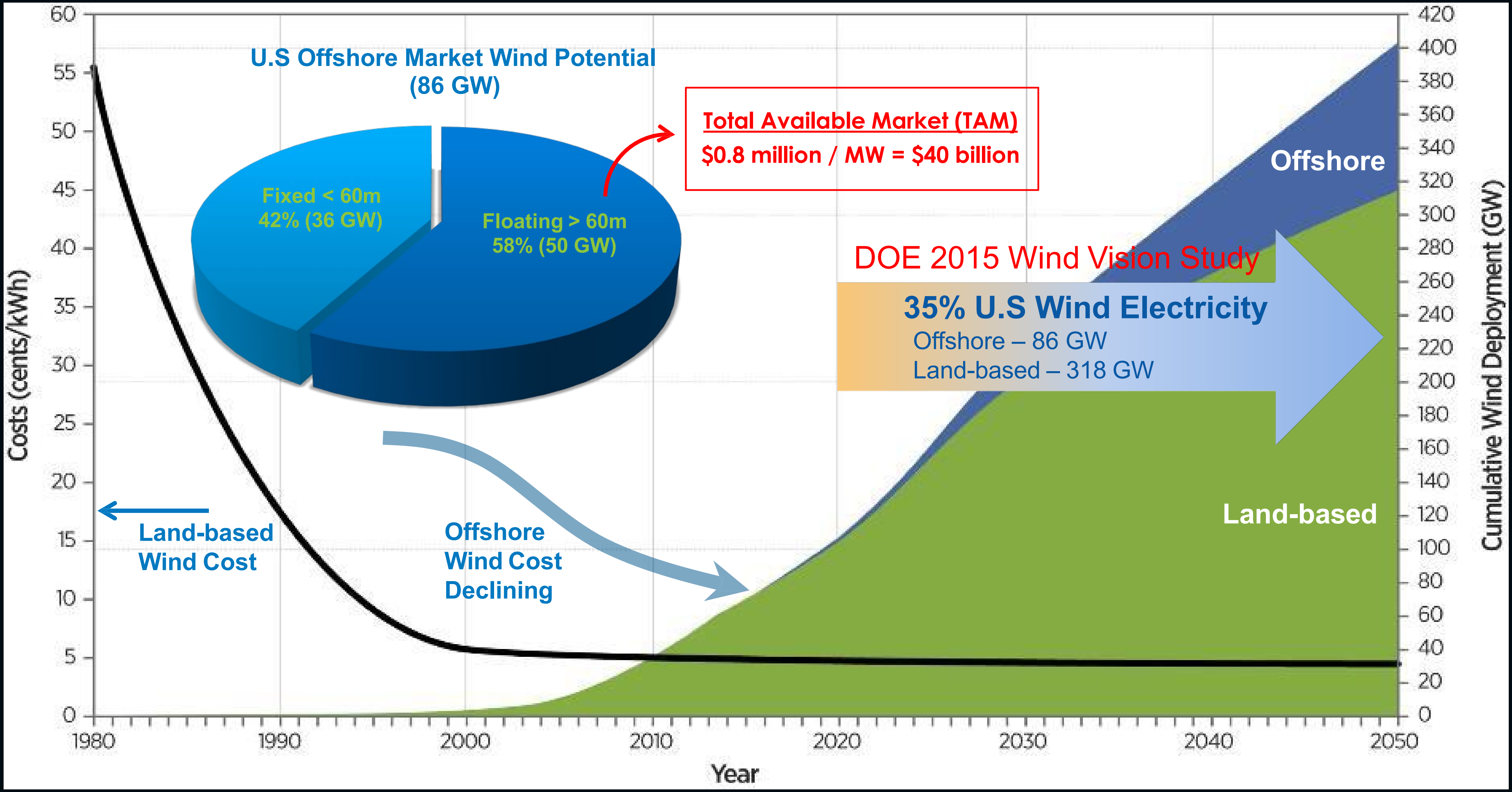
- ✓ World-class facilities, renowned technology experts
- ✓ Nearly 1,700 employees, including more than 300 early-career researchers and visiting scientists
- ✓ Nearly 750 active partnerships
- ✓ Campus is a living energy laboratory
- ✓ National economic impact of $872M annually



NREL - Flatiron Campus



Why Floating Offshore Wind?



Floating Offshore Wind Problem

Offshore floating wind designs are based on **Oil & Gas technology** that have resulted in **bulky and expensive substructure ($1 million / MW)** **... need to lower the LCOE for economic feasibility.**

Oil & Gas Technology

Offshore Floating Wind Technology

Less than 7.5 cents/kWh

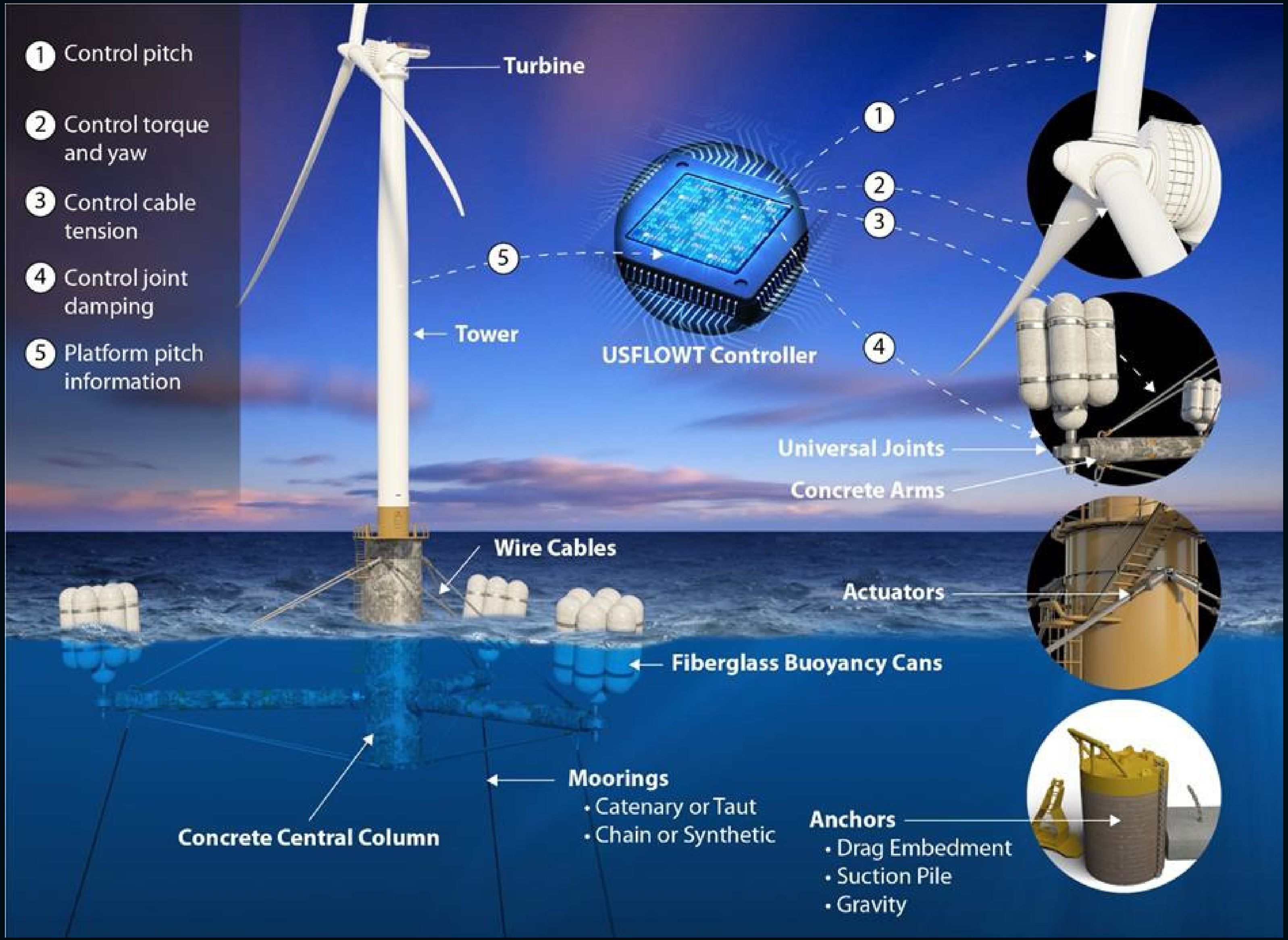
USFLOWT = SpiderFLOAT+10 MW Turbine

Project Vision

Tailored floating substructure design to meet the challenges of offshore floating wind market by effectively capturing the planet's abundant deep-water wind resources for energy production.

Project Impact

A modular floating offshore wind substructure that offers a substantial cost reduction in CAPEX and OPEX, leveraging local supply chain and onsite manufacturing.



Project Team

Senu Sirnivas, PI
senu.sirnivas@nrel.gov
Floater Design

Intern: Kirana Bergstorm

Lucy Y Pao
pao@colorado.edu
Turbine & Floater Control Design

Students: Mandar Phadnis
David Stockhouse

Rick Damiani
rdamiani@mines.edu
Structural Design

Student: James Dinius

Eric Loth
el9r@virginia.edu
Floater Actuator Design

Students: Kevin Fletcher
Edem Tetteh

Kathryn Johnson
kjohnson@mines.edu
Turbine & Floater Control Design

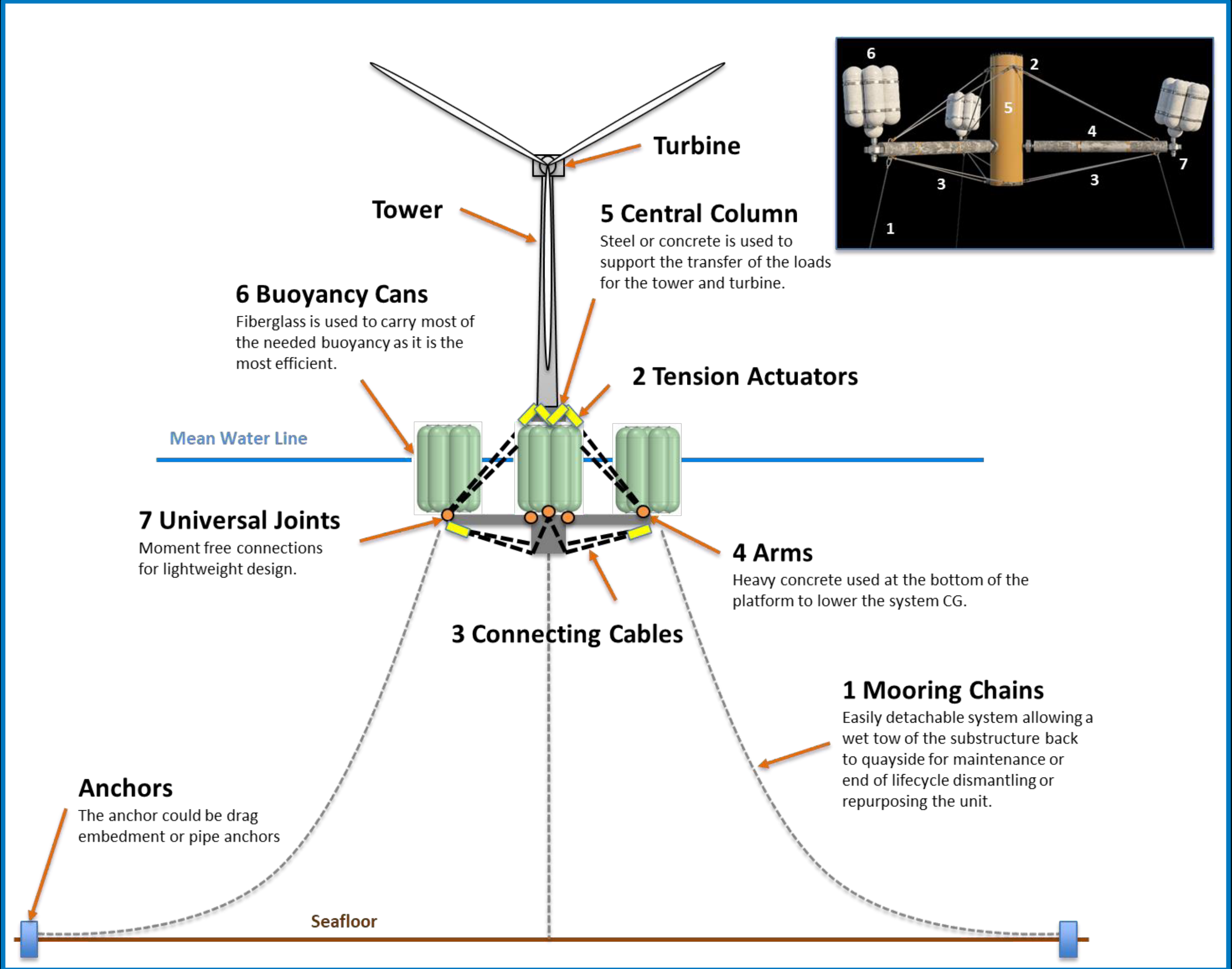
Student: Elenya Grant

Qing Yu
qyu@eagle.org
Approval in Principle

Co-worker: Xiaohong Chen

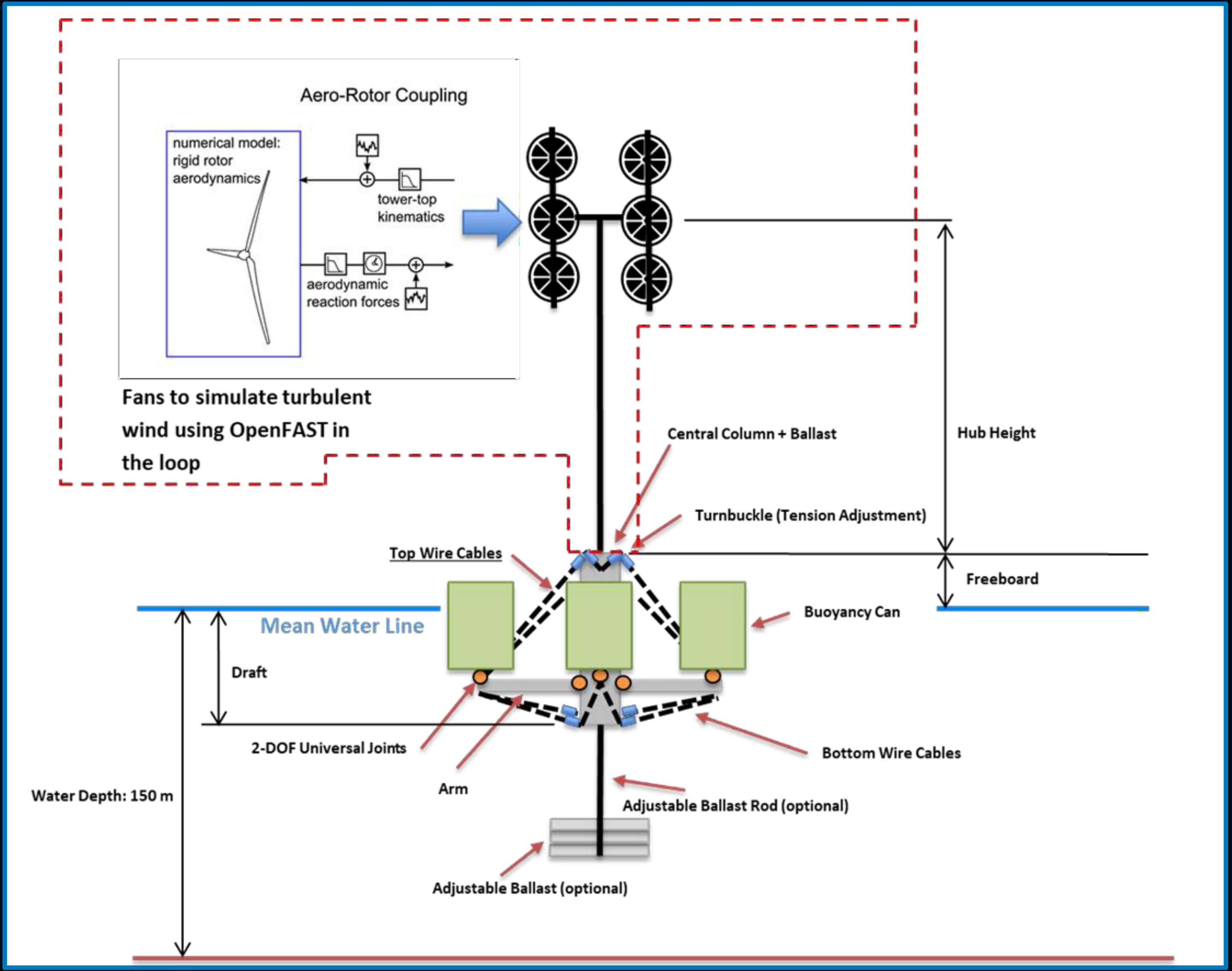
Innovation & Objectives

- ✓ Cost cutting beyond conventional designs:
  - Onsite manufacturing and assembly of pre-constructed modular components at port.
  - Quayside pre-commissioning of substructure to minimize offshore operations.
  - Moment free connections for lower cost substructure design.
  - Material use optimized for purpose.
  - Easily detachable system allowing a wet tow back for maintenance.
  - Minimize transfer of wave induced loads and motion to turbine.
  - Additional savings can be realized in installation and maintenance cost.
- ✓ Cost efficient design to address the nation's target of 35% renewable energy by 2050.



Challenges / Mitigation

- ✓ Design with Unprecedented Flexibility:
  - Must be proven for sea-keeping and reliability.
  - Involve control experts, structural engineers and industry advisors to ensure structural integrity.
  - Perform a wave basin model test to validate sea-keeping response to simulations.
- ✓ Modeling Tools for Dynamic Response:
  - Multibody co-simulation tools with linearization do not exist.
  - Use WEIS developed tools to perform CCD-inspired approach - discovery through simulations and engineering creativity.
- ✓ Innovative Controls for USFLOWT
  - The platform control articulation system needs to provide active actuation.
  - Balance risks of relying on active versus passive control design.



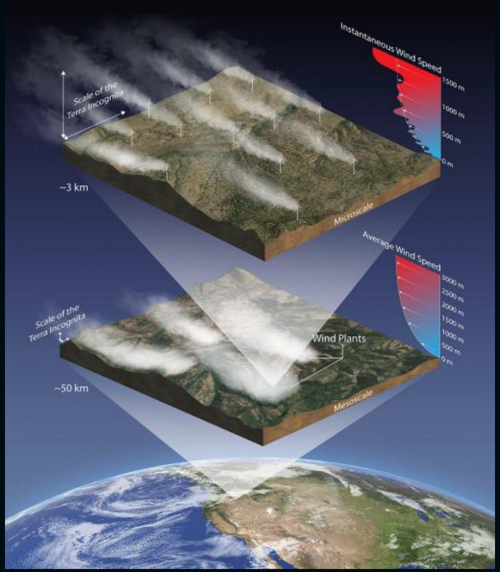
Research Needs (Three Grand Challenges)

[Grand challenges in the science of wind energy](https://science.sciencemag.org/content/366/6464/eaau2027)

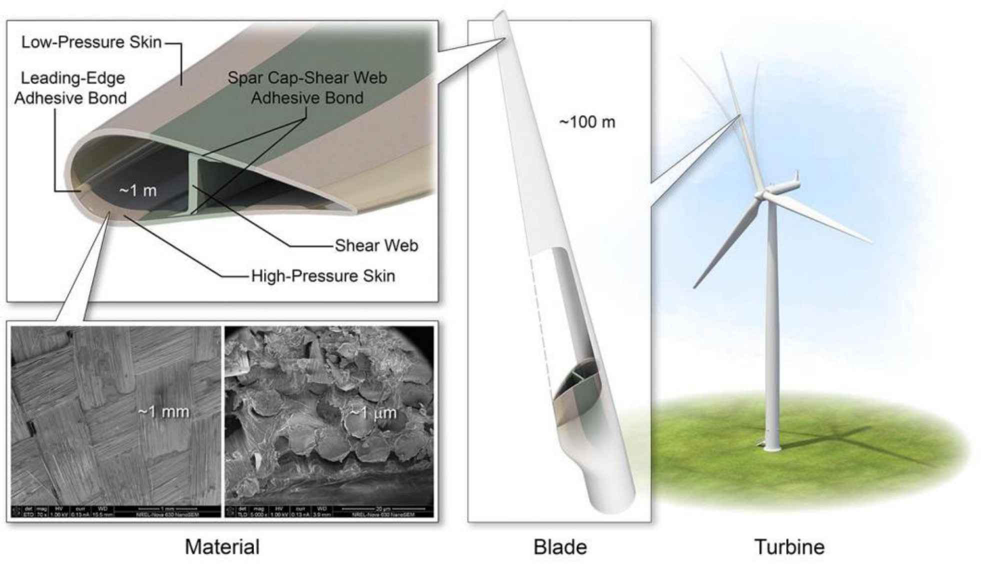
Paul Veers, Katherine Dykes, Eric Lantz, Stephan Barth, Carlo L. Bottasso, Ola Carlson, Andrew Clifton, Johney Green, Peter Green, Hannele Holttinen, Daniel Laird, Ville Lehtomäki, Julie K. Lundquist, James Manwell, Melinda Marquis, Charles Meneveau, Patrick Moriarty, Xabier Munduate, Michael Muskulus, Jonathan Naughton, Lucy Pao, Joshua Paquette, Joachim Peinke, Amy Robertson, Javier Sanz Rodrigo, Anna Maria Sempreviva, J. Charles Smith, Aidan Tuohy and Ryan Wiser

https://science.sciencemag.org/content/366/6464/eaau2027

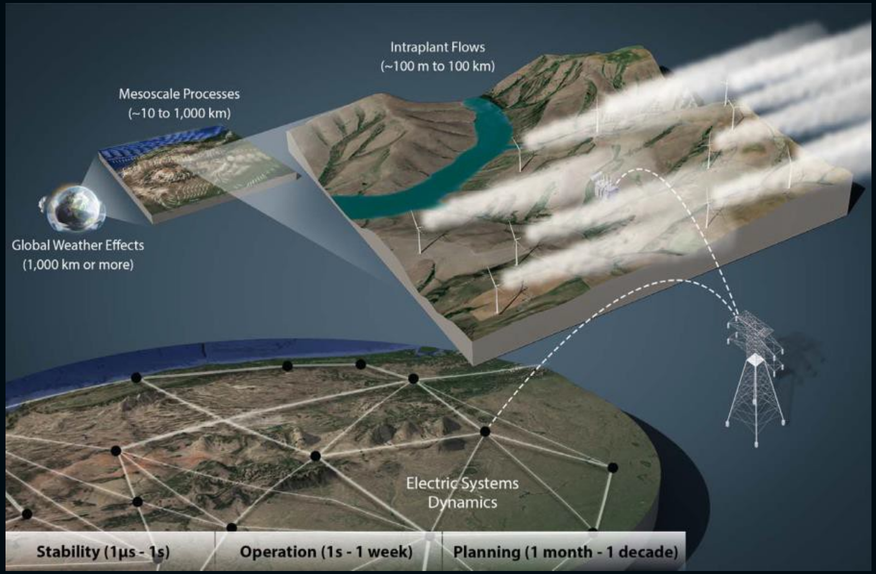
1. Improved understanding of atmospheric and wind power plant flow physics.



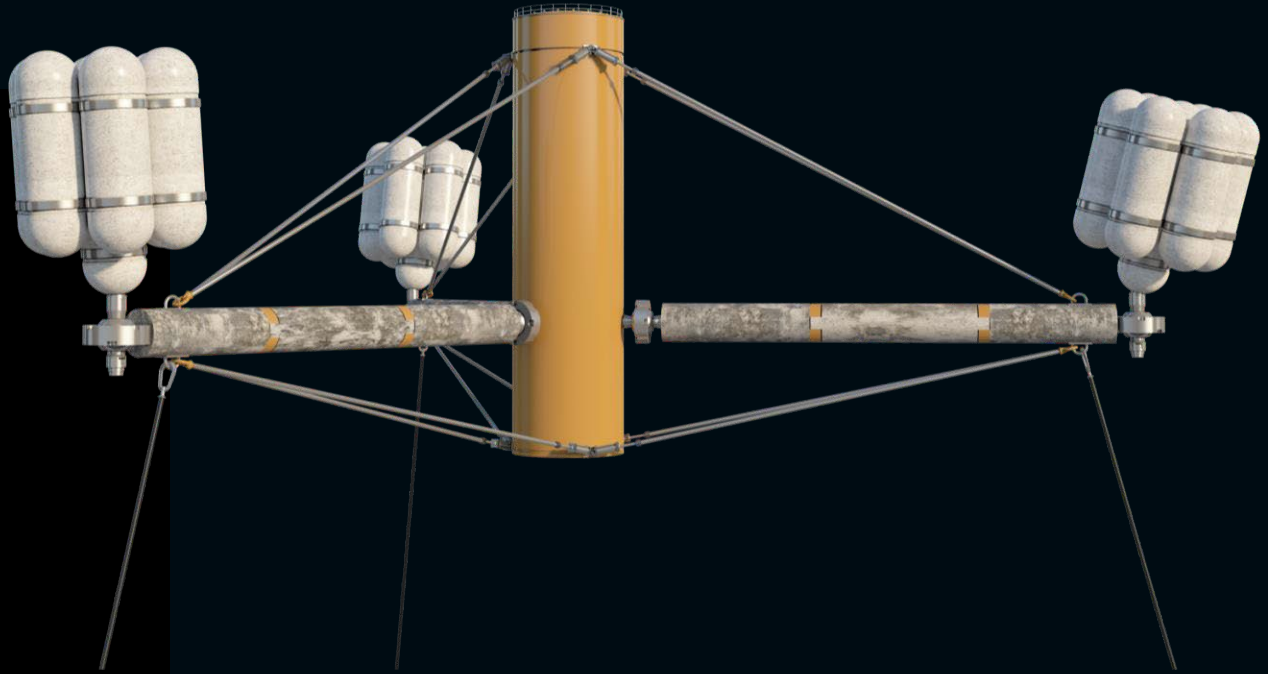
2. Aerodynamics, structural dynamics, and offshore wind hydrodynamics of enlarged wind turbines



3. Systems science for integration of wind power plants into the future electricity grid



Thank You



Senu Sirnivas
senu.sirnivas@nrel.gov

California Energy Commission Floating Offshore Wind Workshop

July 14, 2021

Zack Westgate, PhD, PE
Manager US Offshore Wind, Norwegian Geotechnical Institute
Associate Professor, University of Massachusetts at Amherst

Introduction

- Norwegian Geotechnical Institute
  - Independent international center for research and consultancy
  - Engineering-related geosciences
  - Geotechnical, geological and geophysical expertise

Geotechnics and Environment

Offshore Energy

Natural Hazards

GeoData and Technology

- Transitioning from Manager of Offshore Wind (US) to part-time consultant engineer

Introduction

- University of Massachusetts at Amherst
- Joining as Associate Professor of Civil Engineering
  - Marine geotechnics
  - Foundation design
  - Cable/pipeline-soil interaction
  - Development of marine geotechnical curriculum and related multi-disciplinary programs
- Wind Energy Center (formerly RERL)
  - Oldest wind energy education program in the US
  - Leader in wind energy research

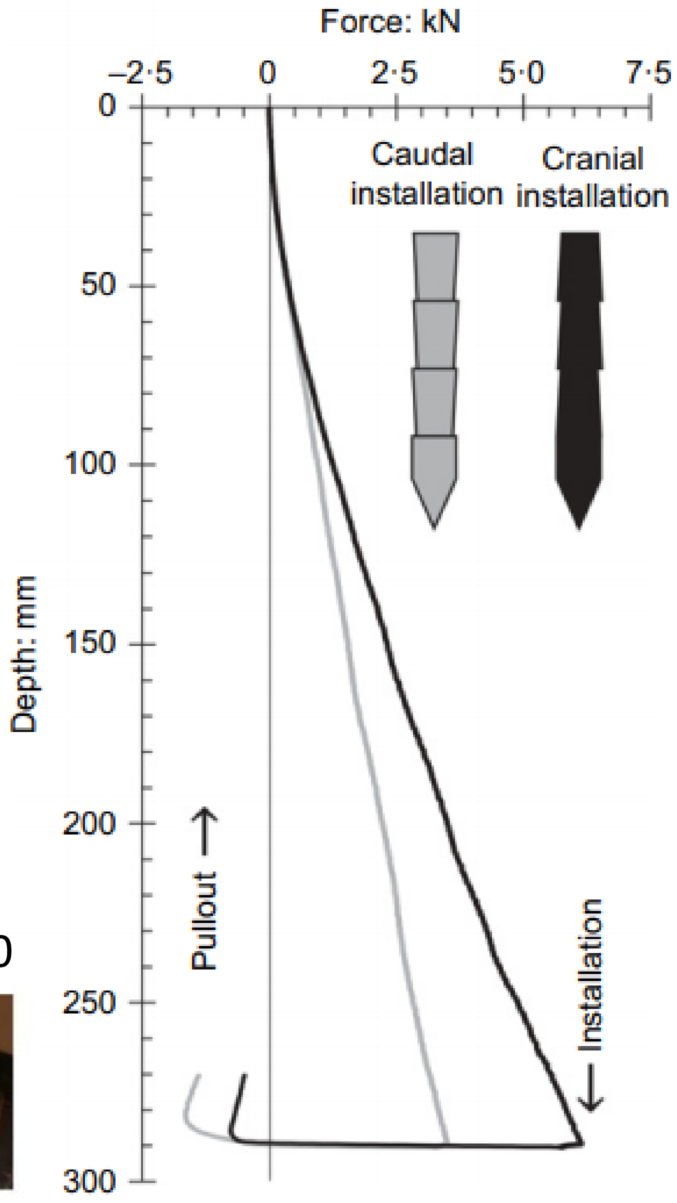
NGI's experience with floating structures

- **Suction anchors** for floating LNG facilities and offshore wind
- **Earthquake-triggered debris flow** impact on anchors for floating bridge projects
- **Multiline anchors** for Hywind Tampen project
- Ankerite JIP lead by NGI with DNV for to develop **drag anchor solutions** in sands and silts

Research and development needs

- Reducing uncertainty and risk:
  - Seismic risk (landslides, debris flow, liquefaction)
  - Shallow geological characterization
  - Shallow gas
  - Trenching feasibility for cables
  - Cable and mooring line-seabed interaction
- Exploring cost reduction opportunities:
  - Intelligent ground modelling
  - Anchor and mooring configurations
  - Novel foundation options
  - Bio-inspired geotechnics

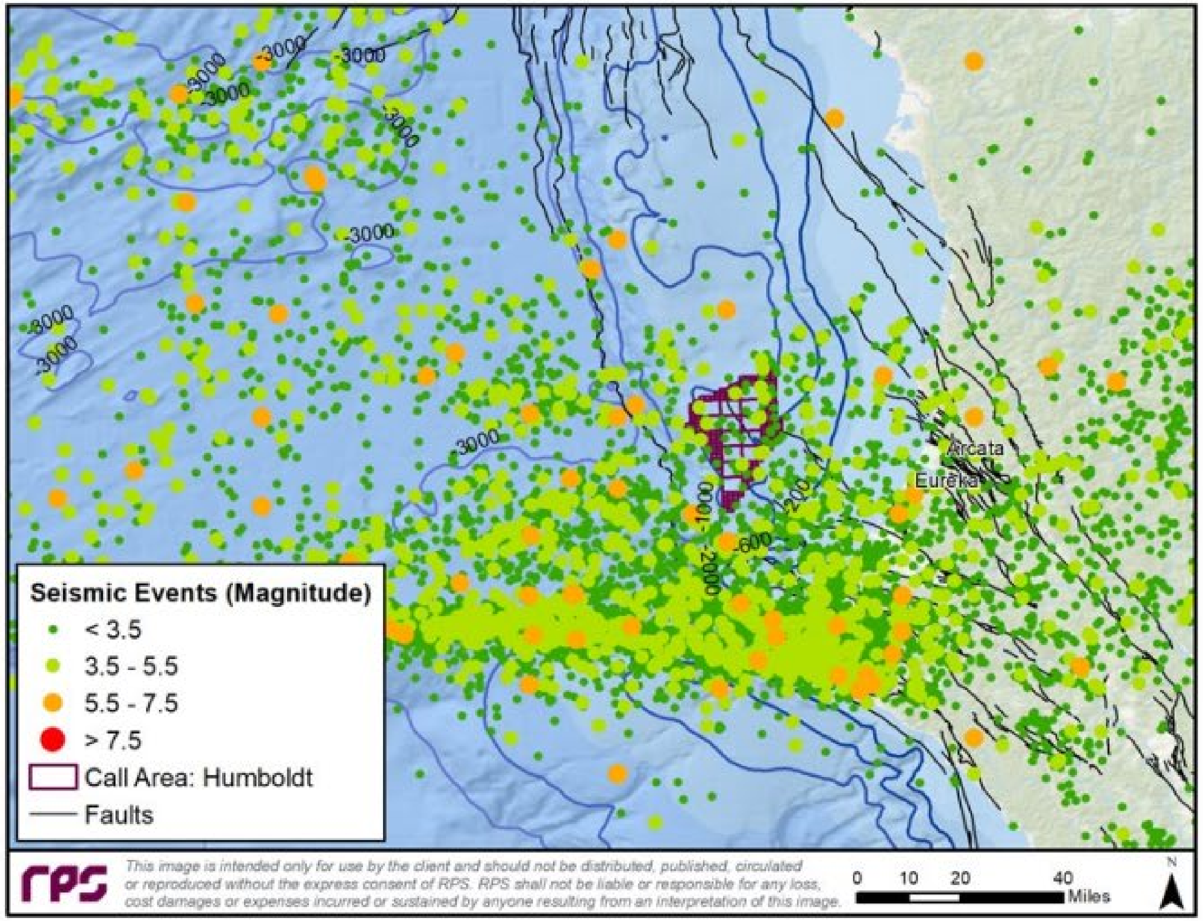
Martinez et al 2020



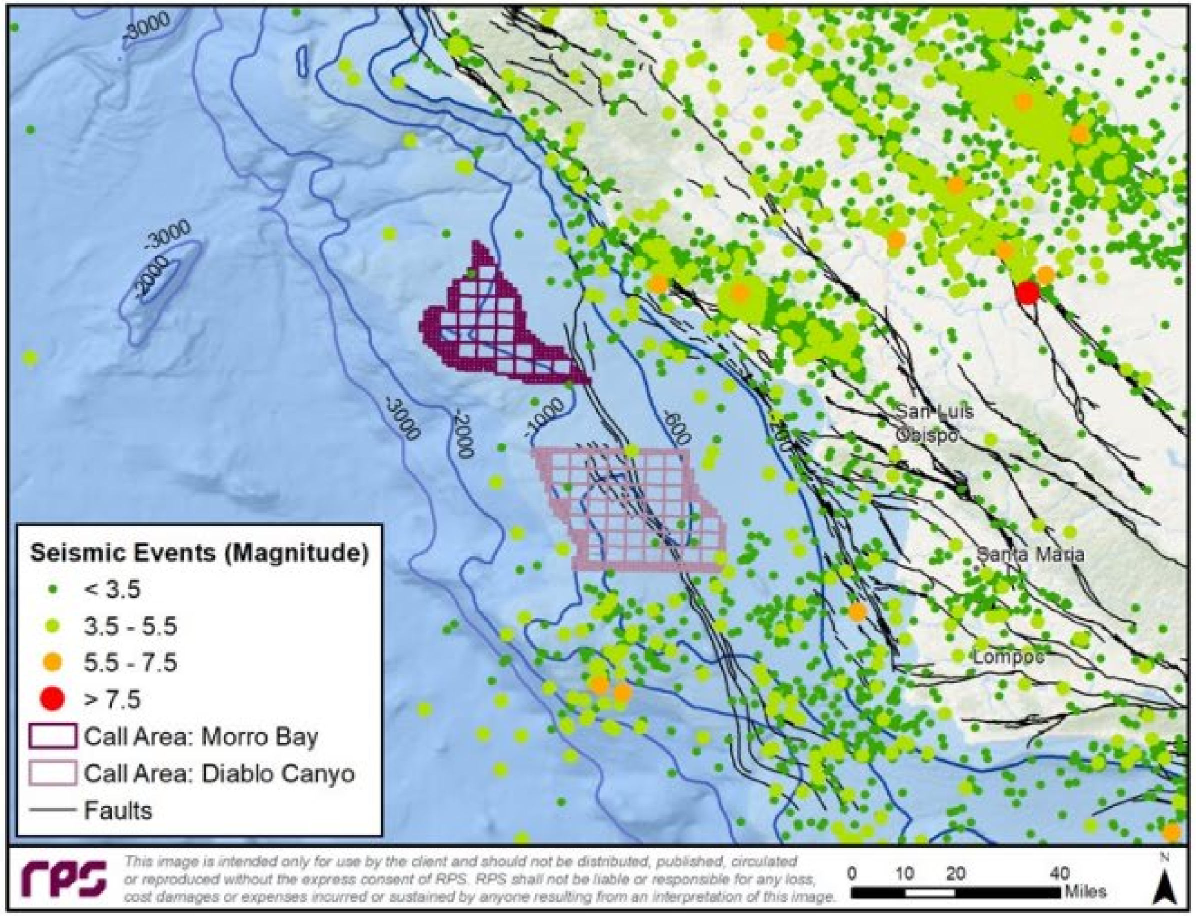
NGI

Seismic hazard

- Humboldt:
  – Cascadia Subduction Zone

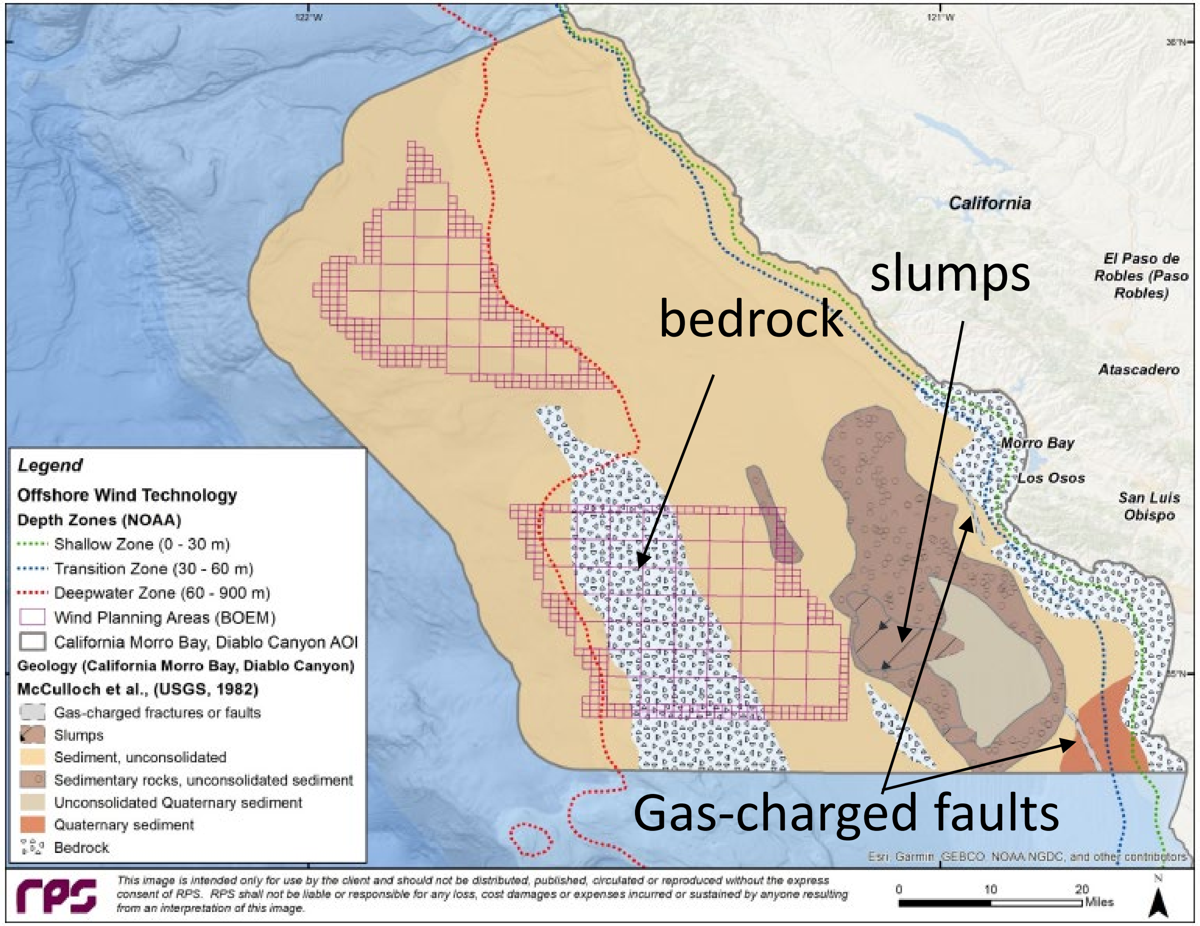


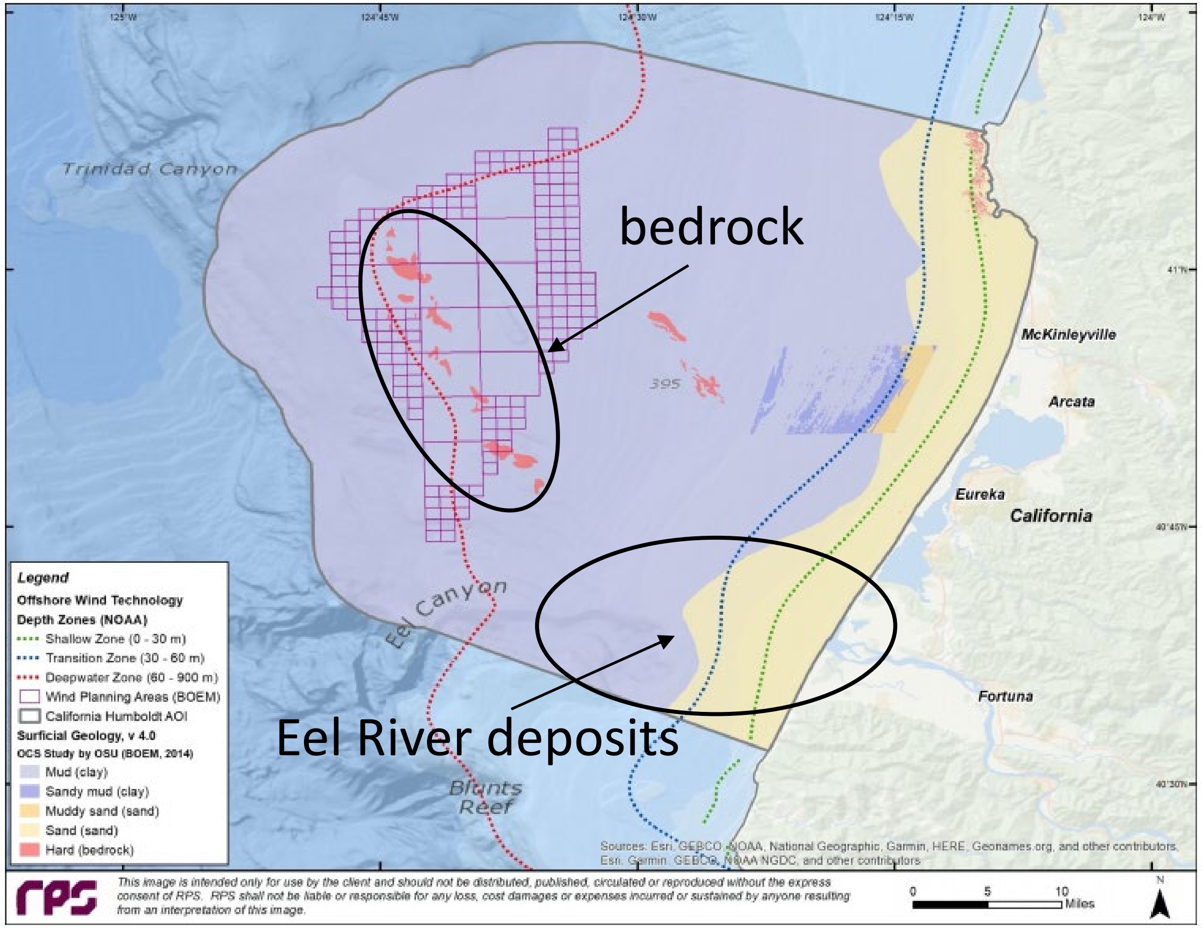
- Morro Bay, Diablo Canyon:
  – San Andreas Fault



Shallow ground conditions

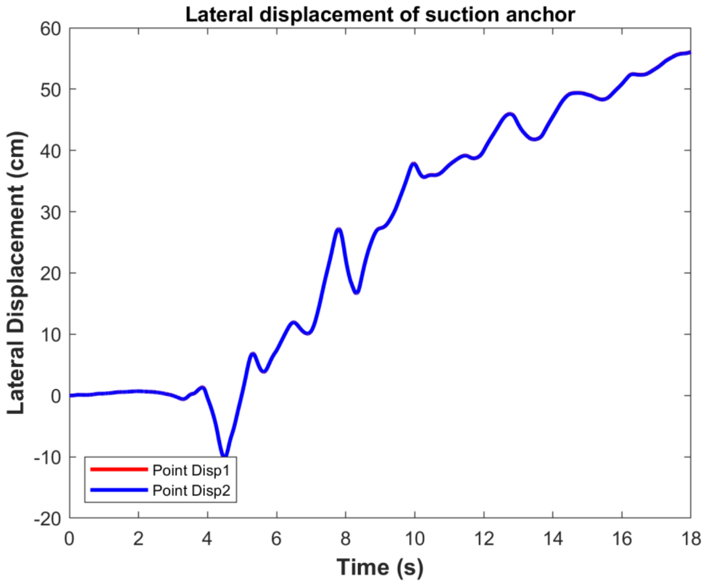
- Sediment distribution (clay, silt, sand, bedrock)
- Tectonic uplift, rapid sedimentation, shallow gas

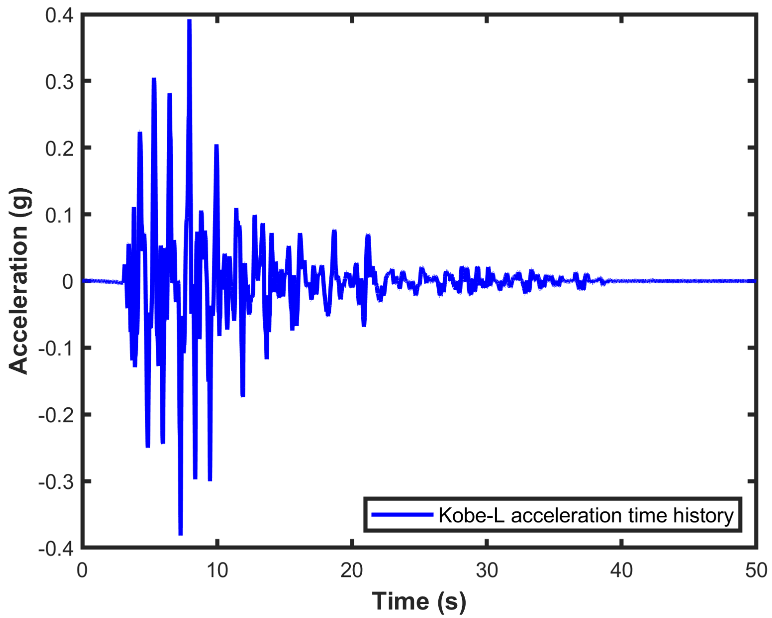


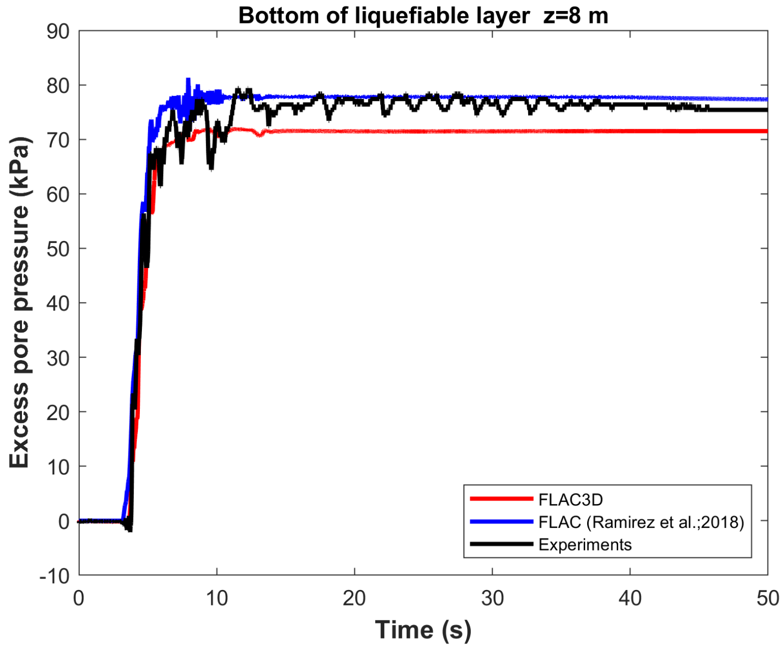


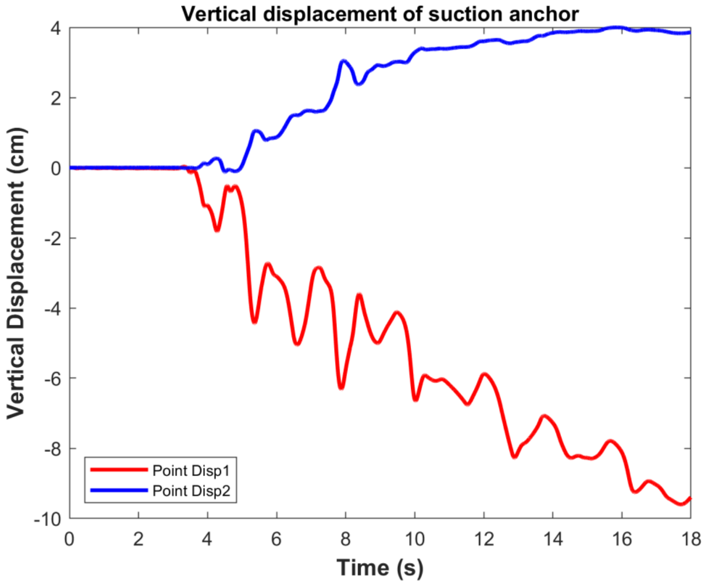
Seismic soil-structure interaction

- Earthquake loading applies ground motions
- Dynamic loading on mooring lines
- Liquefaction of soil
- Permanent foundation displacement









Floating wind foundation options

Suction anchors

Pile anchors

Drag anchors

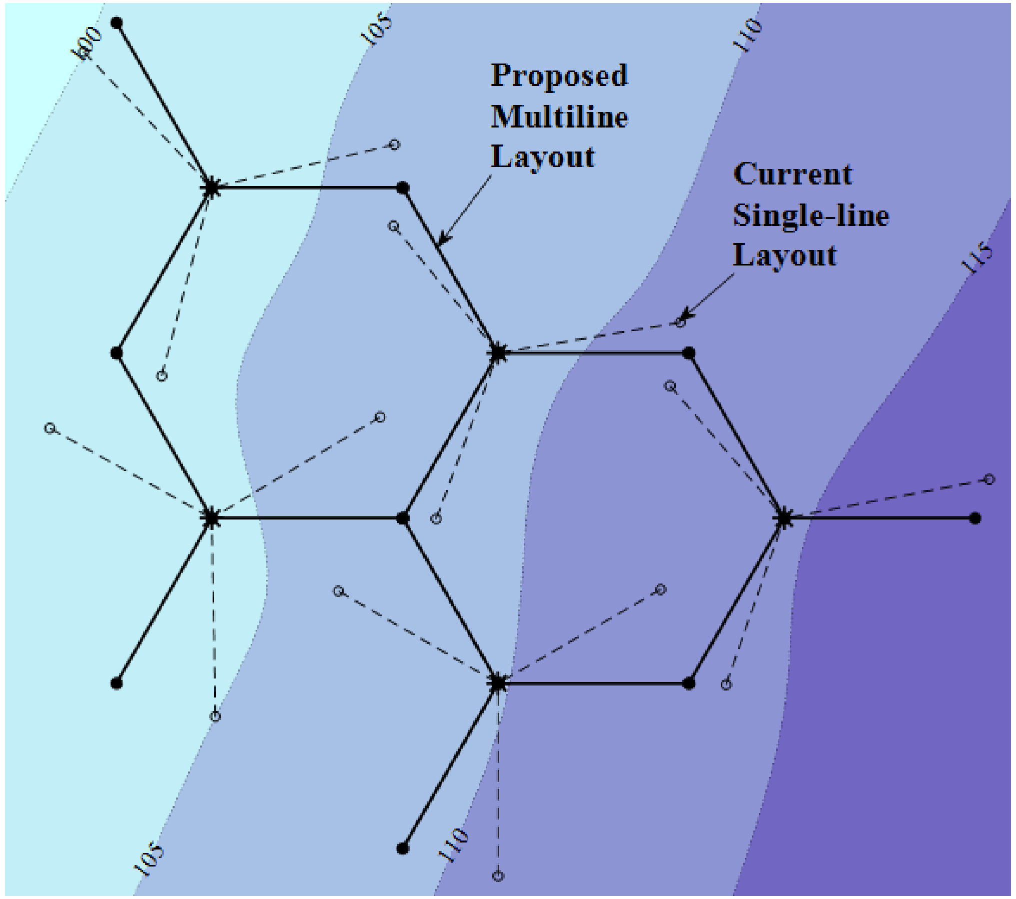
Gravity anchors

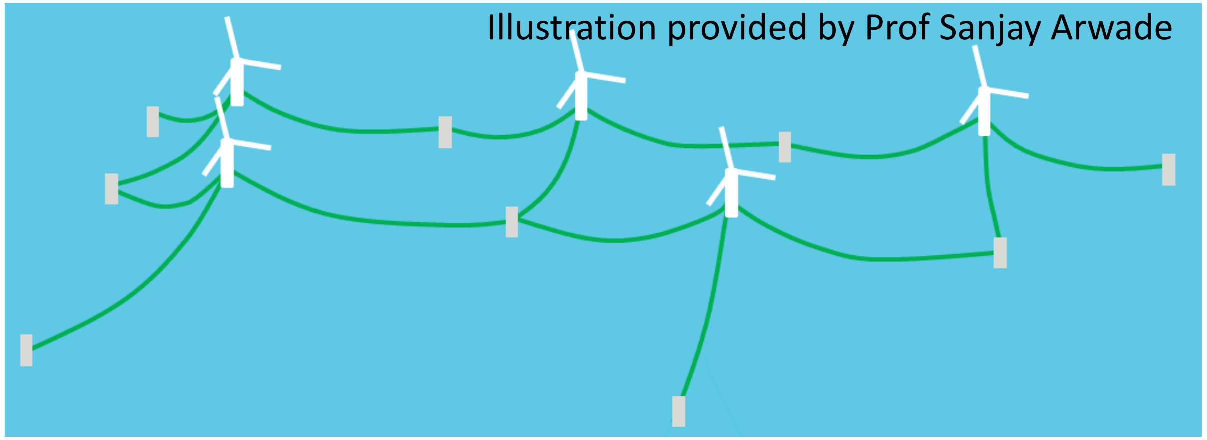
NGI

Optimal solution depends on many factors

Multiline anchoring

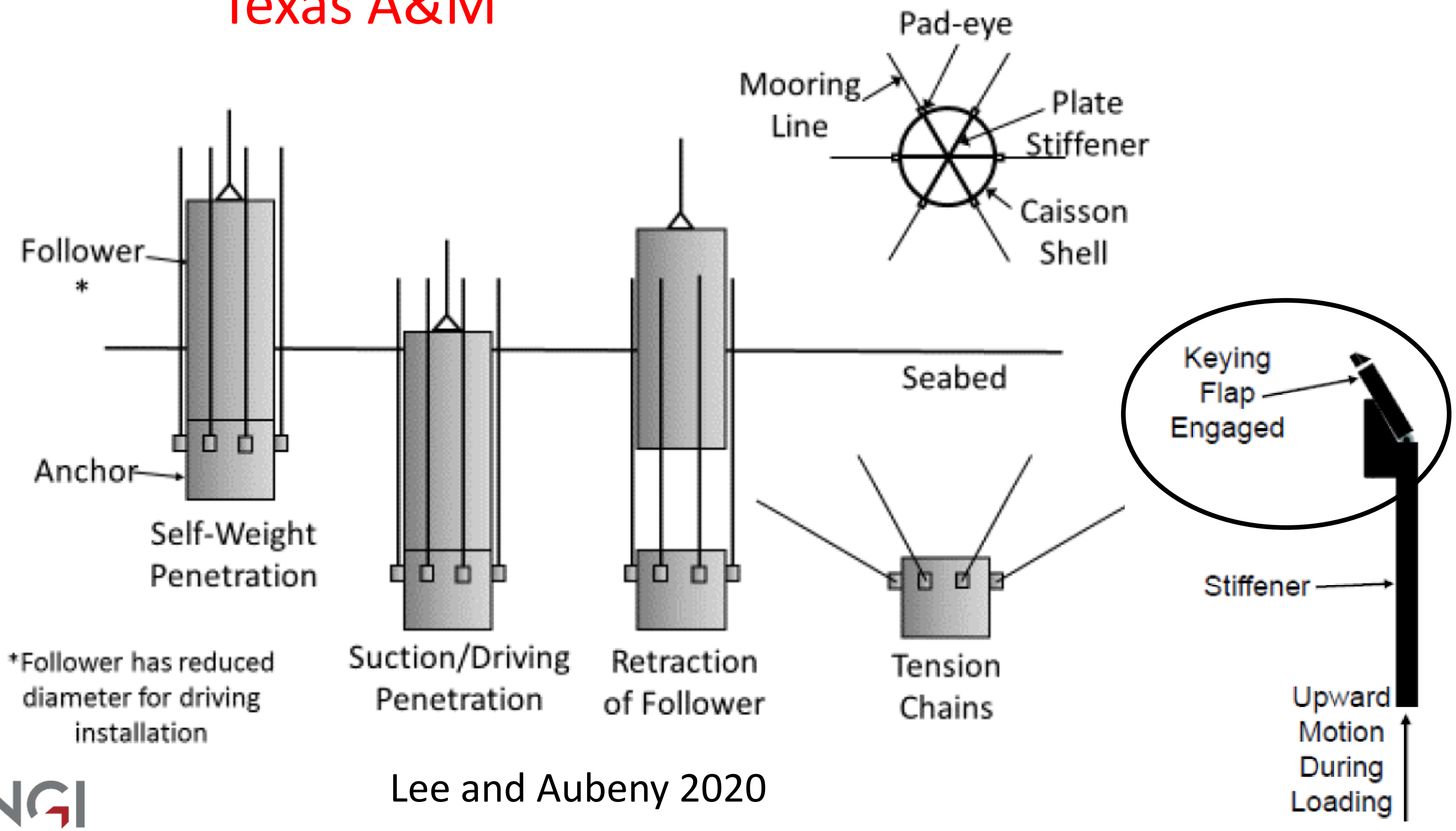
- NSF-funded work at UMass Amherst and Texas A&M
- Study performed on Hywind project with 5 turbines
  - Reduction from 15 to 9 anchors
  - 40% reduction in anchor steel
  - Lower site characterization, material, fabrication, and installation costs
- Multilines being used on Hywind Tampen, and a core focus of future R&D





Multiline anchoring

- NSF-funded work at UMass Amherst and Texas A&M

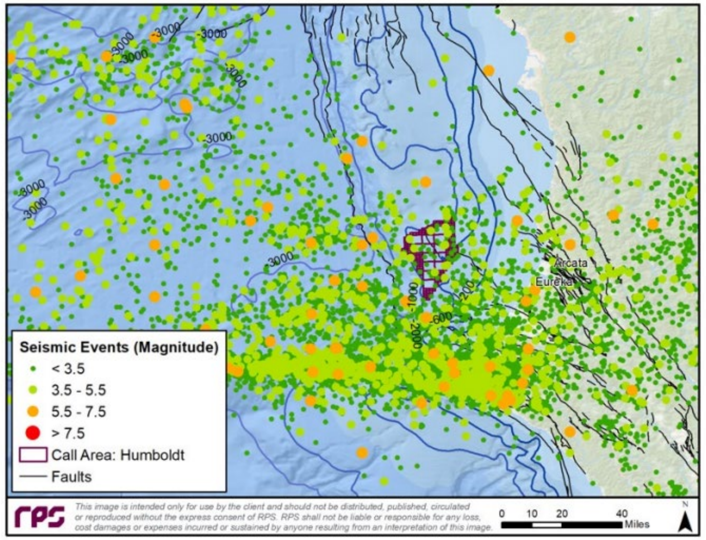


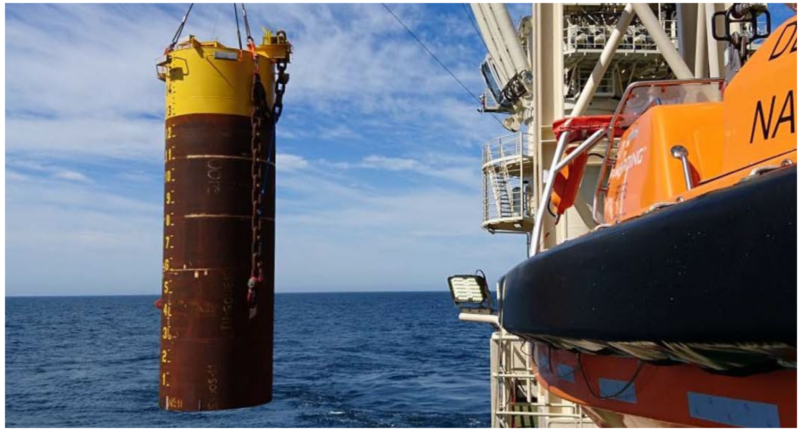
Lee and Aubeny 2020

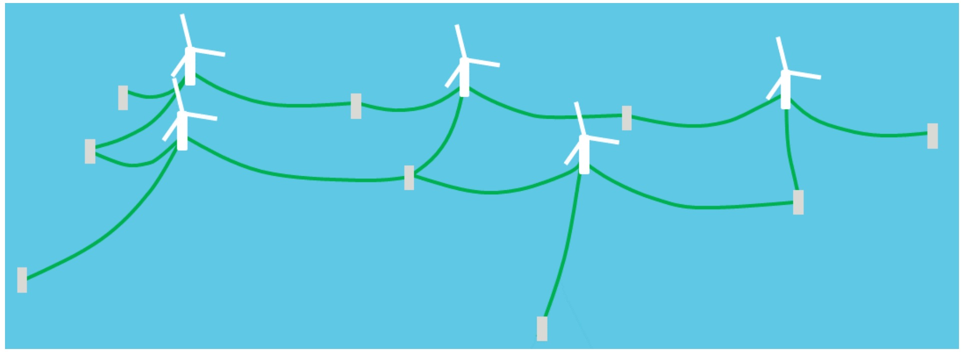
- High reliability
- Low material, fabrication, and handling cost
- High transportation efficiency
- High lateral efficiency (capacity/weight) to suction anchors
- Vertical efficiency can be improved using keying flaps

Summary

- Limited seabed data offshore California
- Known area of high seismicity
- Proven anchoring solutions from the oil & gas industry
- Cost reduction opportunities with multiline anchors
- Further cost reductions from foundation anchor optimization
- Interesting developments in bio-inspired geotechnical solutions







NGI

Session I: Research and Development Opportunities for Floating Offshore Wind

Panel Discussion Questions

1. What technical developments are most critical to early deployment (next 5 to 10 years) of floating offshore wind in California?

2. What specific research needs, or promising innovations, would help address cost reductions?

3. What target performance metrics, other than levelized cost of energy, would you recommend to measure success of floating offshore wind systems?

Workshop Agenda

Time	Item
1:00 PM	Welcome and EPIC 4 Introduction
1:10 PM	**Session I** Research and Development Opportunities for Floating Offshore Wind
2:10 PM	**Session II** Facilitating Early Floating Offshore Wind Deployments in California
3:10 PM	**Session III** Floating Offshore Wind Environmental Impact Assessment and Minimization
4:10 PM	Public Comment
4:30 PM	Adjourn

Session II: Facilitating Early Floating Offshore Wind Deployments in California

Moderator: Eli Harland, CEC

Panelists

A. Adrienne Downey, New York State Energy Research & Development Authority
B. Markus Wernli, WSP
C. Travis Douville, Pacific Northwest National Laboratory

New York's Offshore Wind Program

Adrienne Downey
Principal Engineer, Offshore Wind

CEC Workshop: Offshore Wind Energy R&D Opportunities for EPIC 4
July 14, 2021

NEW YORK STATE OF OPPORTUNITY. | NYSERDA

New York State Clean Energy Goals

now

CLEAN ENERGY ECONOMY
nearly 159,000 clean energy jobs

by 2025

RENEWABLE ENERGY
6,000 MW of distributed solar

RESILIENT and DISTRIBUTED GRID
1,500 MW of energy storage

ENERGY EFFICIENCY
185 TBtu end-use savings
in buildings and industrial facilities

by 2030

RENEWABLE ENERGY/
CLEAN ENERGY STANDARD
70% electricity from renewable energy

GHG REDUCTION
40% reduction in greenhouse
gas emissions from 1990 levels

3,000 MW of energy storage
30,000 employed in storage sector

by 2035

RENEWABLE ENERGY
9,000 MW of offshore wind

by 2040

CLEAN ELECTRICITY
100% zero-emission
electricity

by 2050

GHG REDUCTION
85% reduction in greenhouse
gas emissions from 1990 levels

9,000 MW of offshore wind by 2035

10,000 JOBS

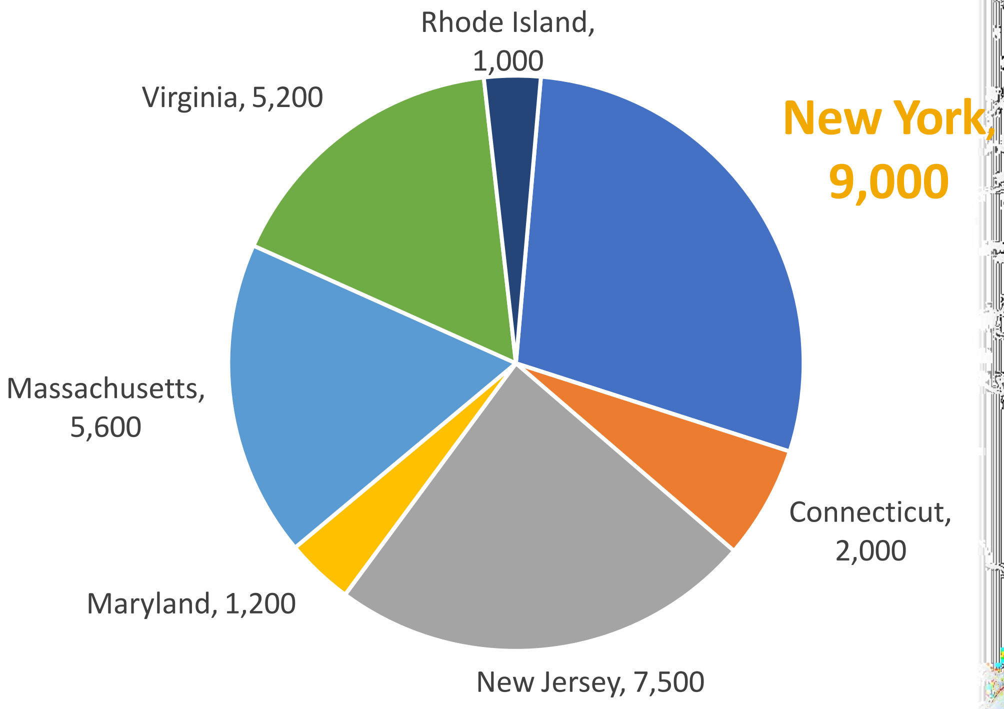
ENOUGH TO POWER
6 MILLION HOMES

BILLIONS IN
INFRASTRUCTURE

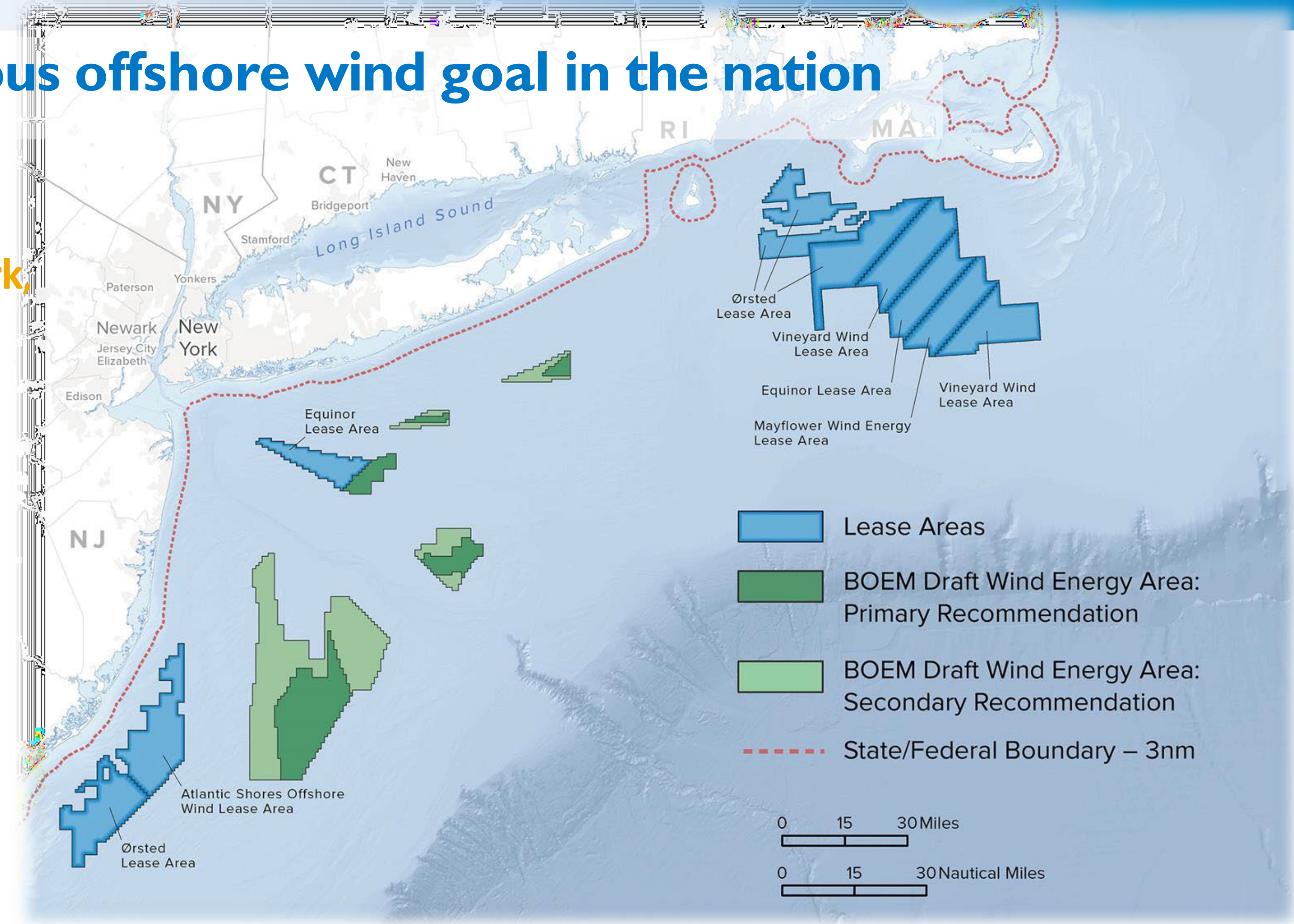
30% OF NEW YORK'S
ELECTRICITY LOAD

Regional OSW Market Potential of ~30 GW

New York has the most ambitious offshore wind goal in the nation



Offshore Wind Goals by State (MW)



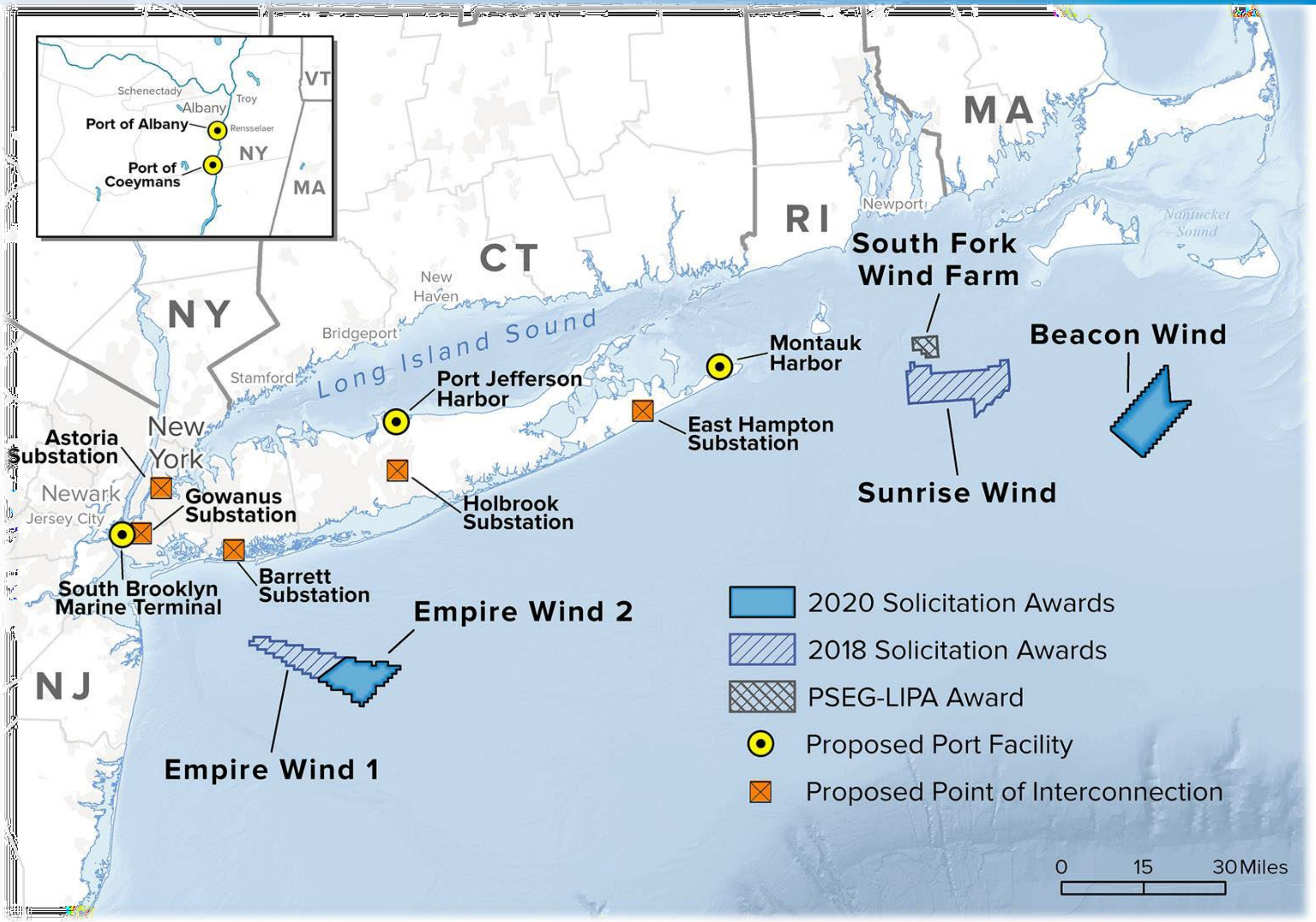
More than 4,300 MW in Active Development

Leading the Nation with Five Projects in Active Development

> More than **6,800** direct jobs

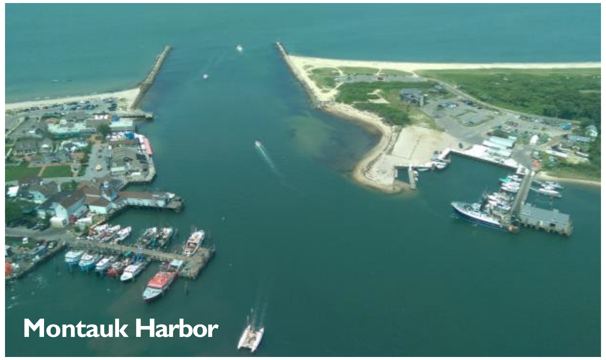
> Combined economic activity of **$12.1 billion** in labor, supplies, development and manufacturing statewide

> **Recent Milestone, March 2021:** The Public Service Commission has approved the export cable landing route for the South Fork Wind Farm, New York's first offshore wind project, as part of New York State's Article VII permitting process.



Port Investments and Supply Chain Growth

- Supported by combined public and private investments of more than **$700 million for port infrastructure**
- Nation's first tower and transition piece **manufacturing** at Port of Albany
- **Fabricating** gravity-based foundations at Port of Coeymans
- State-of-the art **staging** facility at South Brooklyn Marine Terminal (SBMT)
- Regional **operations and maintenance** hubs at SBMT and Port Jefferson, and additional O&M support at Montauk Harbor
- With many additional New York port facilities with potential to support the offshore wind industry, New York is attracting **long-term supply chain investments**

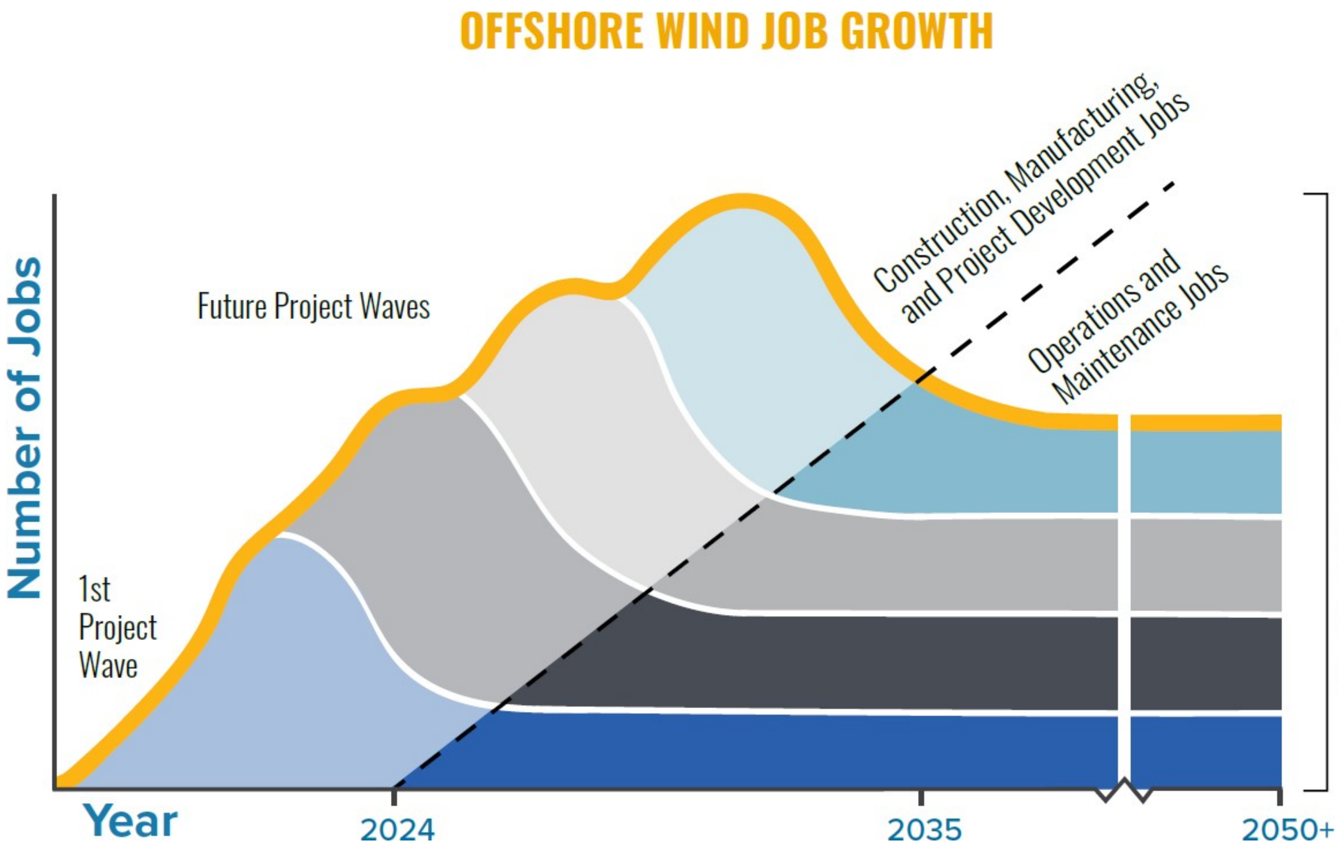


Creating Good-Paying Jobs for New Yorkers

> Prioritizing benefits to Disadvantaged Communities and supply chain opportunities for MWBEs to support the equity goals of the Climate Act

> OSW contracts backed by prevailing wage and supportive of project labor agreements

> **NEW** State requirements to Buy American and for project peace agreements



Building 9,000 megawatts of offshore wind power by 2035 will create more than 10,000 new jobs

Training New York’s Workforce

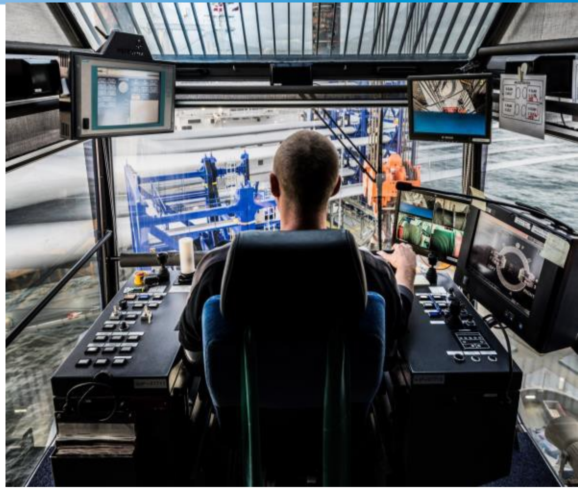
Combined $45 million in public and private Workforce Development commitments

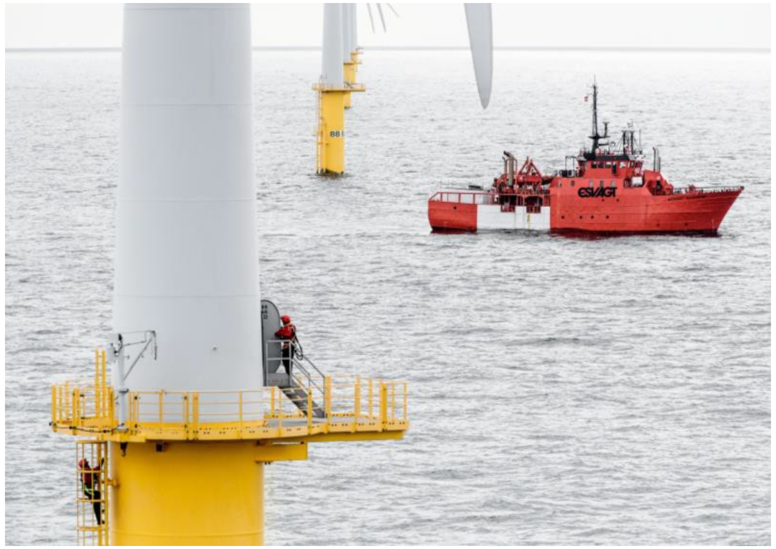
> **$20 million** Offshore Wind Training Institute (OWTI) to educate 2,500 New York workers

> **$10 million** to support training programs through the City University of New York (CUNY)

> **$15 million** in private investments in workforce development, training, and just access funding

> **Building strong partnerships** between the offshore wind industry, academia, labor, and disadvantaged communities and priority populations to build an **inclusive clean energy economy.**





Transmission Planning to Support Clean Energy

As part of the 2020-2021 enacted State Budget, New York State announced passage of the Accelerated Renewable Energy Growth and Community Benefit Act (Act)

> The Act instructs the State to conduct a **Power Grid Study** to inform transmission systems investments that will be necessary to achieve the clean energy goals of the Climate Act.

The New York State Department of Public Service has prepared an initial report of findings and recommendations, published 1/19/2021

New York Power Grid Study

DPS Matter Master: 20-00905/20-E-0197

Distribution and Local Transmission Capital Plans ("Local Upgrade Plans")

Bulk Transmission System Investment Plan ("Investment Plan")

Thank you

Adrienne Downey
Principal Engineer, Offshore Wind
Adrienne.downey@nyserda.ny.gov

nyserda.ny.gov

Follow NYSERDA

Electric Program Investment Charge 2021-2025 Investment Plan Scoping:

Offshore Wind Energy R&D Opportunities for EPIC 4

Markus Wernli

July 14, 2021

WSP Global Overview

70

$8B

Net revenue

54,000

Staff

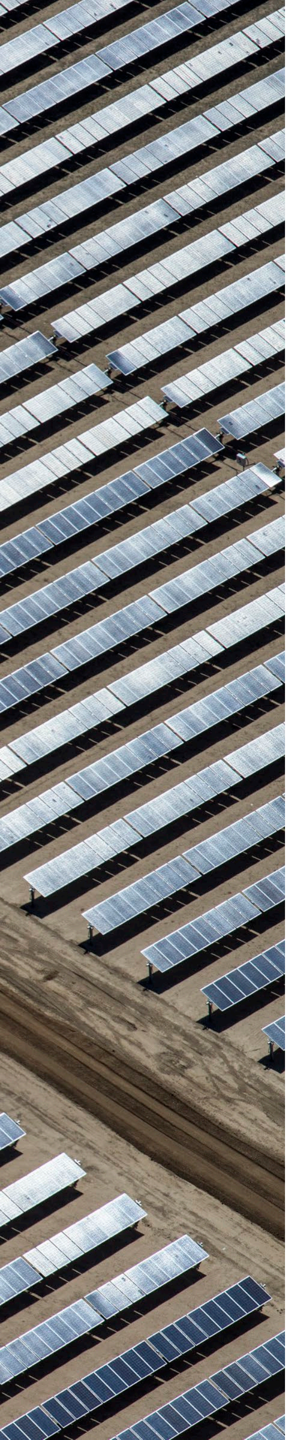
Over **500** offices

in **50** countries

in **6** continents

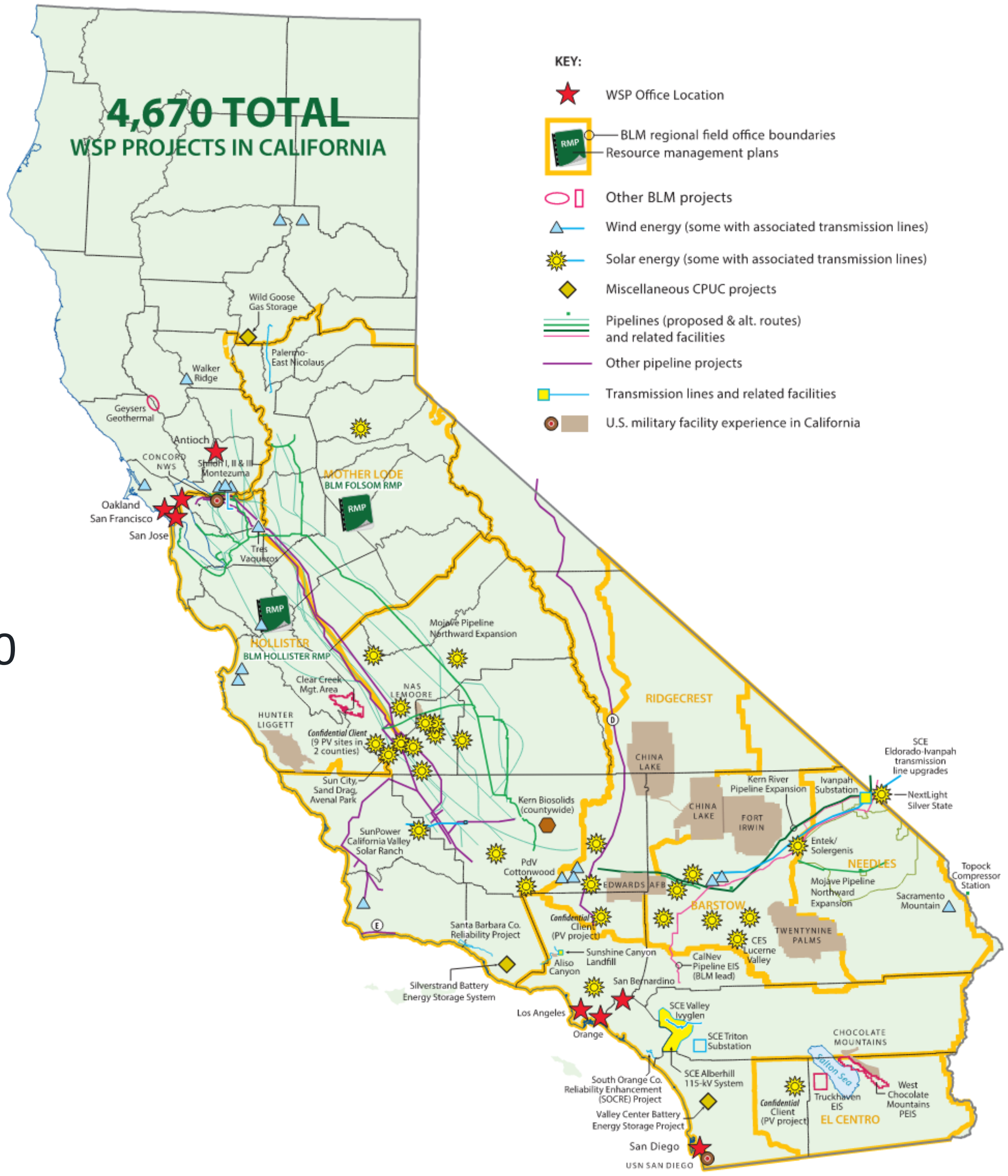
Business Sectors

- Earth & Environment
- Transportation & Infrastructu
- Property & Buildings
- Power & Energy
- Resources
- Industry



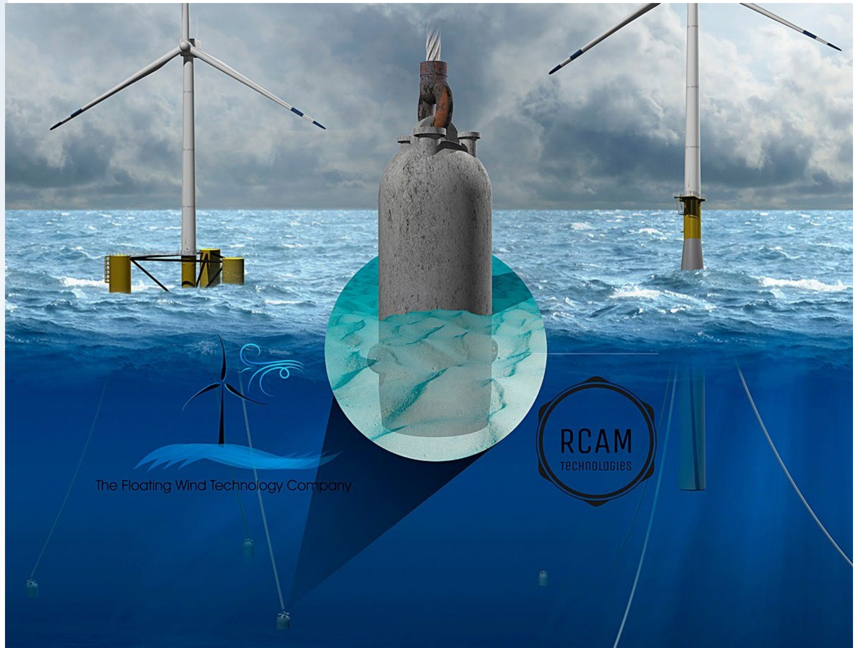
WSP in California

- 11 Offices in California
- Projects in transportation, urban planning and design, bridges, buildings, port facilities, and renewable energy
- Renewable energy projects in over 10 California counties
- Maritime services provided to all major public ports and Navy stations in California
- High-speed rail
- Participation in CEC funded R&D



Offshore Wind Foundation Design Experience

- Hull for New England Aqua Ventus Floating Offshore Wind Demonstration Turbine (NEAV)
- Conceptual Suction Pile Support Structure for 15-MW Offshore Wind Turbines (RCAM/NOWRDC)
- 3D Concrete Printed Suction Anchors for Floating Offshore Wind (RCAM/NSF)
- Monopile foundations for Vineyard Wind (Orsted)



wsp

Offshore Wind Fabrication Yard Identification and Planning Experience

- New Jersey Wind Port (NJEDA)
- Hypothetical 500-MW floating offshore wind park fabrication and assembly study for East and West Coast (confidential client)
- Concept study for fabrication, assembly, and deployment of 15-MW float-in wind turbines for 1000 MW offshore wind park (NOWRDC/RCAM)
- Preliminary site searches for fabrication and assembly of floating and float-in offshore wind turbines at East and West coast (confidential clients)

wsp

Challenges to Floating Offshore Wind Construction

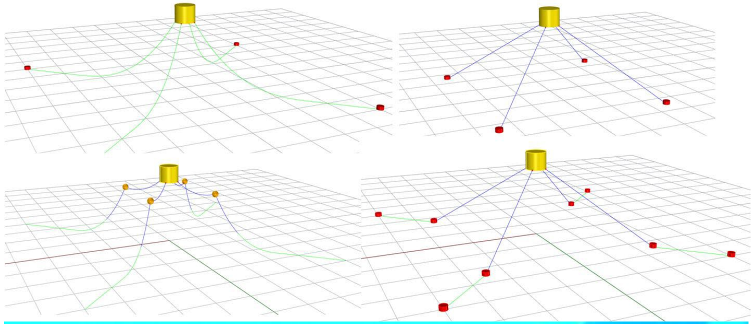
- Deep water
  - *Anchorage*
  - *Dynamic cable*
- Remoteness of Developments from major ports facilities
- Build-up of supply chain and work force
- Mass fabrication of large components
- Transportation, lifting, and support vessels (Jones Act)
- Final assembly and marshalling facility with high-capacity wharf, deep water channel, and no air restriction

Opportunities for Floating Offshore Wind Construction

- Job creation – local content through engagement of local fabricators
- Existing concrete and steel fabrication industry in California
- New industrial development in regions most affected by offshore wind
- Integration of energy storage in offshore wind (green hydrogen/pumped hydro storage)
- Build-up of local knowhow and technology

R&D Needs

- Infrastructure
  - *Fabrication and assembly studies*
  - *Ports infrastructure studies*
  - *Maintenance and training facilities*
  - *Grid Integration/energy storage*
  - *Floating offshore substations*
- Floating Wind Turbine Technology
  - *Dynamic cables*
  - *Mooring systems for deep water*
  - *Advanced Fabrication Technologies*
  - *Bathymetry and Ocean Soil Studies*
  - *Prototype turbines and turbine arrays*
- Environmental Impact
  - *Marine life*
  - *Bird migration*
- Economic Impact
  - *Supply chain, transportation, and workforce development*
  - *Impact on fishing and maritime industry*
  - *Stakeholder identification and involvement*



Contact Information

Markus Wernli Ph.D, PE, LEED AP
Assistant Vice President, Technical Fellow
Maritime Division, WSP

Phone: +1 206 431 2262
Email: markus.wernli@wsp.com

Pacific Northwest
NATIONAL LABORATORY

Offshore Wind Energy Systems Integration

CEC EPIC 4 Workshop

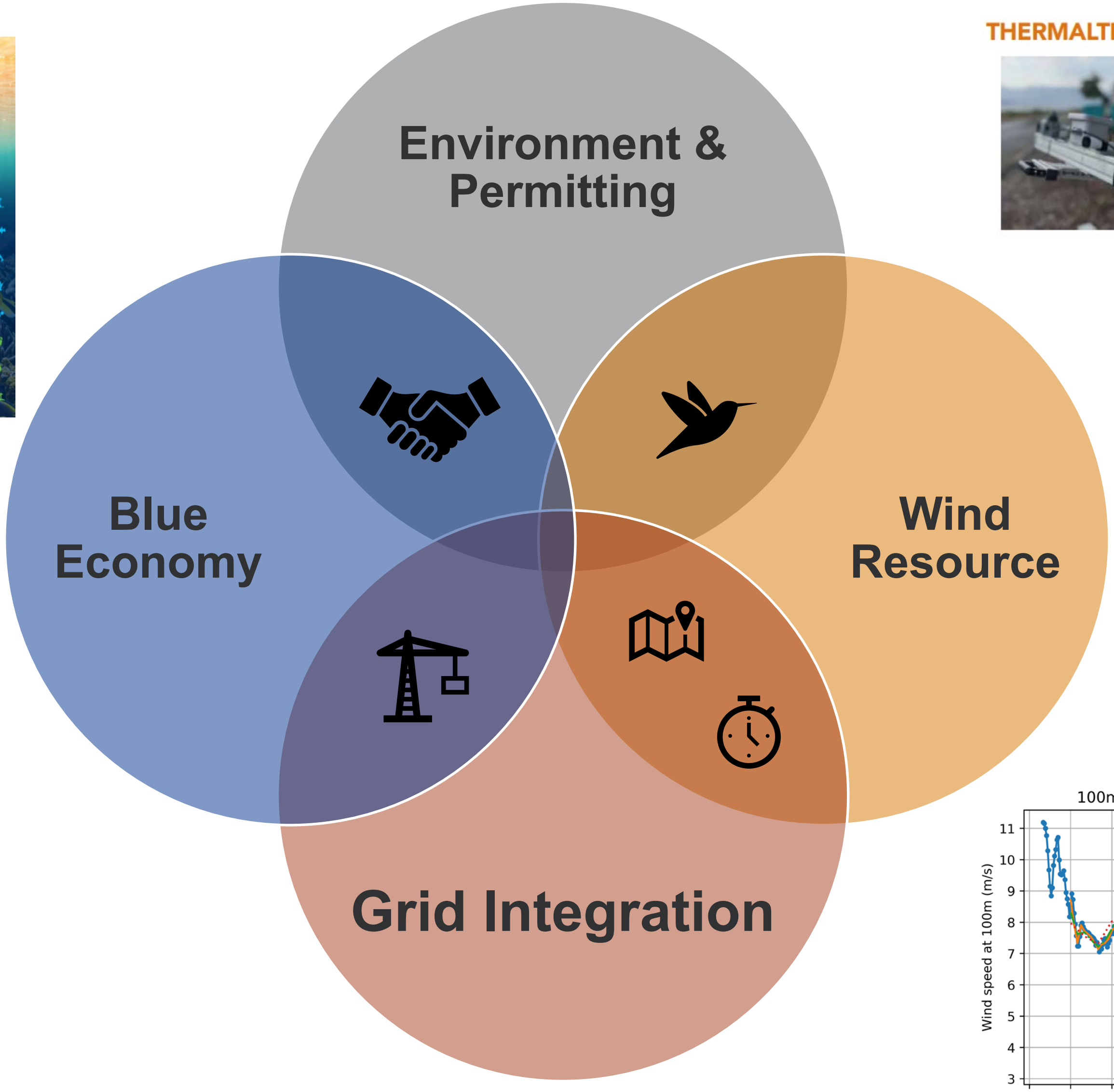
July 14, 2021

Travis C. Douville, PE

U.S. DEPARTMENT OF ENERGY BATTELLE

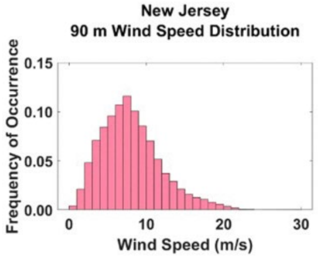
PNNL is operated by Battelle for the U.S. Department of Energy

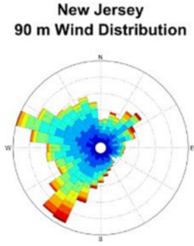
Multi-disciplinary OSW research competencies



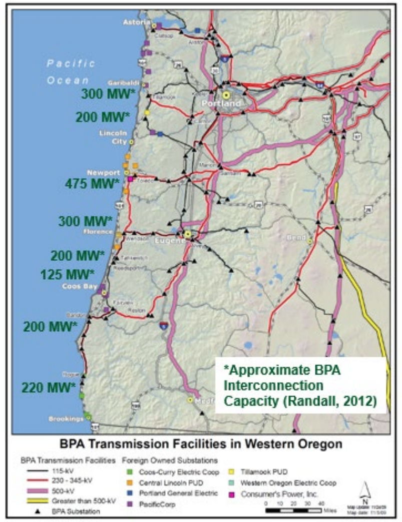
THERMALTRACKER-3D

DOE buoy off Morro Bay, CA

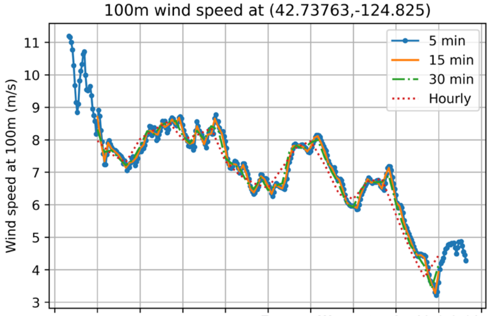




Sheridan et al. (2020)

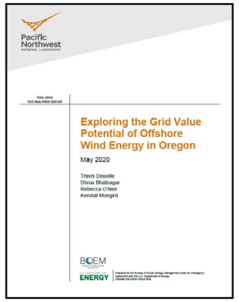


Pacific Energy Ventures (2009)



Douville et al. (2020)

Oregon OSW grid value (BOEM 2020-026)

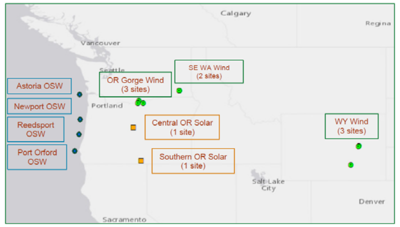


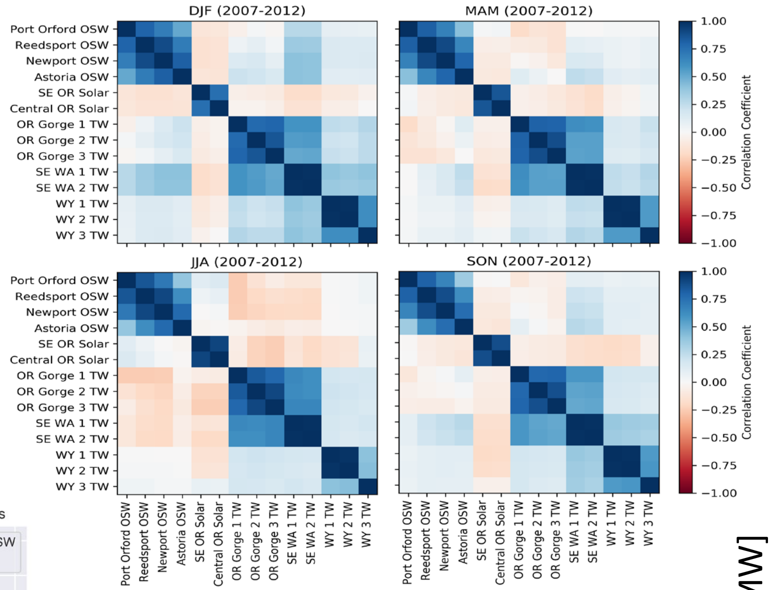
Key Findings

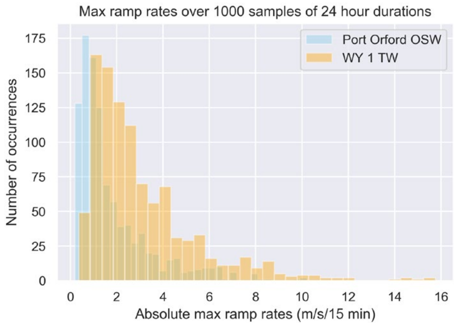
1. Regional transmission may carry 2-3GW of Offshore Wind (OSW) with minimal transmission investment and power export.
2. OSW power flows relieve historic E-W transmission flows, serving coastal loads & freeing transmission for new generation.
3. OSW complements regional hydropower, onshore wind, and solar energy resources.

OR HB3375: 3GW by 2030 Target

VRE Study





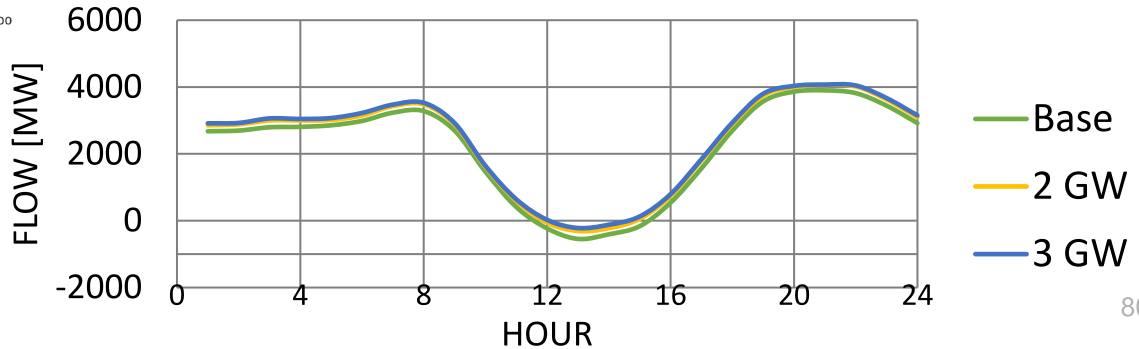


Sub-hourly ramp rates
OSW indicates less extreme ramp rates than energetic Wyoming wind.

Production Cost Modeling

Total OSW Penetration	Curtailment (%)			
	Port Orford	Reedsport	Newport	Astoria
1 GW	0.2	0.1	0.0	0.1
2 GW	2.0	7.2	0.2	3.1
3 GW	20.5	28.1	10.3	14.6
4 GW	36.8	42.2	26.1	30.1
5 GW	47.3	51.5	37.3	40.9

+ S into CA

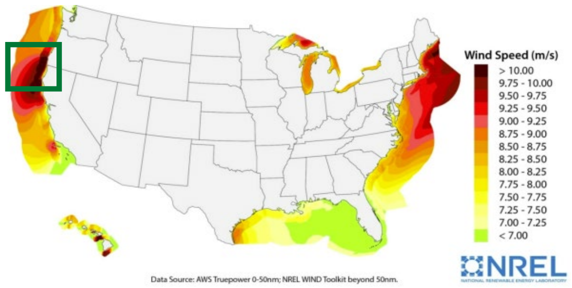


Extension of work by NOWRDC[1]

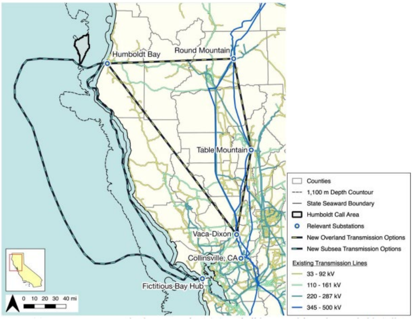
NOWRDC Solicitation 1.0 Award:

An Offshore Wind Energy Development Strategy to Maximize Electrical System Benefits in Southern Oregon and Northern California

- 18-month effort
- Optimization of generation footprint for system value
- Evaluation of three conceptual transmission scenarios
- Guided by an Industry Advisory Board
- Extension in-work to evaluate Bay Area power flows



Musial, et. al (2016)



Severy, et. al (2020)

Capabilities to deploy:

- Customized dispatch modelling
- Resource adequacy estimation
- Large-scale HVDC and MTDC Modeling
- Low-frequency AC transmission design
- Energy storage co-location
- Real-time path rating
- Hybrid EMT-TS[2] simulations
- Remedial Action Schemes
- Deferrable Loads Feasibility

[1] *National Offshore Wind Research and Development Consortium*

[2] *EMT-TS: Electromagnetic transient-electromechanical transient stability*

Grid integration research needs

System OSW dispatch and power flow analyses

- Key transmission flow gates
- Utility of operational transmission strategies
- Focused, near-term studies to aid transmission planning considerations
- Evaluation of constraints from generation all the way to load centers
- Feasibility of deferring transmission investments through storage or deferrable loads

Capacity valuation

- Regional generation mix
- Clean energy policies
- Variability of hydro production
- Complementarity with projections of generation and load

Resilience valuation

- Wildfires
- Regional heat waves
- Reinforcing coastal grids

Port infrastructure research needs

<u>Integrated, State-wide Planning for Ports and Supply Chain</u>

- Multi-port strategies
  - How can multiple ports be used to create an economically efficient supply chain to deliver OSW components across the state?
  - E.g. Some ports built for cargo may not have sufficient ground carrying capacity for OSW components
- Multi-use port strategies
  - How to leverage turbine shipping, manufacturing, and towing infrastructure for other purposes
  - How can OSW support and initiate port electrification

<u>Understanding Navigational Constraints in California</u>

- Channel widths to support towing of floating turbines are a key parameter
  - Future turbine and substructure growth may exceed navigational width of existing channels
  - Widening channels requires a lengthy approval and permitting process
- Tow distance and service port envelope studies
  - Develop understanding of which ports can serve different OSW locations
    - Can central and northern California ports work together to provide complementary support and service to the same OSW farms?

References

Douville T, Bhatnagar D, O'Neil R, and Mongird K. 2020. *Exploring the Grid Value Potential of Offshore Wind Energy in Oregon*. PNNL-29935, Pacific Northwest National Laboratory, Richland, Washington. Available at: https://www.pnnl.gov/main/publications/external/technical_reports/PNNL-29935.pdf

Musial W, D Heimiller, P Beiter, G Scott, and C Draxl. 2016. *2016 Offshore Wind Energy Resource Assessment for the United States* (Technical Report). Golden, CO: National Renewable Energy Laboratory. NREL/TP-5000-66599. Available at http://www.nrel.gov/docs/fy16osti/66599.pdf

Pacific Energy Ventures. (2009). Utility Market Initiative: Integrating Oregon Wave Energy into the Northwest Power Grid. Oregon Wave Energy Trust.

Randall, C. (2012). Generation Interconnection to BPA's Transmission System on the Oregon Coast.

Sheridan L, Krishnamurthy R, Gorton A, Shaw W, and Newsom, J. 2020. "Validation of reanalysis-based offshore wind resource characterization using lidar buoy observations." *Marine Technology Society Journal* 54(6).

Severy, Z. Alva, G. Chapman, M. Cheli, T. Garcia, C. Ortega, N. Salas, A. Younes, J. Zoellick, & A. Jacobson (Eds.) California North Coast Offshore Wind Studies. Humboldt, CA: Schatz Energy Research Center. schatzcenter.org/pubs/2020-OSW-R4.pdf

Thank you

Session II: Facilitating Early Floating Offshore Wind Deployments in California

Panel Discussion Questions

1. What are some research opportunities for advancing floating offshore wind energy to accelerate the transition to clean energy?

2. What innovations would help the offshore wind industry capitalize on its complementary generation profile with solar?

3. What does the grid of the future look like and what are key challenges to grid integration and transmission that can be addressed through research?

Workshop Agenda

Time	Item
1:00 PM	Welcome and EPIC 4 Introduction
1:10 PM	**Session I** Research and Development Opportunities for Floating Offshore Wind
2:10 PM	**Session II** Facilitating Early Floating Offshore Wind Deployments in California
3:10 PM	**Session III** Floating Offshore Wind Environmental Impact Assessment and Minimization
4:10 PM	Public Comment
4:30 PM	Adjourn

EPIC 4 Offshore Wind Energy R&D Workshop

Session III: Floating Offshore Wind Environmental Impact Assessment and Minimization

Moderator: David Stoms CEC

Panelists

A. Kristen Hislop, Environmental Defense Center/Pacific Offshore Wind Energy Research
B. Jim Lanard, Magellan Wind/Pacific Offshore Wind Energy Research
C. Justine Kimball, Ocean Protection Council

Floating Offshore Wind Environmental Impact Assessment and Minimization

July 14, 2021

California Energy Commission Workshop: Electric Program Investment Charge: 2021-2025 (EPIC 4) Investment Plan Scoping: Offshore Wind Energy R&D Opportunities for EPIC 4

Kristen Hislop

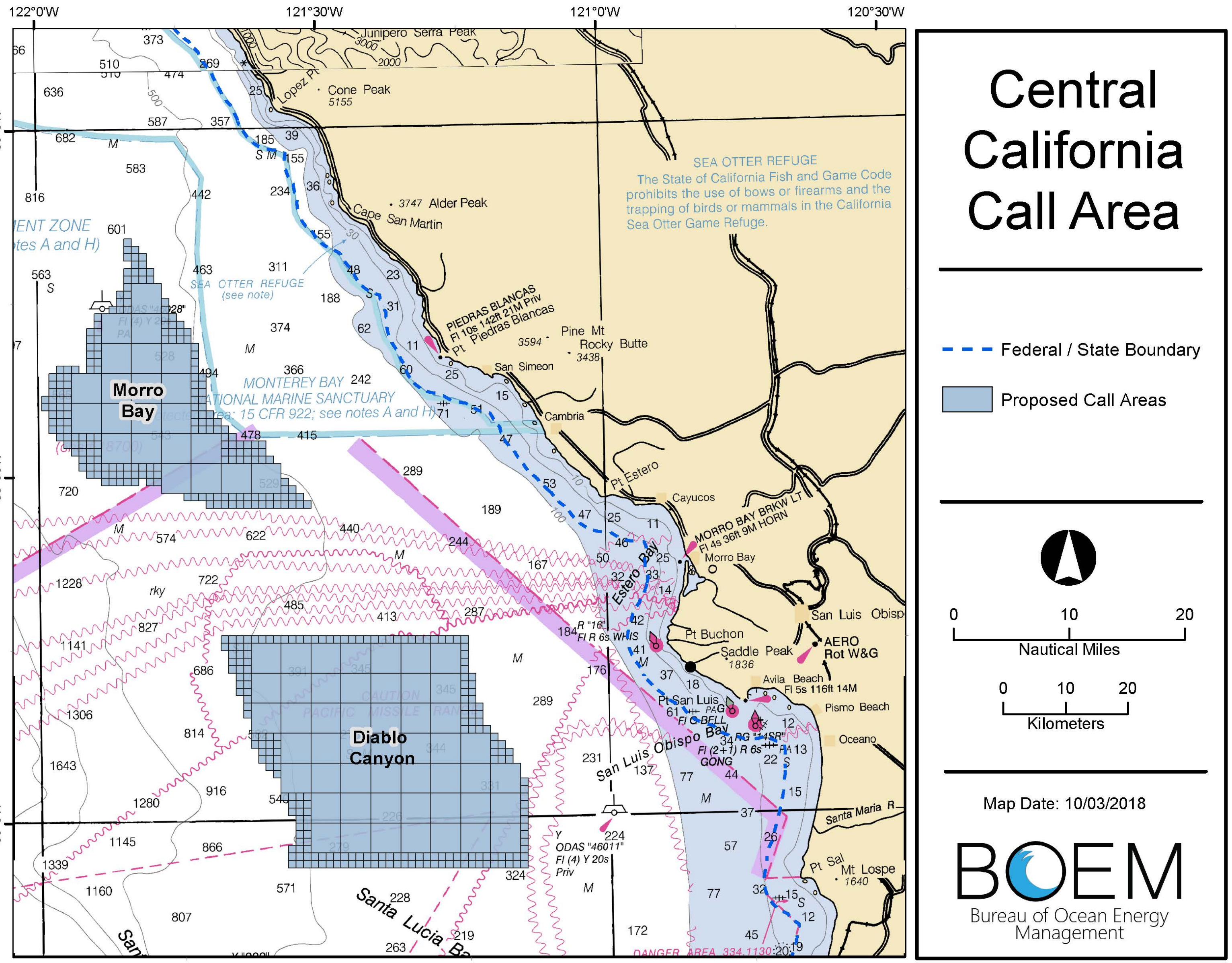
Director, Marine Conservation Program

Environmental Defense Center

Photo Credit: Equinor
Hywind Scotland

environmental
DEFENSE CENTER

The Environmental Defense Center works to protect and enhance the local environment through education, advocacy, and legal action.



Environmental Defense Center's service area includes the counties of San Luis Obispo, Santa Barbara, and Ventura. The Central Coast Call Areas are offshore San Luis Obispo County.

environmental DEFENSE CENTER

www.environmentaldefensecenter.org

Environmental Considerations

Advance responsible offshore wind energy while setting a high bar for planning, monitoring, adaptive management, and mitigation

J. Calambokidis

K. Davis-Koehn

Pacific Offshore Wind Energy Research Group

A working group comprised of environmental nonprofits and industry to forward progress on identifying floating offshore wind research needs early in the process.

Research needs sent to BOEM December 2020:

Birds/Bats

- Establish a Motus radio-tracking network; radio/satellite telemetry study of avian and bat species
- Long-term, fine scale digital aerial seabird surveys to inform siting, risk assessment, and monitoring
- Regional population viability analysis of key seabird species of California
- Development of a standard protocol for regional seabird offshore wind displacement study

Photo Credit: Equinor
Hywind Scotland

Pacific Offshore Wind Energy Research Group

A working group comprised of environmental nonprofits and industry to forward progress on identifying floating offshore wind research needs early in the process.

Marine Mammals, Fishes, and Benthic Habitats

- Analysis of secondary entanglement risk from floating offshore wind turbines
- Marine mammal habitat displacement risk analysis
- Analysis of distribution impacts to marine mammals and fishes
- Analysis of offshore wind-related structures impact on benthic habitats
- Evaluation of electromagnetic field (EMF) risk to sensitive species

Monitoring

- Creation of a monitoring technologies development roadmap

Photo Credit: Equinor
Hywind Scotland

Additional Needs

- Shut down protocols
- Fishing effort data
- Cumulative impacts
- Mitigation funds
- Adaptive management
- Methods to ensure consistent data collection across projects to foster comparison of monitoring, etc.

Photo Credit: Equinor
Hywind Scotland

Kristen Hislop
Director, Marine Conservation Program
Environmental Defense Center
khislop@environmentaldefensecenter.org
906 Garden Street, Santa Barbara, CA, 93101
805.963.1622

Photo Credit: Equinor
Hywind Scotland

environmental DEFENSE CENTER

www.environmentaldefensecenter.org

CEC Workshop on EPIC 2021-2025 Investment Plan Scoping

Offshore Wind Energy R&D Opportunities for EPIC 4
Environmental Impact Assessment and Minimization

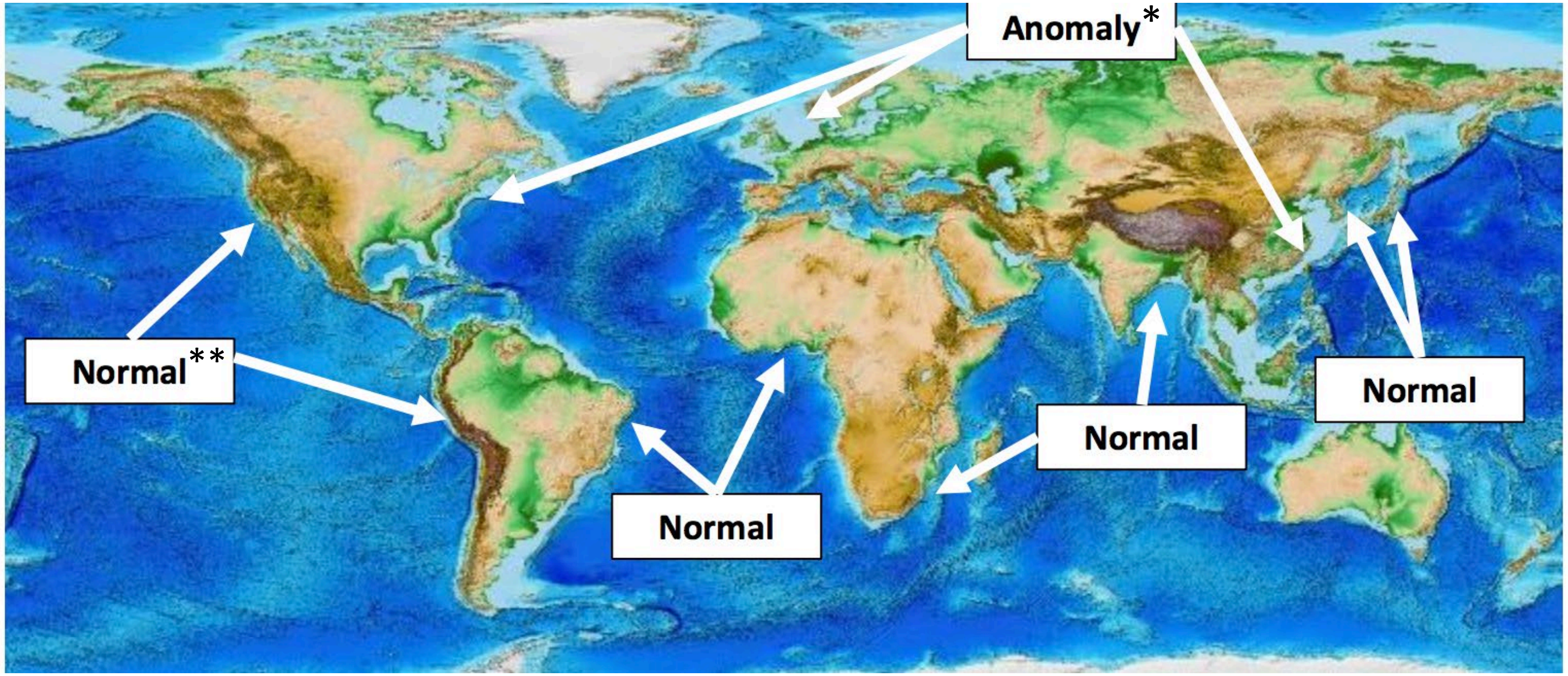
Presented by
Jim Lanard, Magellan Wind
July 14, 2021

Magellan Development Team

- Magellan Wind, LLC
  - Jim Lanard, CEO
  - Jeff Kehne, Chief Development Officer and General Counsel
  - Dan Reicher, Policy Advisor
- Copenhagen Infrastructure Partners
  - Joint Development Partner
  - Co-developer of Vineyard Wind projects
- Henrik Stiesdal, Founder and CEO, Stiesdal A/S
  - Technology Advisor; holds over 1,000 patents
  - Developer of Industrialized Tetra Foundations

Deep Water Projects on Floating Foundations

Water Depths Near Population Centers

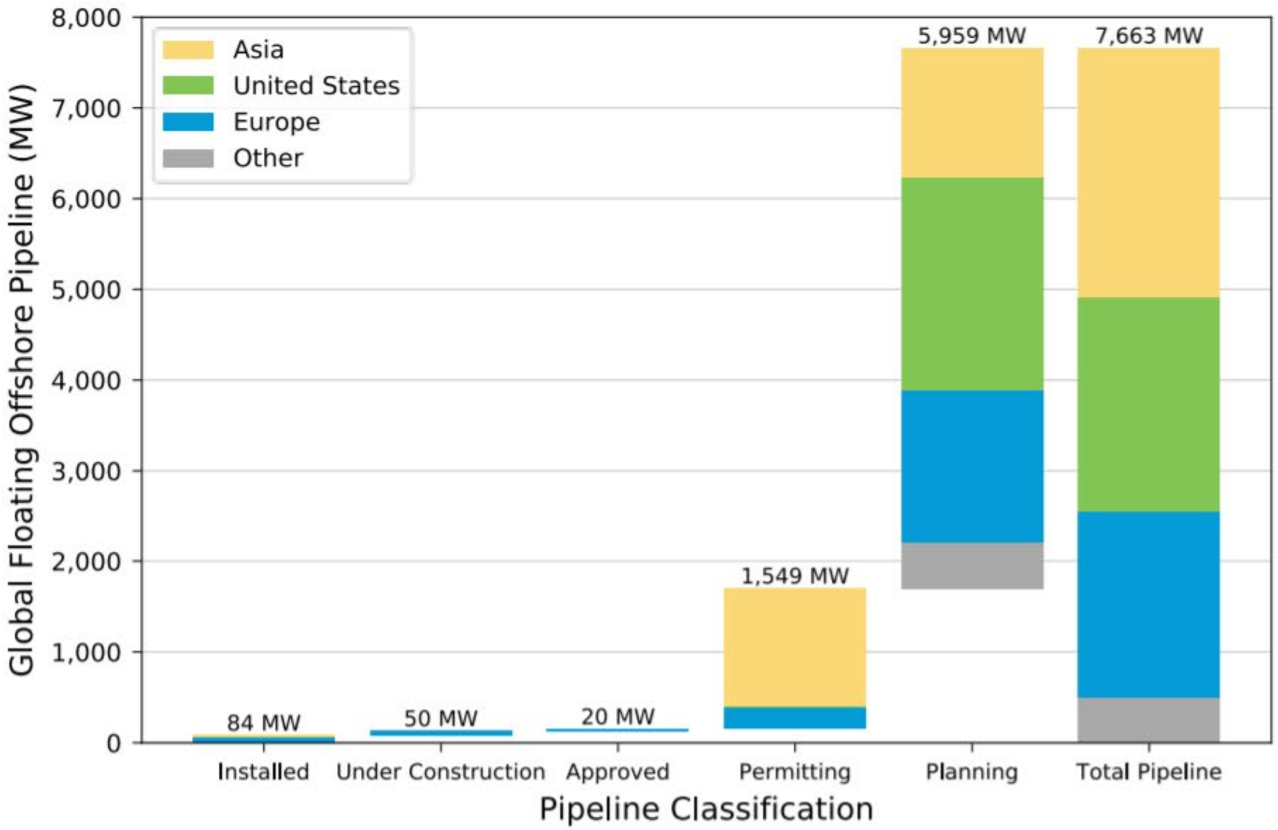


Source: NOAA

*Anomaly: Limited world-wide shallow water areas (<50m) for fixed foundations

**Normal: Considerably more developable wind farm areas will require floating foundations

Floating Offshore Wind Technologies Advancing Rapidly

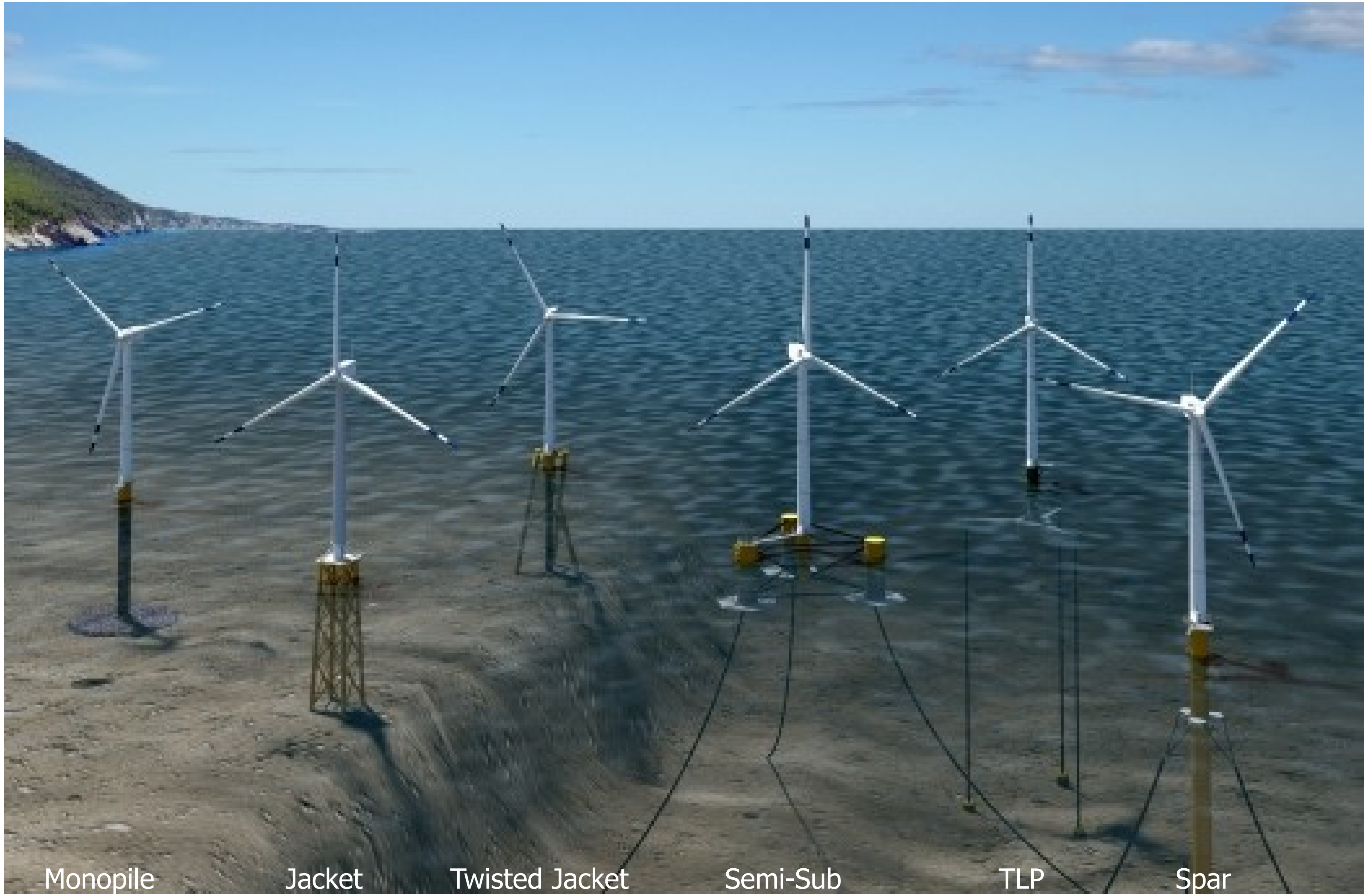


- The total global floating offshore wind pipeline was 7,663 MW at the end of 2019, based on projects that have announced their planned capacity.
- 1,549 MW of floating offshore wind has reached the permitting stage.
- The 25.2-MW WindFloat Atlantic, the second floating project in Europe, became fully operational in 2020.
- The primary driver for pipeline expansion is the movement toward commercial-scale projects developing in Asia.

- Asia and the Middle East – 23 projects totaling > 3.2 GW
- Europe – 41 projects totaling > 2 GW
- North America – 7 projects totaling > 2 GW

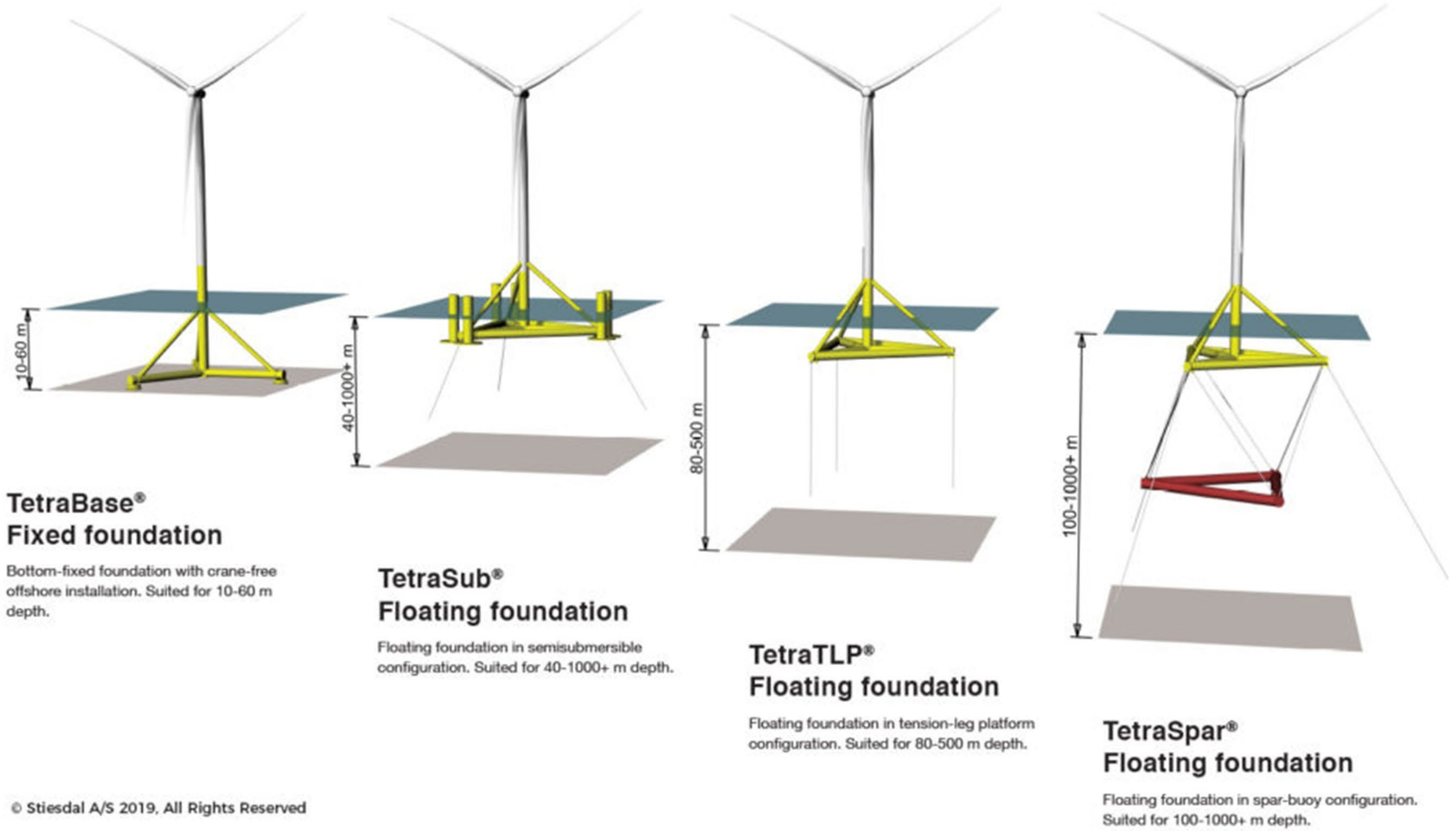
Source: NREL "2019 Offshore Wind Technology Data Update," October 2020

Bottom-Fixed and Floating Foundation Technologies



Source: NREL

Stiesdal Offshore Technologies: Industrialized Tetra Foundations



Assembly of TetraSpar

Up-ending of the center column at the port of Grenaa, Denmark.
Photo credit: The TetraSpar Demonstrator Project ApS

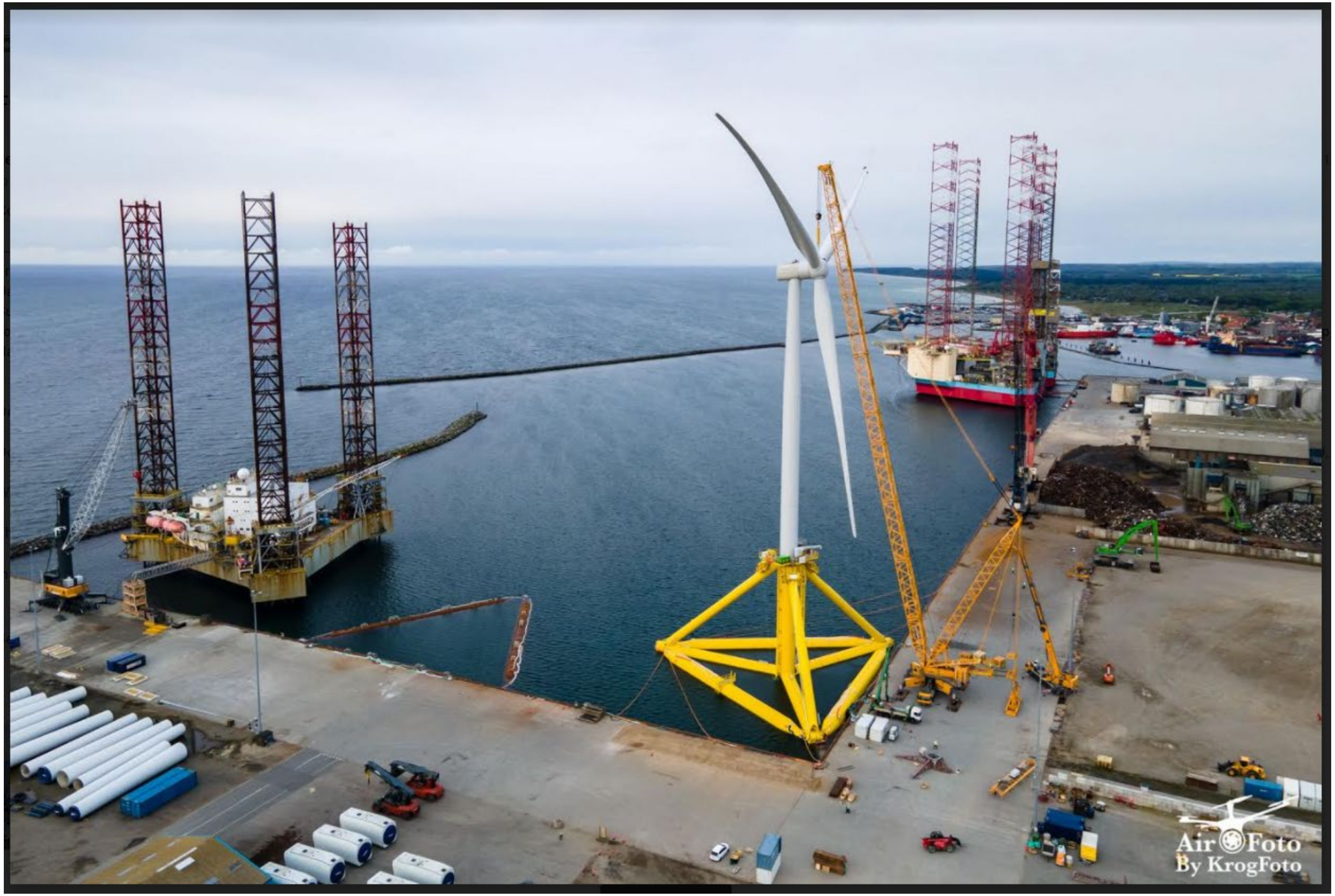
Assembly of TetraSpar

Mounting of the diagonals using maintenance-free proprietary technologies for fast assembly.
Photo credit: The TetraSpar Demonstrator Project ApS

Completed TetraSpar Foundation and Keel

Completed foundation and keel.   Photo credit: The TetraSpar Demonstrator Project ApS

Preparing TetraSpar Demo for Tow Out



TetraSpar Demo Video
Tow Out from Grenaa Seaport in Denmark
Monday, 12 July 2021

https://twitter.com/RWE_AG/status/1414467432194904066

General Questions and Comment*

- Current status of wildlife detection systems at offshore wind farms
  - What new technologies would benefit species found in the California Current?
- Do wind farms lead to prey migration?
- What's the best way to ensure all stakeholders including commercial fishers, California Tribes, and environmental justice communities have opportunities to be fully engaged in the development of offshore wind policies?
- What are best practices for installation and operations and maintenance
- Potential for cumulative impacts of multiple wind farms
- It is recommended that the CEC and BOEM consult on research priorities that might be funded through EPIC 4 and BOEM's 2022-2023 Studies Development Plan; see https://www.boem.gov/sites/default/files/documents/environment/environmental-studies/SDP_2022-2023.pdf

*Questions on this and the following slides are derived from collaborative discussions (still ongoing) among participants in the Pacific Offshore Wind Energy Research (POWER) Group.

Protecting Avian/Bat Species

- What's out there?
- Will birds/bats fly through a wind farm? At what heights?
  - Are collision risk models adequate for species in the California Current?
  - Can technology be developed so that real time data can inform the need to temporarily – but quickly – shut down a turbine or a string of turbines?
  - Mitigation options/new technology development to prevent/reduce collisions
- Will birds/bats fly around wind farms?
  - How to measure?
  - Cost of energy to get to feeding areas
  - Implications if there is a change in migratory patterns
- Does aircraft warning lighting create a risk of collisions? Should there be mitigation?
- Will new avian/bat species be attracted to wind farms?
  - Would this be a benefit – increased biodiversity – or a risk? If a risk, what measures could be adopted to reduce colonization of new species?

Protecting Marine Species

- What’s out there?
- During deployment and O&M, there will be increased vessel traffic to/from an offshore wind farm. What precautions will be needed? Observers? Speed restrictions? Seasonal restrictions?
- Will marine species swim through a wind farm?
    - Potential for collisions? Mitigation options/new technology development to prevent/reduce collisions
- Will marine species swim around wind farms?
    - Cost of energy needed to get to foraging areas
    - Implications if there is a change of migratory patterns
- Do offshore wind farms create additional risks of secondary entanglement caused by derelict fishing gear?
    - Is there a need for new monitoring systems to identify entangled gear?
    - Would removal of derelict gear caught in the mooring system of a floating wind turbine reduce overall risk of entanglement? What is best way to remove ensnared derelict gear?
- Do offshore wind farms create sounds – mooring line movements, vibrations – that are problematic to marine life?
- Is EMF a risk? What are potential mitigation measures?
- Risks associated with inter-array cables
- Will new marine species be attracted to wind farms?
    - Would this be a benefit – increase in biodiversity – or a risk? If a risk, what measures could be adopted to reduce colonization of new species?

Protecting Benthic Habitats

- Mooring systems
  - Are catenary or taut lines better at managing potential risk?
  - Would anchoring systems create risks to the seabed?
  - Are there bottom scour reduction options?
- Do floating inter-array cables affect water column turbulence that could affect prey distribution/composition?
- Potential to attract new animals or plants to the seabed
  - Implications of this potential

Thanks for Your Attention

Jim Lanard
Magellan Wind LLC
JLanard@MagellanWind.com

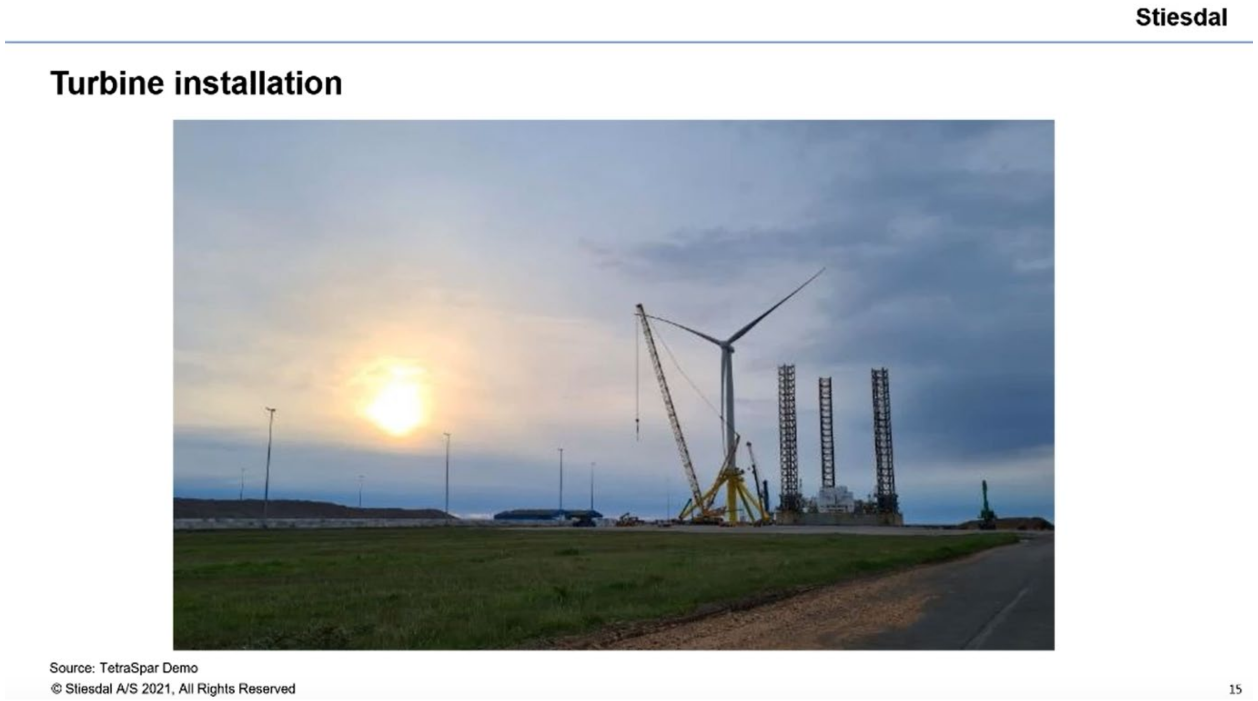


Photo courtesy of Welcon A/S

Ocean Protection Council’s role

State of California EXECUTIVE BRANCH

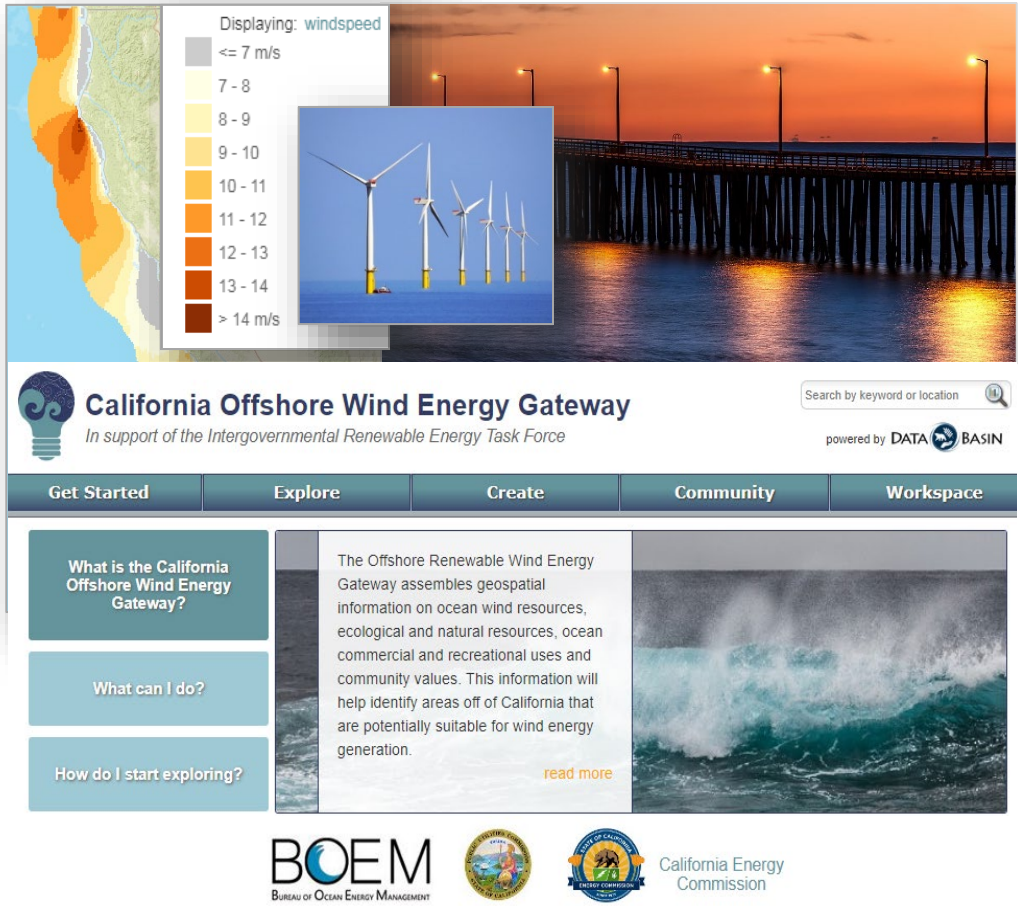
GOVERNOR
Gavin Newsom

- **Transportation Agency**
- **Dept. of Corrections and Rehabilitation**
- **Environmental Protection Agency**
- **Dept. of Finance**
- **Heath and Human Services**
- **Dept. of Food and Agriculture**
- **Labor and Workforce Development Agency**
- **Natural Resources Agency**
  Secretary, Wade Crowfoot
- **Dept. of Veterans Affairs**
- **Government Operations Agency**
- **Business, Consumer Services, and Housing Agency**

CALIFORNIA
OCEAN PROTECTION COUNCIL

California Ocean Protection Act, 2004:
Ensuring healthy, resilient, and productive ocean and coastal ecosystems for the benefit of current and future generations. Committed to basing decisions and actions on best available science and promoting the use of science among all entities involved in the management of ocean resources.

Key OPC Investments and Next Steps



https://caoffshorewind.databasin.org/

- Feasibility analysis of offshore wind development in the North Coast region (completed)
- Mapping ocean fishing grounds west of the California coastal counties of Del Norte, Humboldt and Mendocino (in progress; complete Dec. 2021)
- Identifying offshore wind energy least-conflict areas and incorporation of marine environmental data into existing online planning tools (in progress; complete Sept. 2021)
- Analysis of existing marine environmental data in relation to BOEM Call Areas (in progress; complete Dec. 2021)
- **$2M appropriated in 2021-22 Budget to support additional environmental and port studies**

OCEAN PROTECTION COUNCIL

OCEAN PROTECTION COUNCIL

Thank You

Justine Kimball, Senior Climate Change Program Manager

Justine.Kimball@resources.ca.gov

Session III: Floating Offshore Wind Environmental Impact Assessment and Minimization

Panel Discussion Questions

1. What areas of environmental research are most critical to support sustainable development of floating offshore wind on California's Outer Continental Shelf?

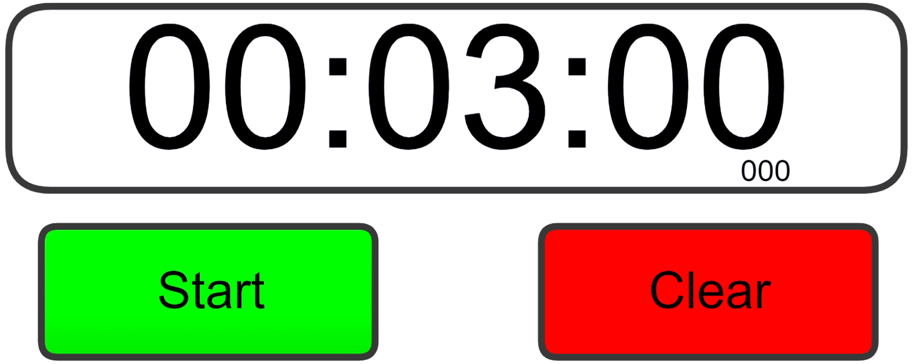
2. What mitigation tools can and should be prioritized for development, where environmental impacts are sufficiently understood? Can some impacts be reduced through smarter design of floating offshore wind technologies?

3. What advances in monitoring technologies are most needed to support adaptive management for floating offshore wind?

PUBLIC INPUT SESSION

Stakeholder Comments

- 3 minutes per commenter, 1 commenter per organization.
- Please clearly state your name and affiliation.
- Use the raise hand function in Zoom and wait to be called upon to unmute.
- Type questions/comments into the Q & A window.



Next Steps

To stay involved in EPIC 4:

Visit **www.energy.ca.gov/epic4.**

To review today's workshop materials:

Visit https://www.energy.ca.gov/event/workshop/2021-07/electric-program-investment-charge-2021-2025-investment-plan-scoping-0.

Submitting Written Comments:

Please use CEC's **e-commenting** system:
https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=20-EPIC-01

See **notice** for **e-mail and U.S. Mail** commenting instructions:
https://efiling.energy.ca.gov/getdocument.aspx?tn=238093

Workshop Comments are due July 26, 2021.

Thank You