Deepwater Offshore Wind

A National Opportunity

August 17, 2010

Dr. H.J. Dagher, P.E., Director
Advanced Structures and Composites Center
DeepCwind Consortium
University of Maine
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Outline

1. UMaine Composites Center
2. US & Europe offshore wind
3. Foundation types & floating platforms
4. Cost – Can we get there?
5. Timeline - DeepCwind Consortium

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UMaine Advanced Structures & Composites Center

Composites Industry

Construction Industry

$30 Million
Offshore Wind addition

- Established by NSF in 1996
- 140 personnel
- 87,000 ft^2 ISO 17025 Accredited Lab
- Analysis & Design ⟷ Prototyping

Code Reports

Testing

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Longest Composites Bridge in the World

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Penobscot Narrows Bridge

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“Bridge in a Backpack”

- Arches inflated on site, filled with concrete
- *Spinoff: Advanced Infrastructure Technologies, LLC*

Arch Placement

Decking Installation

Completed Bridge

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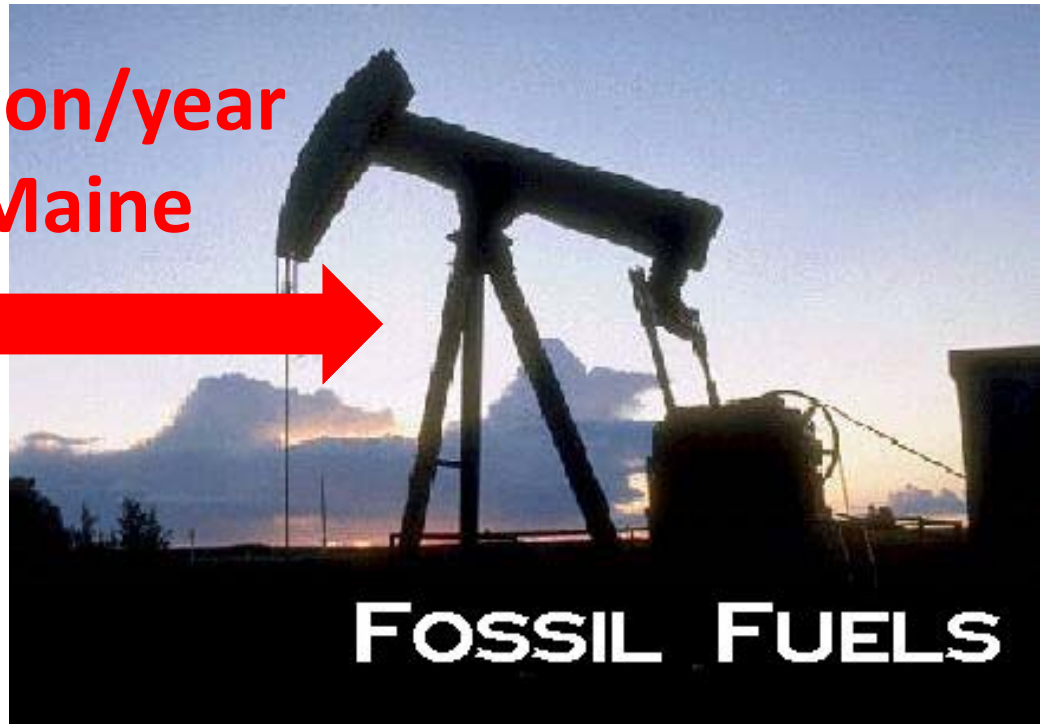
Twice the State Budget Leaves Maine

$ 5 Billion/year
Leave Maine



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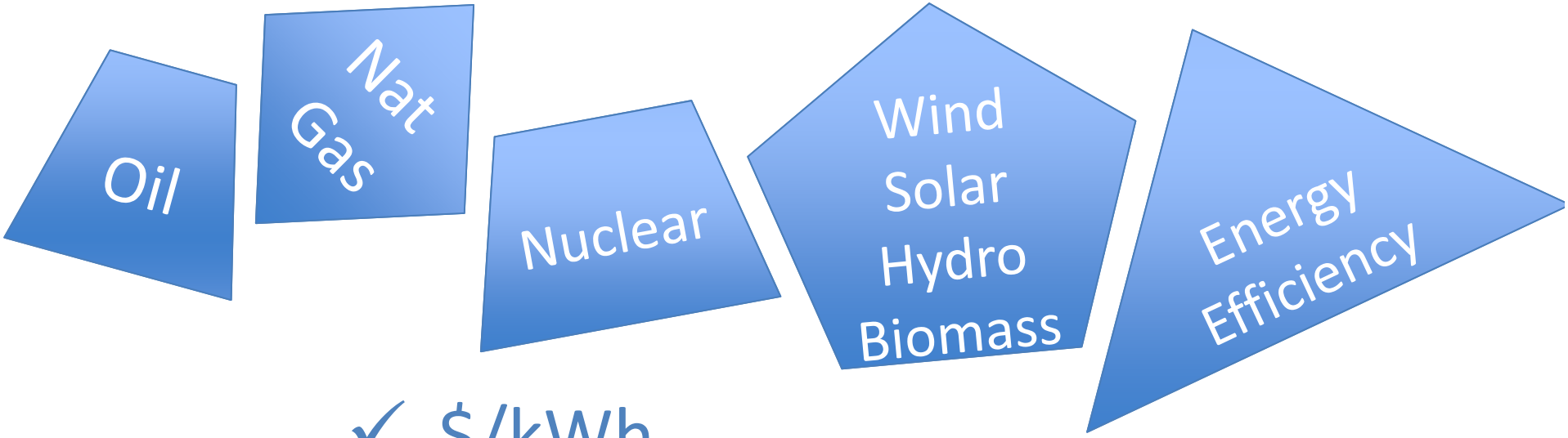
New Energy Mosaic



- ✓ $/kWh
- ✓ Public acceptance?
- ✓ Impact on economy?
- ✓ Impact on environment?

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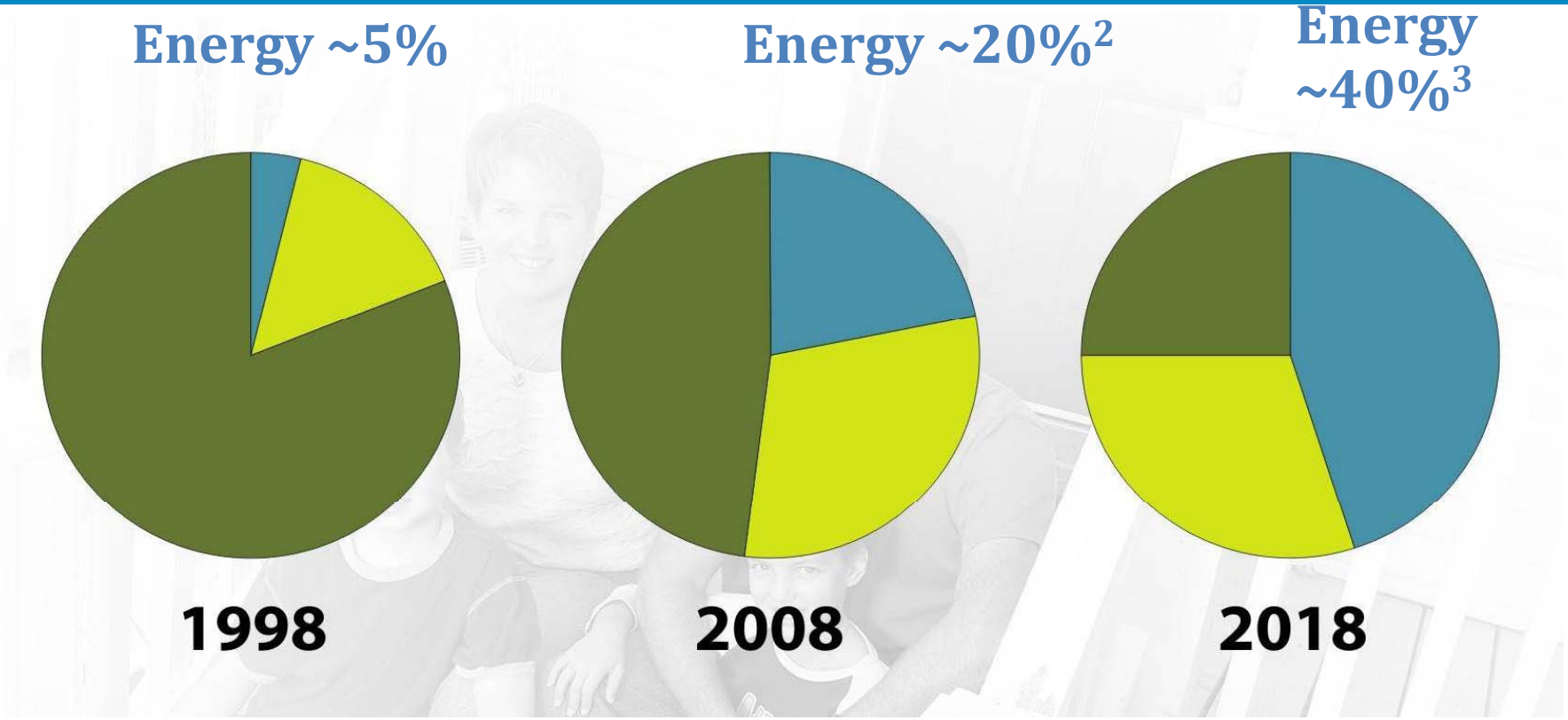
Maine Family Budget



"Family Energy"[1,2] = 50% Transportation
40% Heating
10% Electric Power

[1] Source:, Dr. George Hart, UMaine
[2] Based July '08 energy costs
[3] Assumes that health care costs do not grow past 30% of the average family budget in 2008-2018

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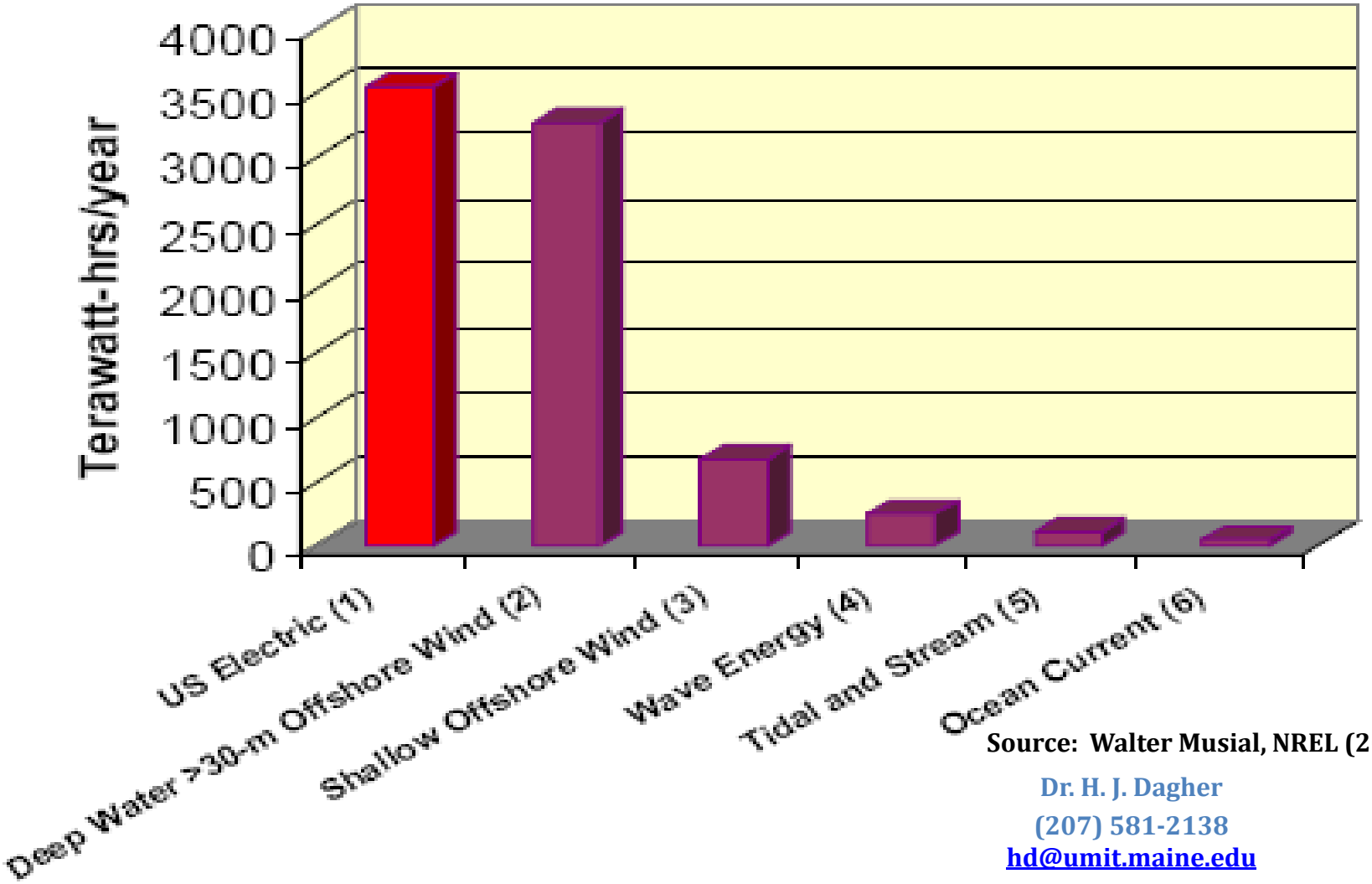
Deepwater Wind:
Largest US Ocean Energy Resource



Source: Walter Musial, NREL (2008)

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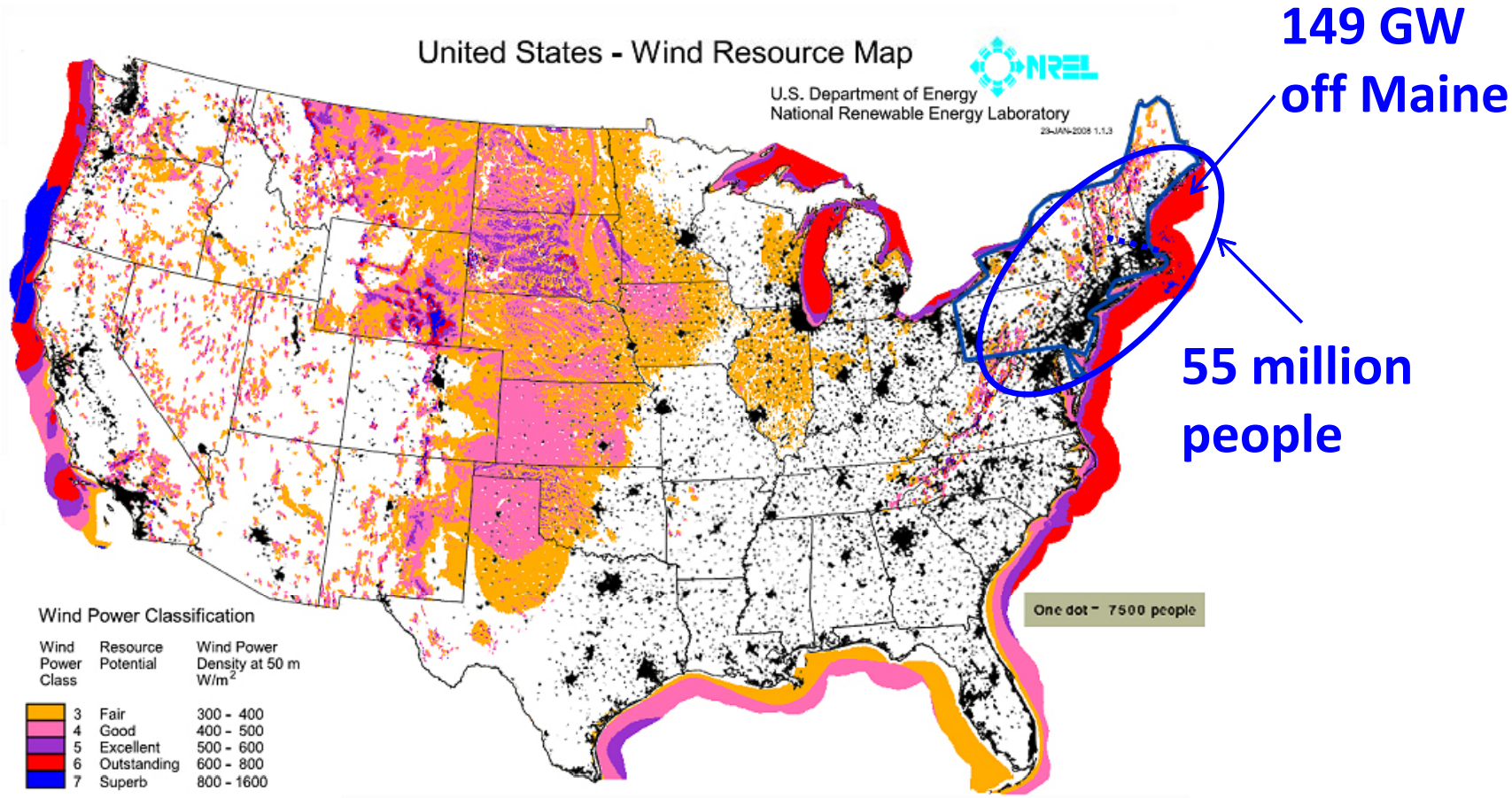
Maine: A Source of Green Energy for the Northeast U.S.



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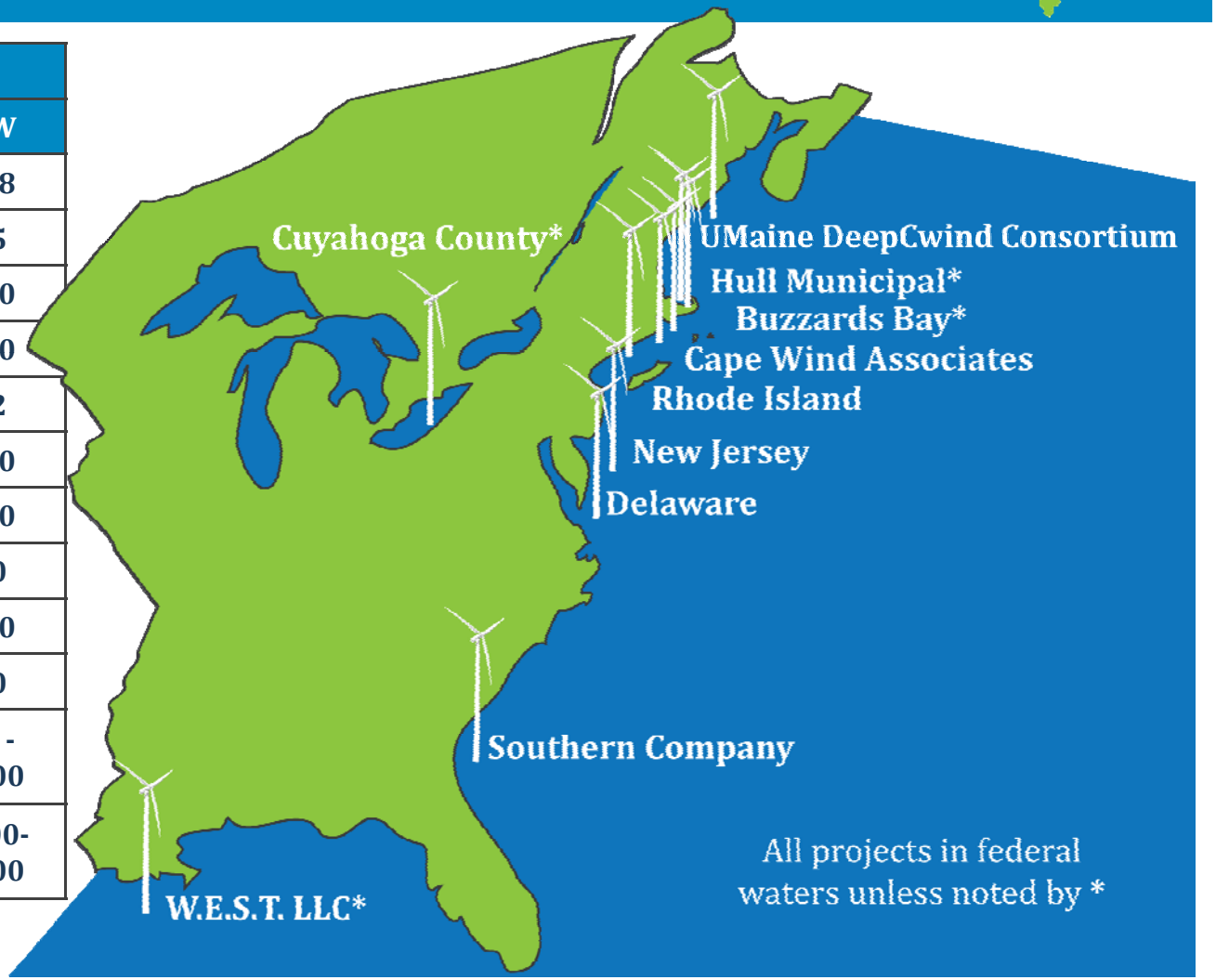
U.S. Proposed Offshore Wind Projects

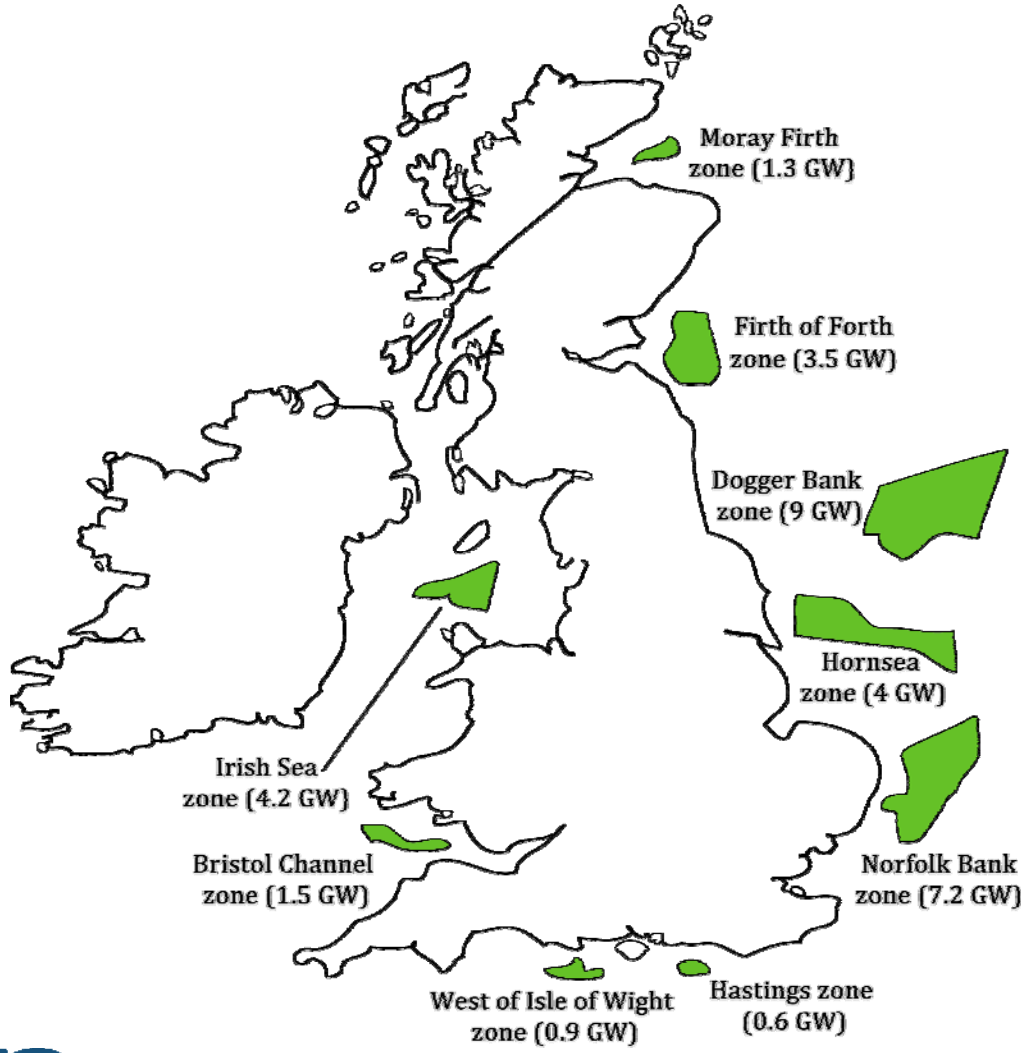
US Offshore Wind Initiatives		
Project	State	MW
Capewind	MA	468
Hull Municipal	MA	15
Buzzards Bay	MA	300
Rhode Island (OER)	RI	400
Winergy	NY	12
New Jersey (BPU)	NJ	350
Delmarva	DE	350
Southern Company	GA	10
W.E.S.T.	TX	150
Cuyahoga County	OH	20
DeepCwind Consortium	ME	25 - 1000
Total MW		2100-3000

None Installed Yet



Source: Walter Musial, NREL (2009)

UK – Round 3 Bidders Selected 1/8/10
25 GW, ¼ of UK's Electricity by 2020



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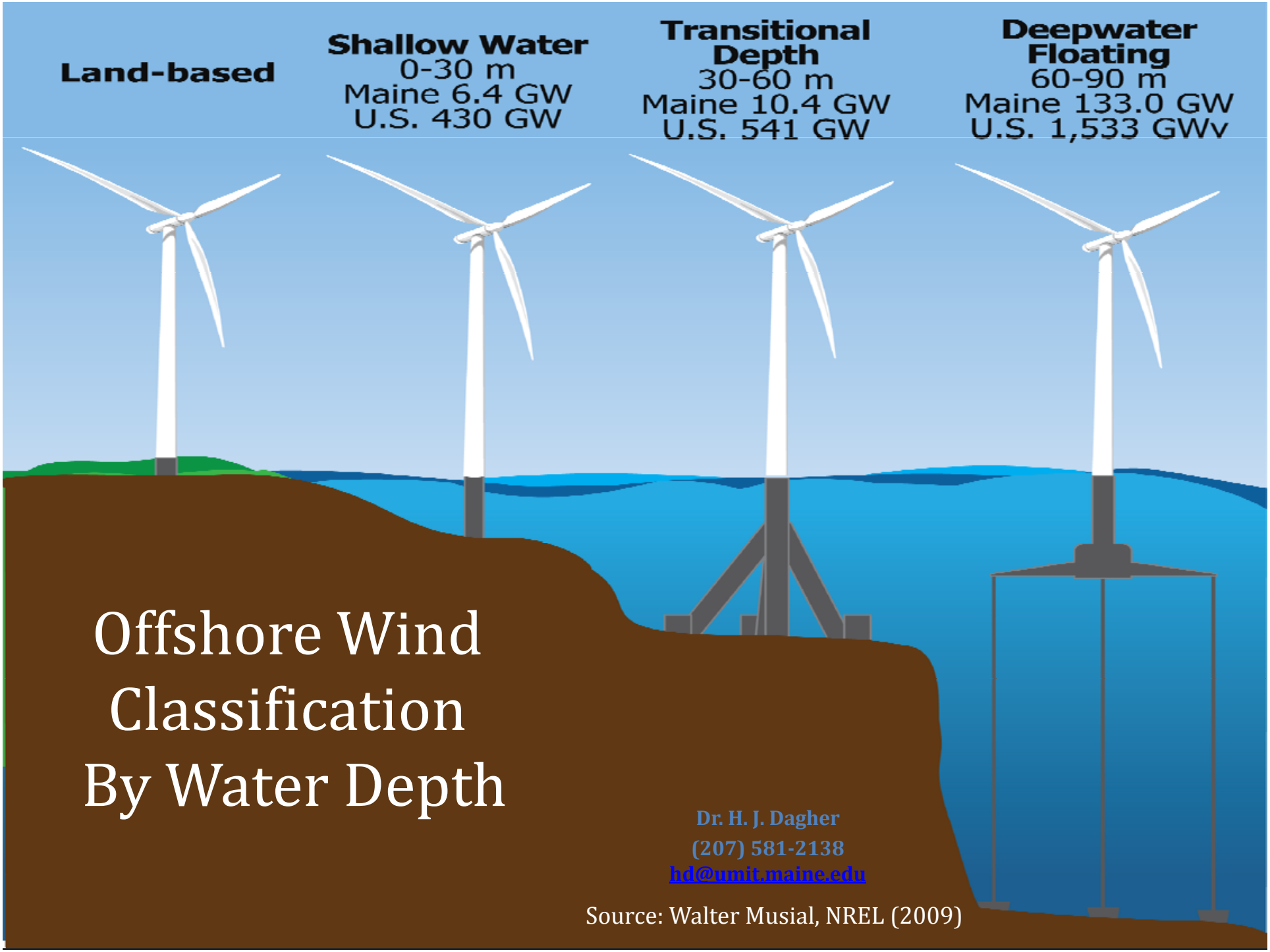

Offshore Wind Classification By Water Depth

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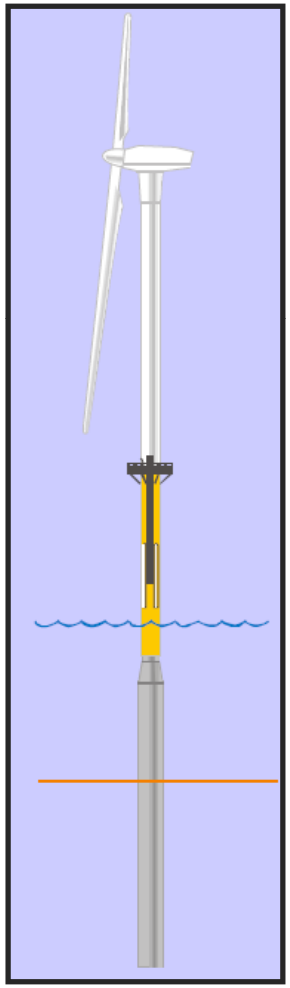
Source: Walter Musial, NREL (2009)

Shallow Monopile Foundations:
2-30 m, Drilled or Driven, Most Common



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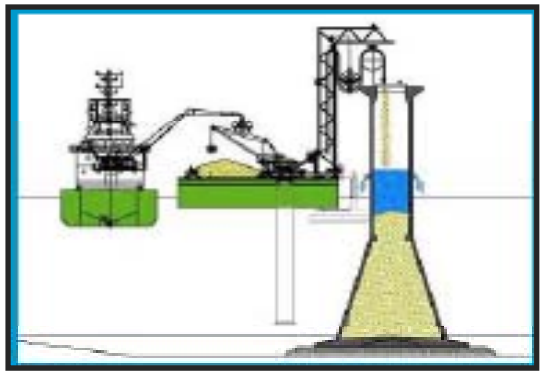
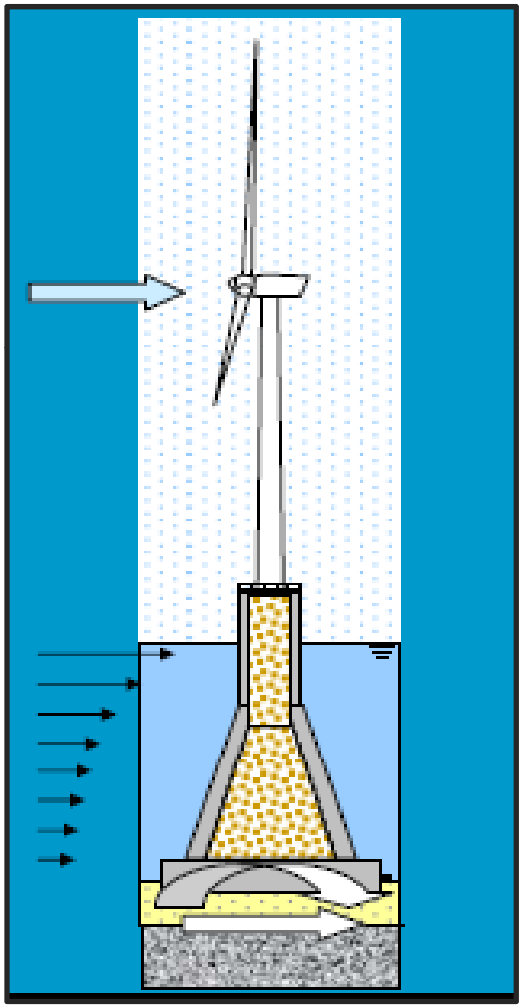
Shallow Gravity Foundations





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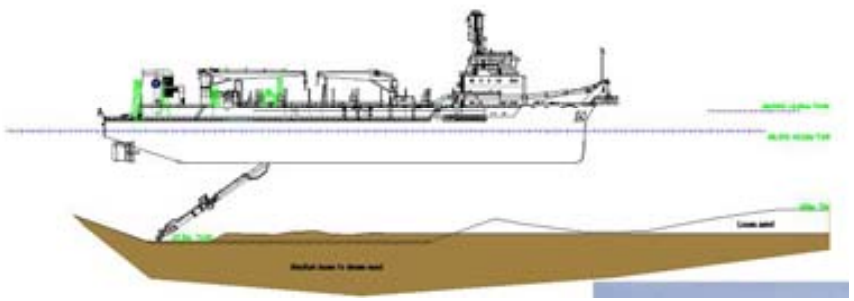
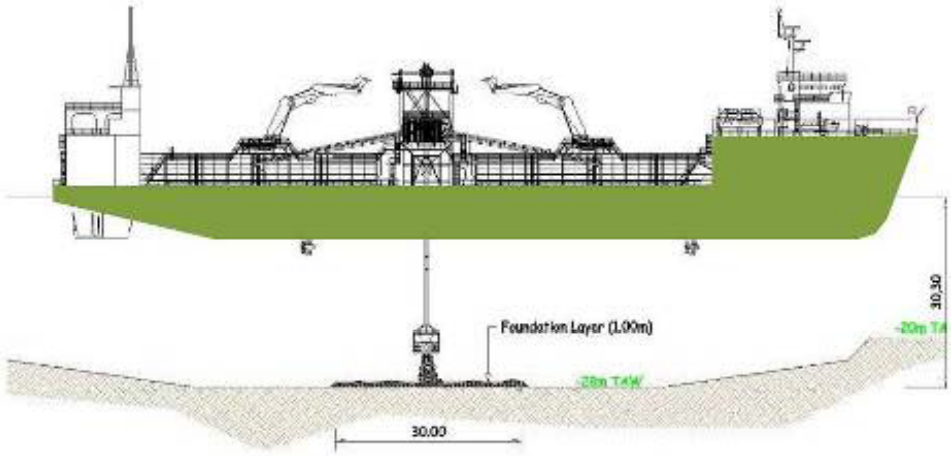
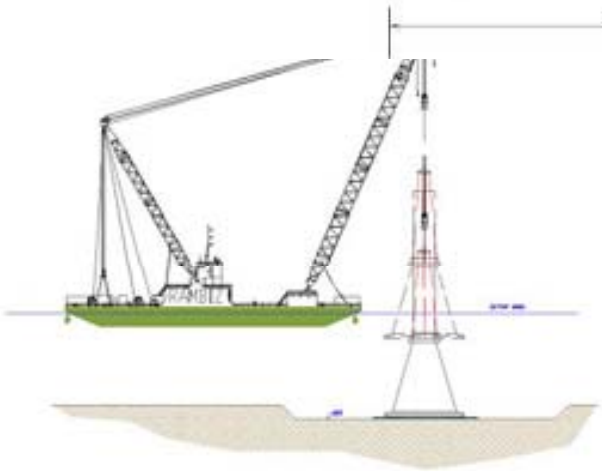
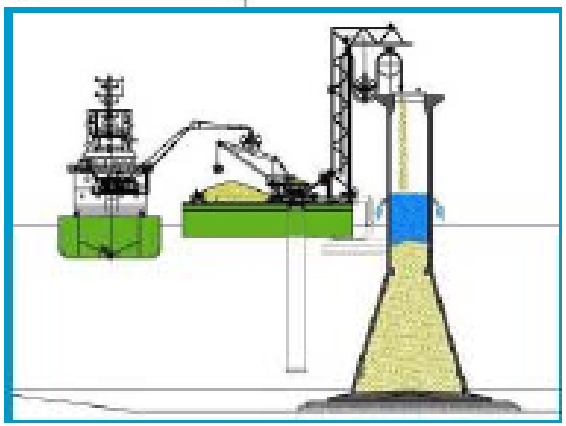
Shallow Gravity Foundations: Seabed Preparation and Installation









Source: TU Delft

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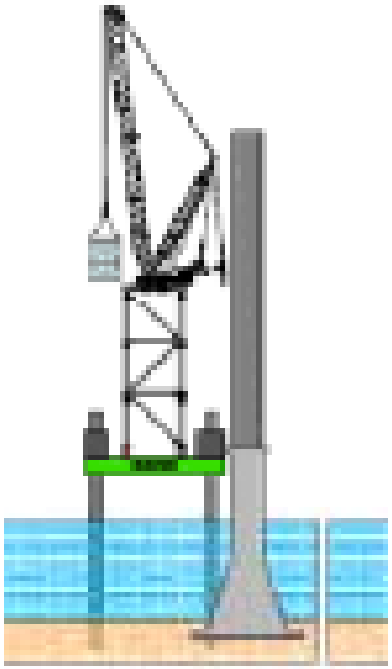
Shallow Gravity Foundations: Tower, Turbine and Blades Installation



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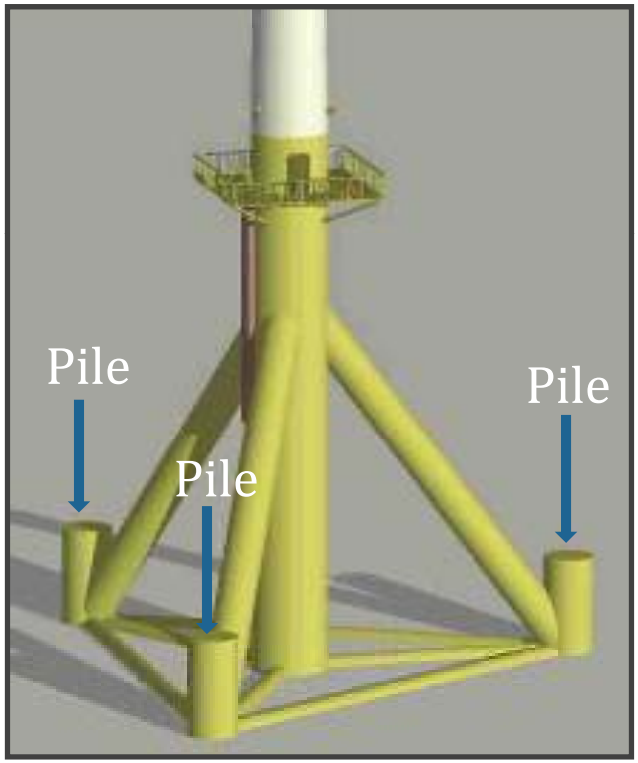
Transitional Waters Foundations (30-60m):



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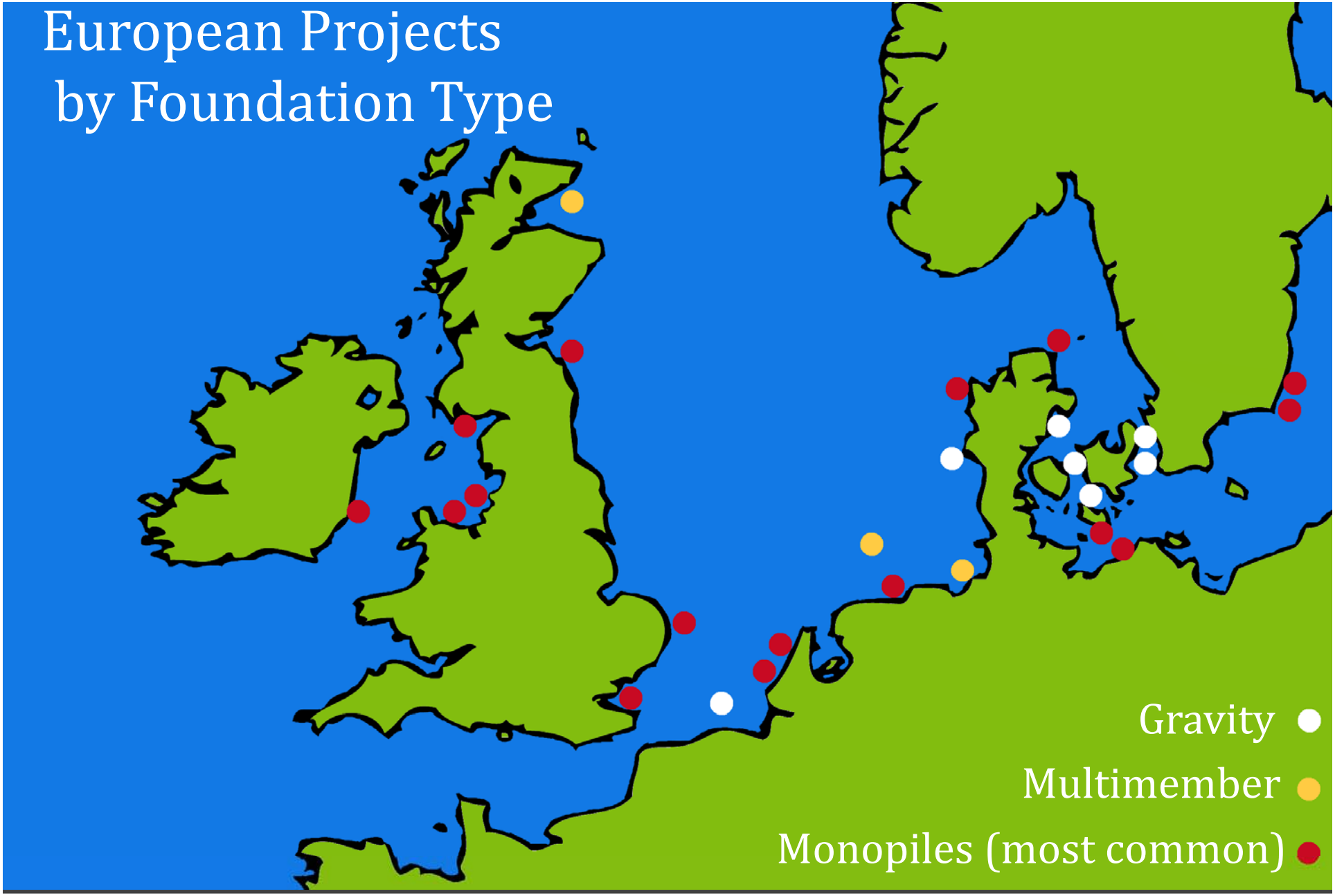
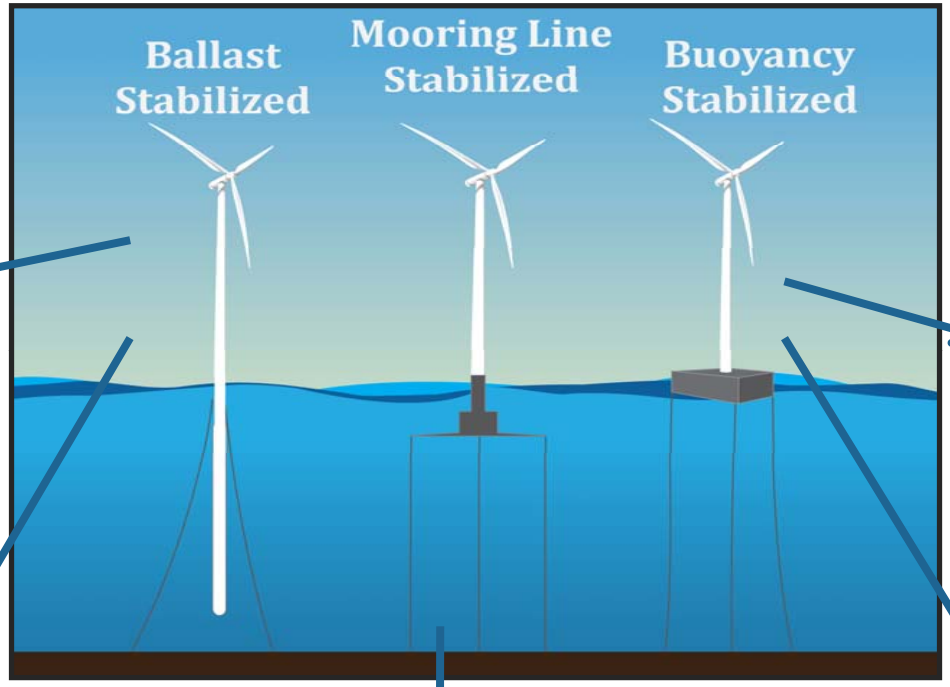
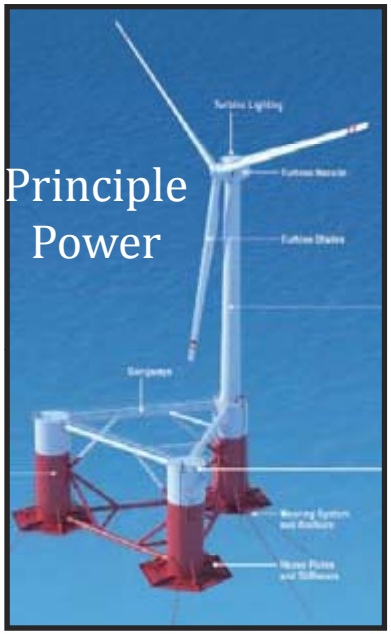
European Projects by Foundation Type

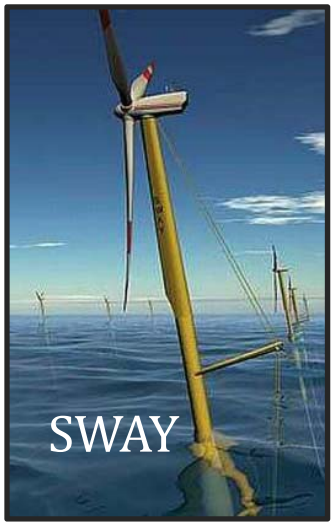


Source: TU Delft

Floating Wind Turbines (>200ft): Design Space Based On Stability







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Statoil Hywind 2.3 MW
213 ft to hub, 20'-27' Diam., Rotor Diam 270'

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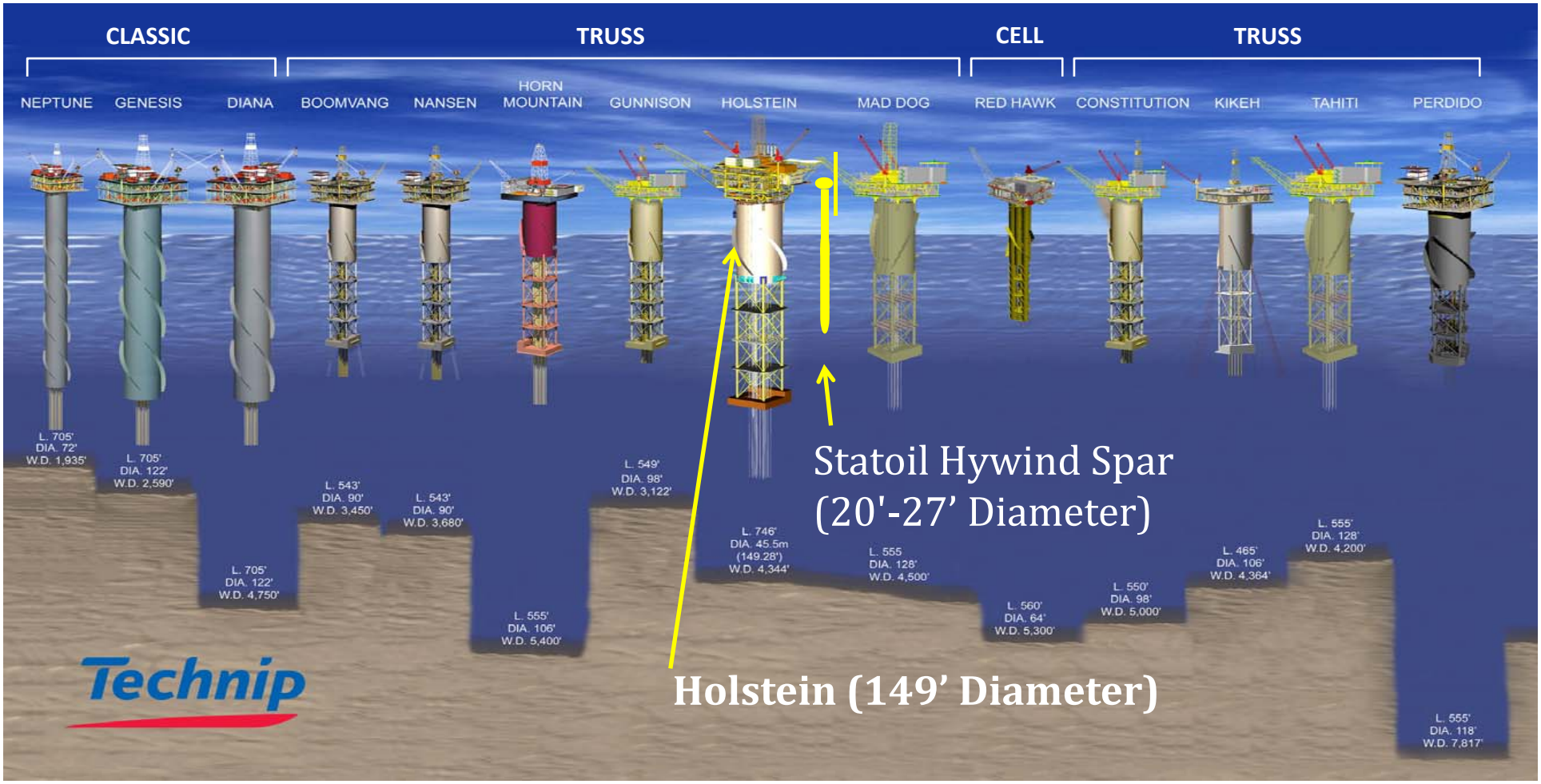
Offshore Wind Slender Tubes Compared to Oil & Gas Designs



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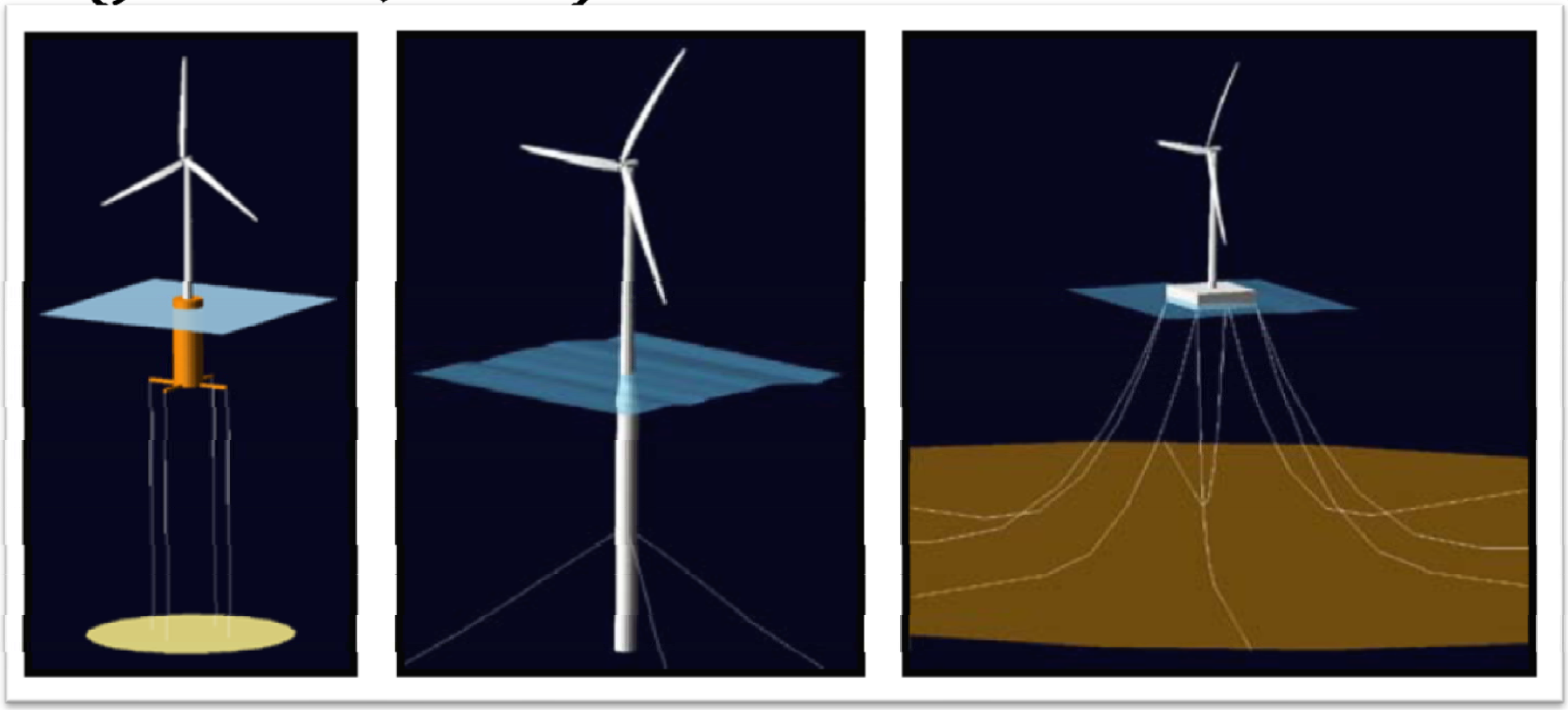
Surviving 100 Year Events

Coupled aeroelastic/hydrodynamic models (Jonkman, NREL)



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Model Simulations

Offshore Foundations Cost More

Horns Rev and Nysted (Average investment per MW)

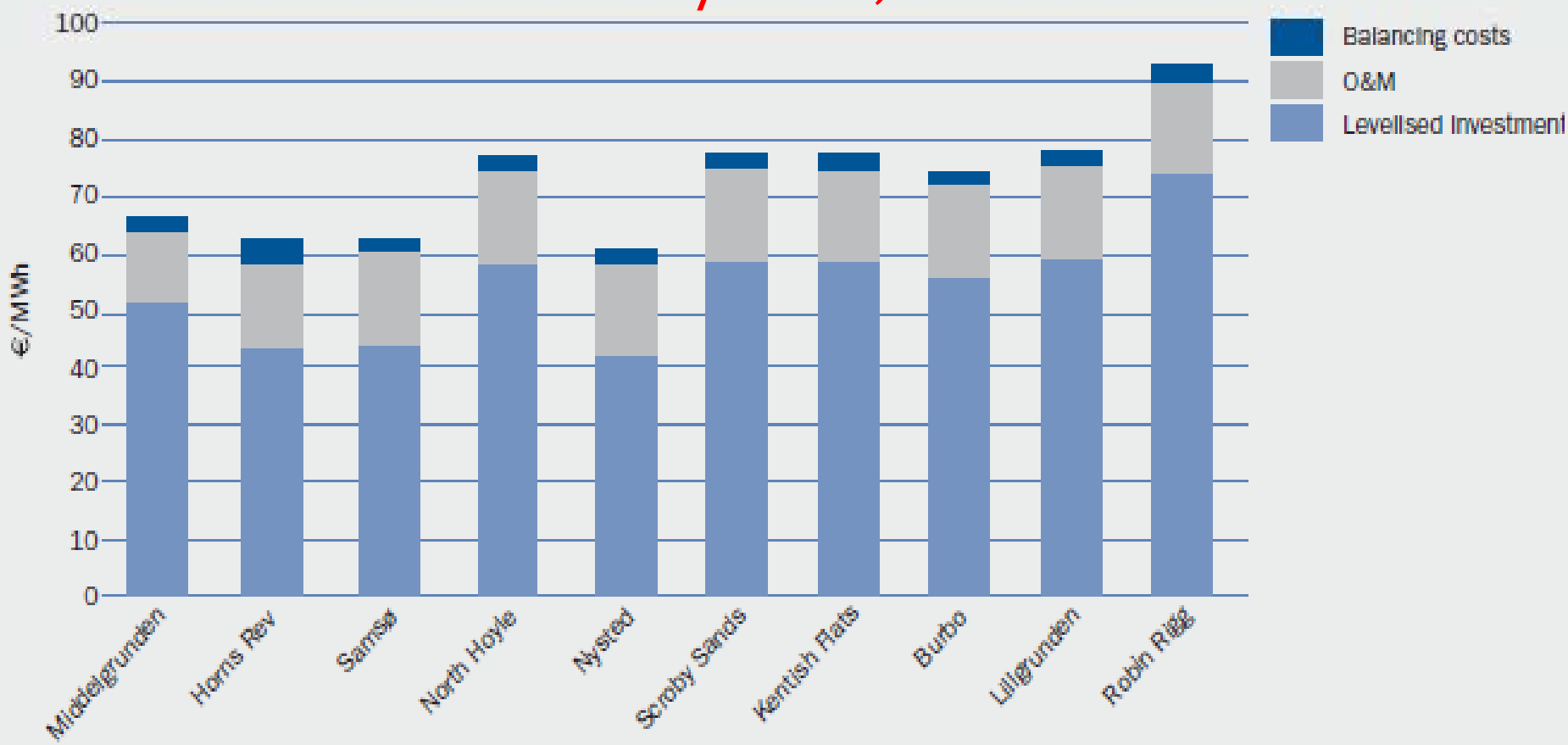
	INVESTMENTS 1000 €/MW	SHARE %
Turbines ex works, including transport and erection	815	49
Transformer station and main cable to coast	270	16
Internal grid between turbines	85	5
Foundations	350	21
Design and project management	100	6
Environmental analysis	50	3
Miscellaneous	10	<1
TOTAL	**1,680**	**~100**

25% Opportunities for Cost Reductions Based on 2009 UK Competition?

[1] Source: EWEA, "Economics of Wind Energy," March 2009

Offshore Wind Production Costs
10 European Farms (2006,€/MWh)[1]

≈ 6-9.2 c€/kWh, now double



[1] Sources : RISØ DTU , EWEA, "Economics of Wind Energy", March 2009

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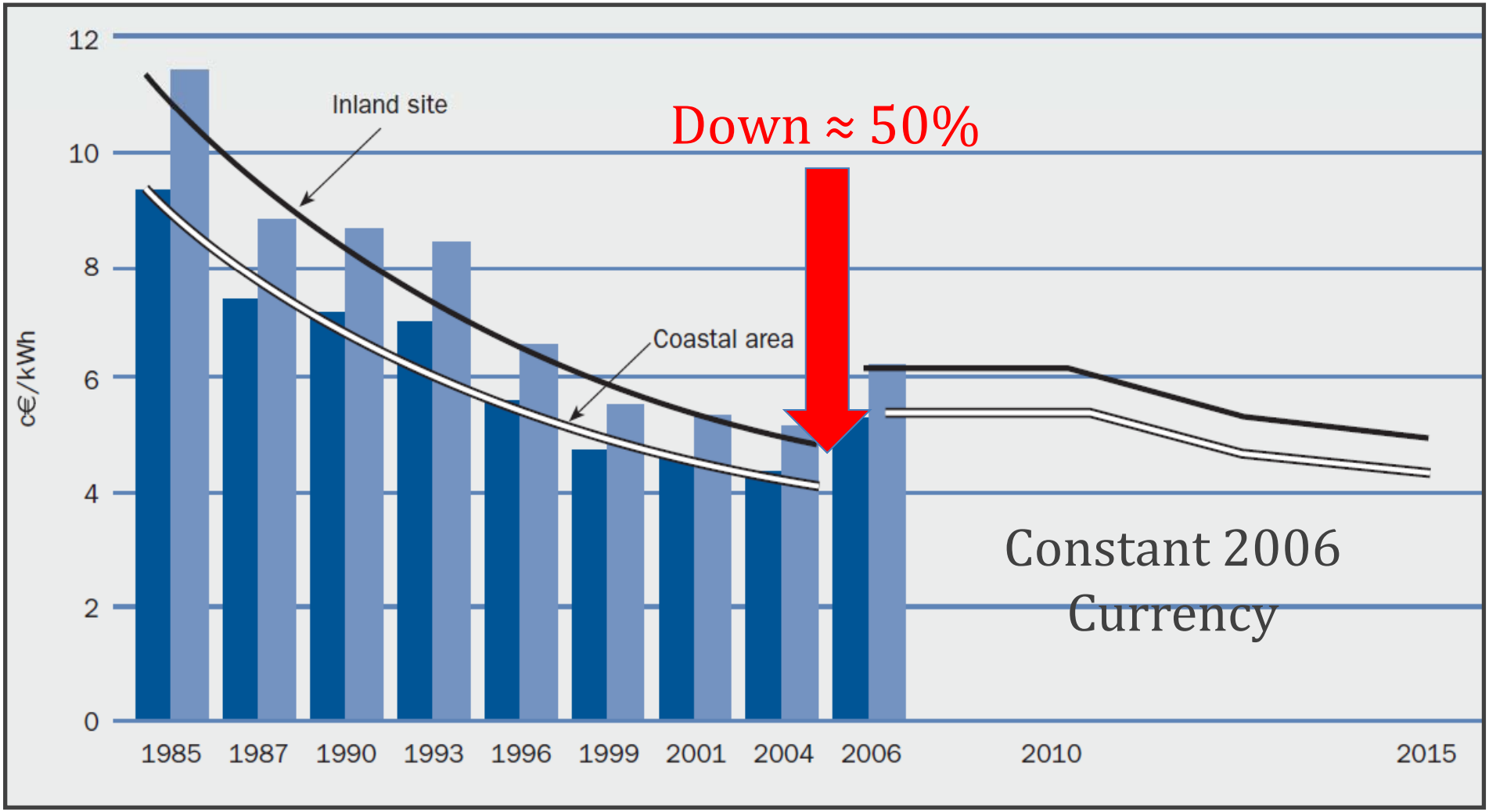
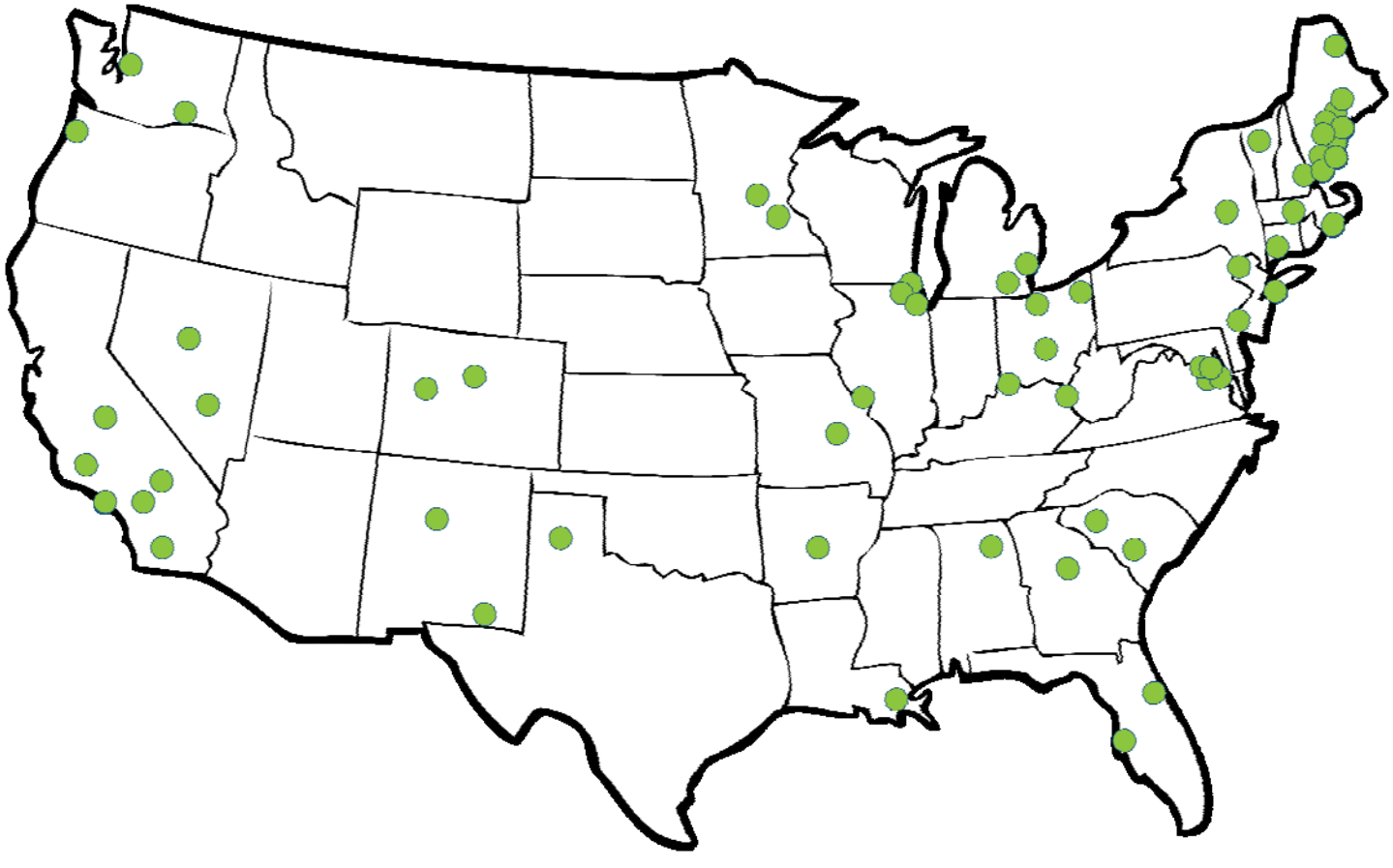
Experience Curves for Land Based Wind[1]
10% Learning Rate Could Apply to Offshore Wind?



[1] Source: EWEA, "Economics of Wind Energy," March 2009

DeepCwind Consortium
DOE Contract January 2010

35 partners



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Maine Offshore Wind Plan

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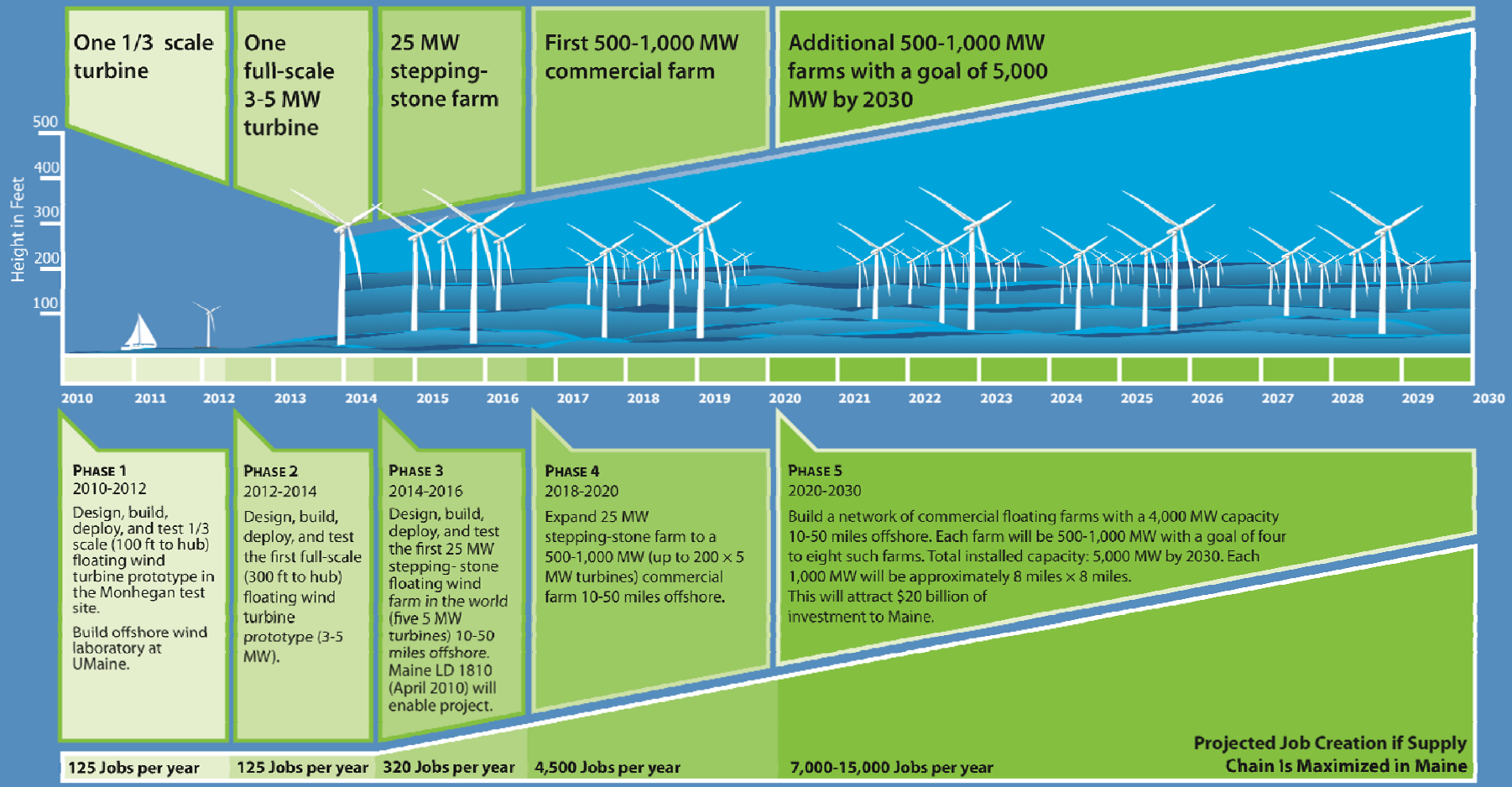

Setting the Course for Energy Independence

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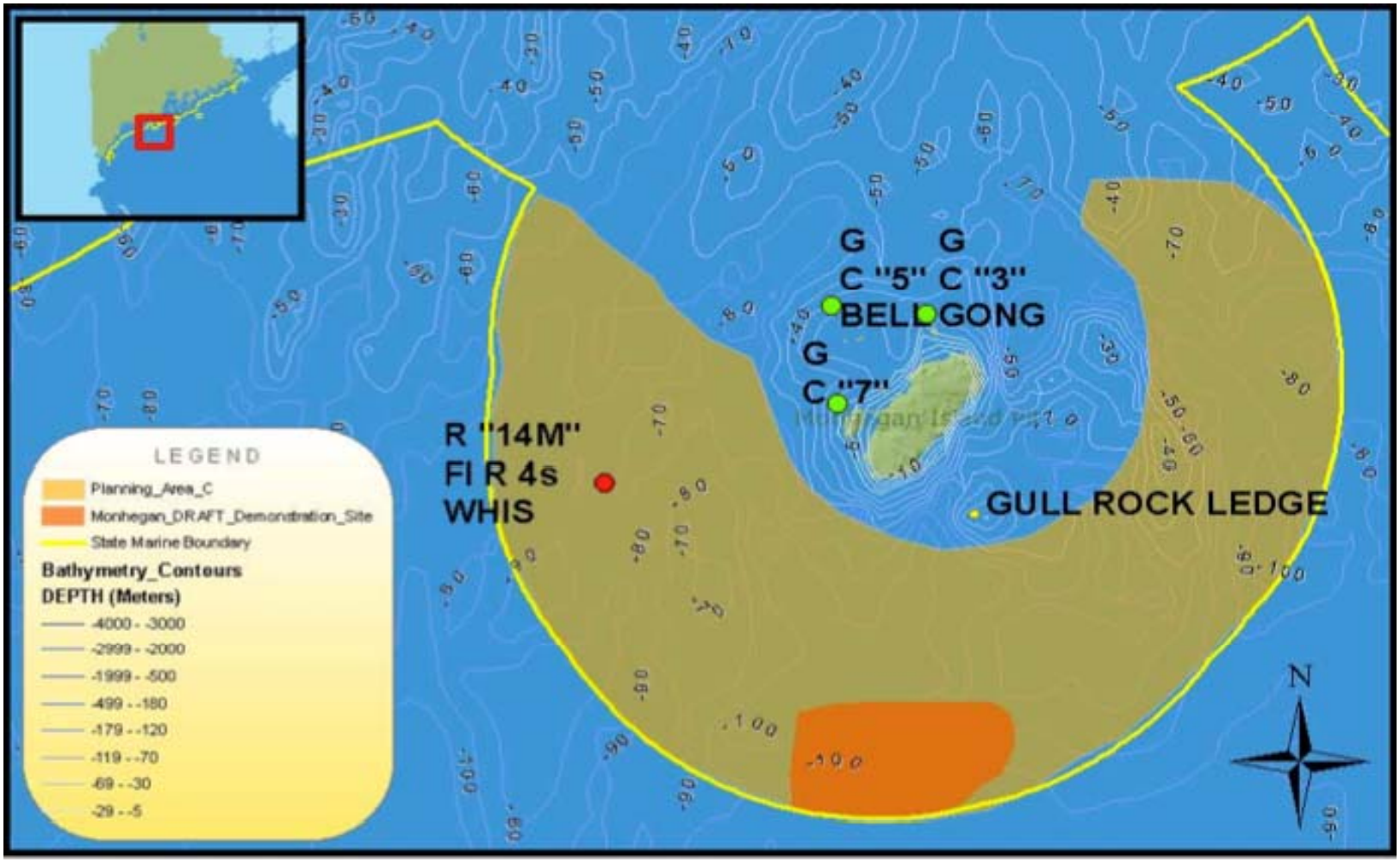
UMaine Deepwater Testbed



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Ecological Data

- 400 Layer GIS
- Benthic invertebrates
- Fish
- Marine mammals
- Birds and bats

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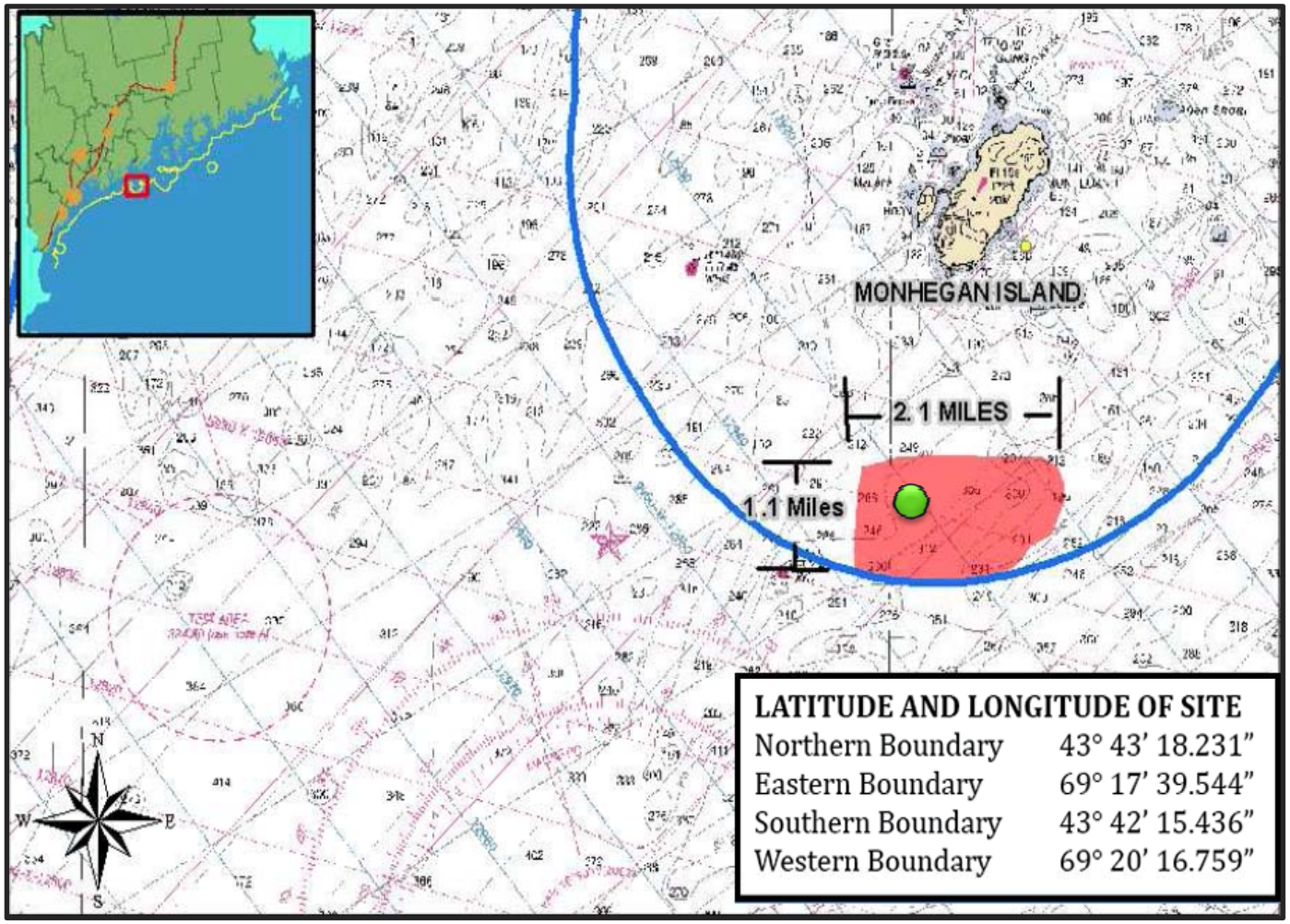
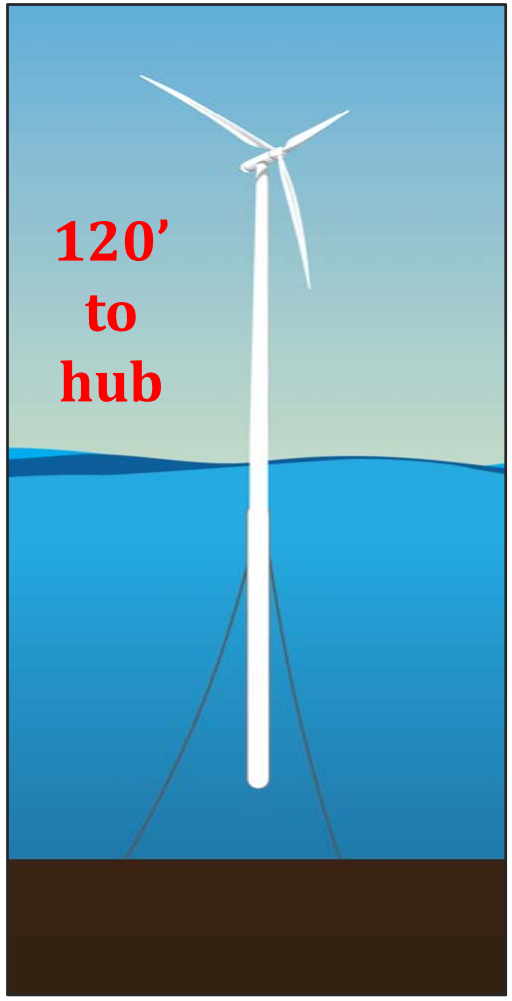
1/3 Scale Model Test 2011-2012





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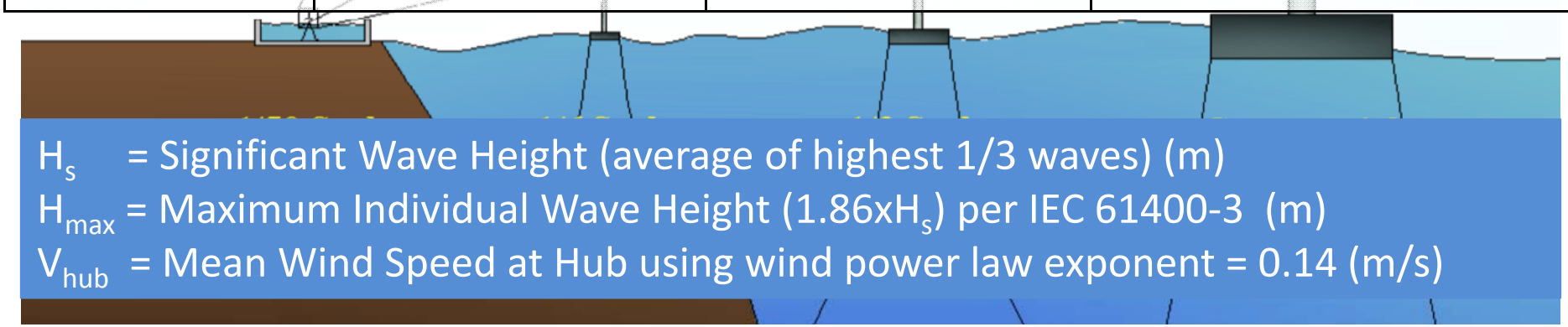
Design Conditions at UMaine Test Site

	Wind/Wave Tank			UM Deepwater Test Site			Commercial		
Geometric Scale	1/50			1/3			Full Scale		
	H_s	H_{max}	V_{hub}	H_s	H_{max}	V_{hub}	H_s	H_{max}	V_{hub}
1-yr	0.14	0.26	3.82	2.37	4.40	15.6	7.1	13.2	27.0
50-yr	0.20	0.37	5.03	3.33	7.19	20.6	10.0	18.6	35.6
100 -yr	0.21	0.39	5.16	3.50	7.75	21.1	10.5	19.5	36.5

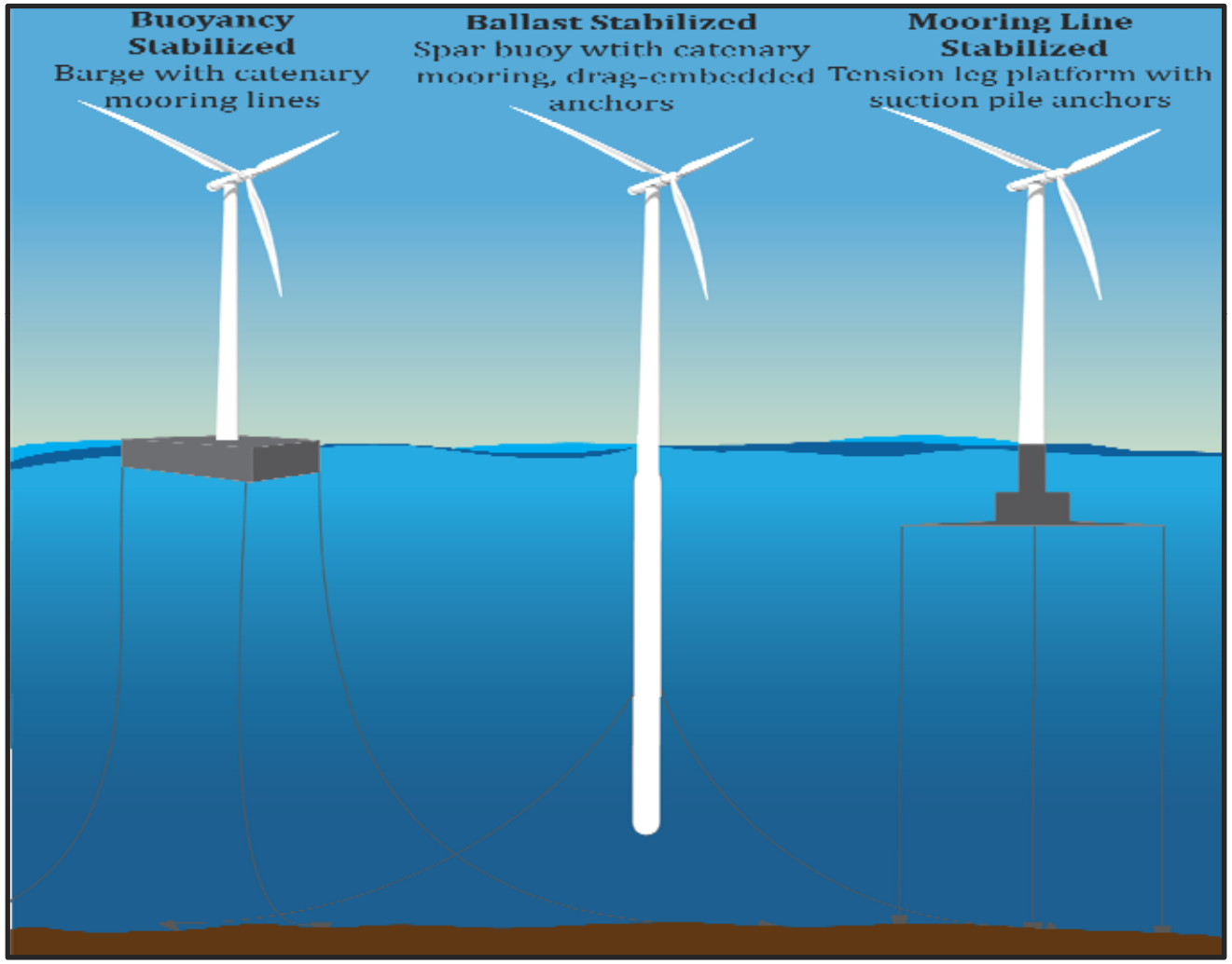


H_s = Significant Wave Height (average of highest 1/3 waves) (m)
H_{max} = Maximum Individual Wave Height ($1.86 \times H_s$) per IEC 61400-3 (m)
V_{hub} = Mean Wind Speed at Hub using wind power law exponent = 0.14 (m/s)

Deployment Period

Month	Probability of Exceeding 1/3 Scale 50 year H_s (3.3m) in one week		
	Lognormal	Weibull	Rayleigh
Jan	47%	52%	43%
Feb	67%	69%	51%
Mar	52%	56%	47%
Apr	42%	47%	42%
May	23%	28%	27%
Jun	5%	7%	9%
Jul	1%	0%	4%
Aug	0%	1%	2%
Sep	7%	4%	12%
Oct	40%	46%	40%
Nov	53%	58%	50%
Dec	73%	73%	59%

3-5 MW Test in 2014



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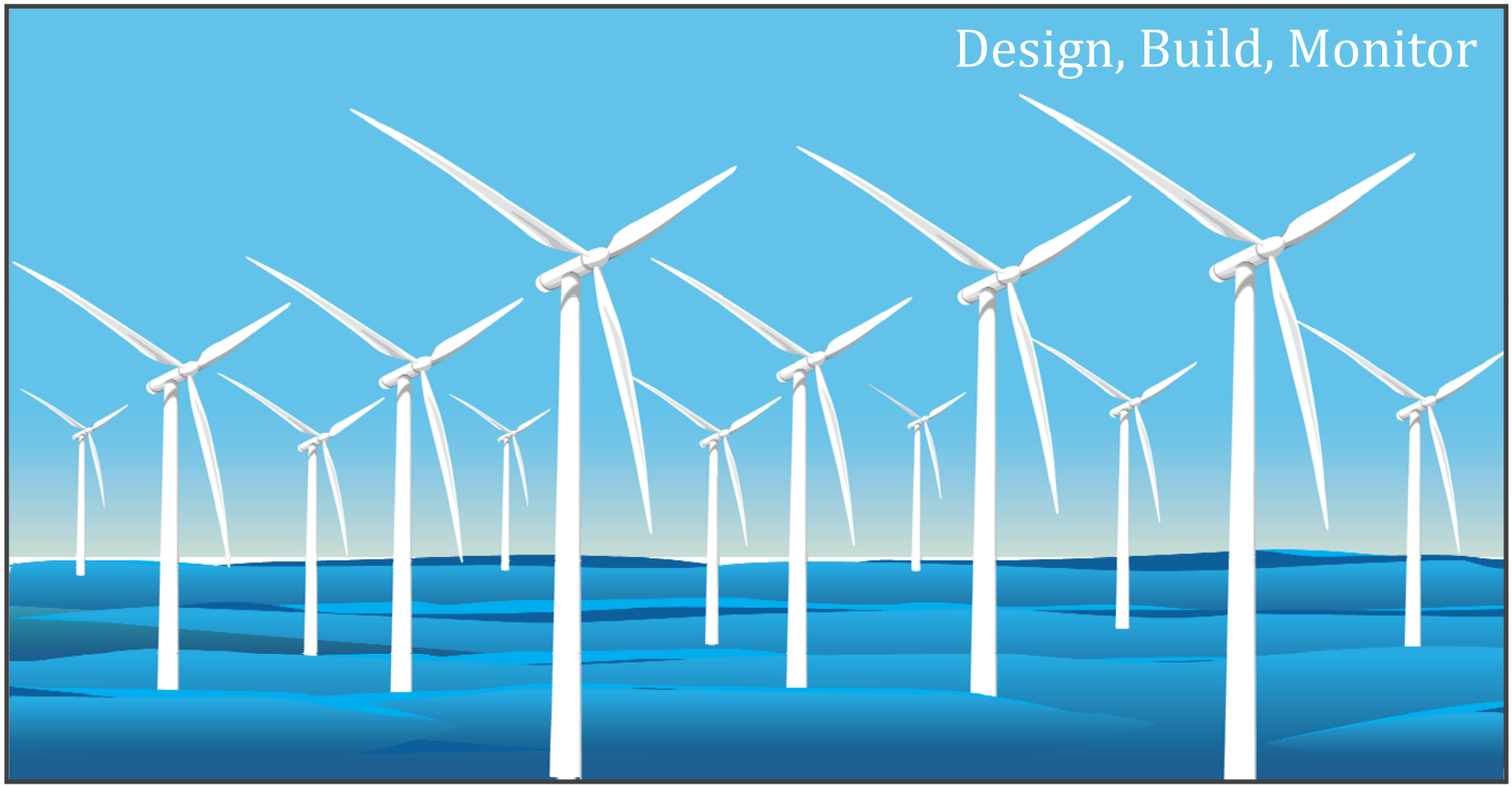
25 MW Stepping-Stone Floating Farm 2016

RFP September 1, 2010 – 5 Years to Build

1000 MW by 2020



Maine Bill LD1810, 20-year PPA

Signed Maine Public Law 270

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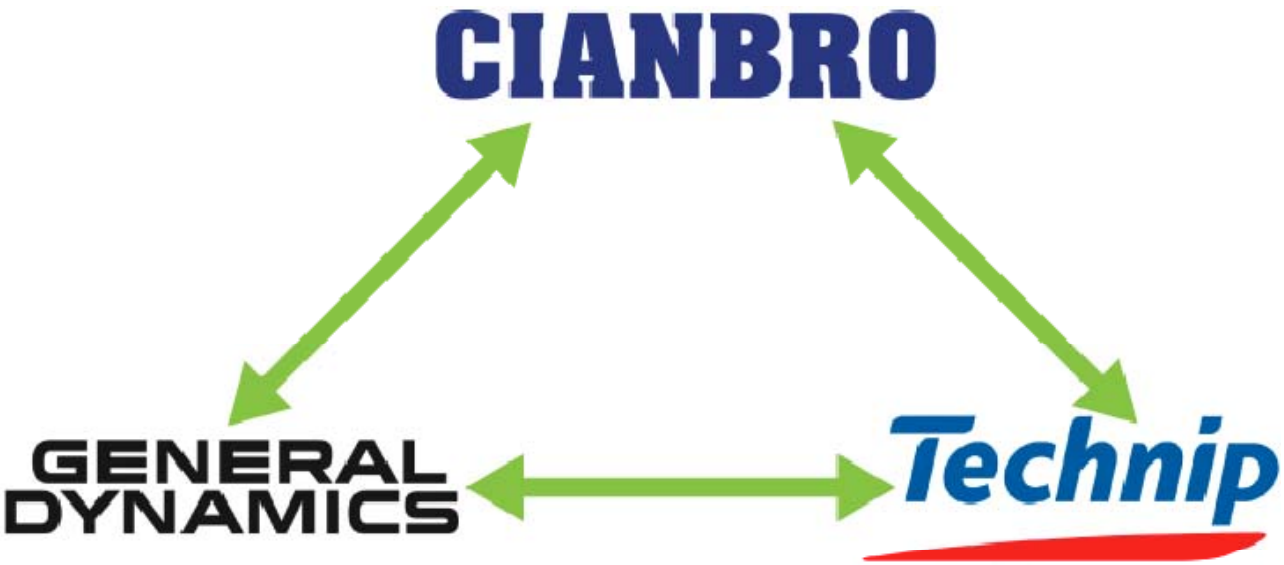
Fabrication & Deployment



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Cianbro

- Task manager for fabrication and deployment.
- 2,500 employees, provides pre-construction, construction, and maintenance services throughout North America.

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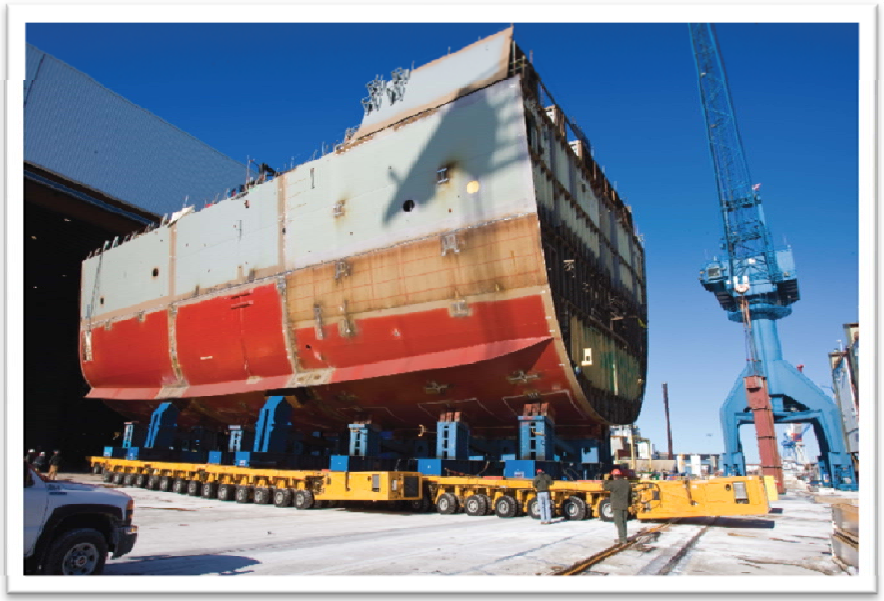
General Dynamics - BIW



- 5,000 employees at Bath Iron Works site.
- Fabrication and deployment.
- Maintains and operates dry-dock.
- Recently launched its Aegis Destroyer “Spruance.”

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Technip

- Fabricated Statoil's Hywind 1.
- Design consultant and fabrication consultant.
- World leader in engineering, technologies, and project management for the oil and gas industries.

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The Maine Plan: Over-the-Horizon Farms:
A National Electrification Model

OFFSHORE WIND
$20 billion, 15,000 jobs

5 GW

HOME HEATING

- Save 40-60%
- Weatherize, 30 years
- Heat pumps, 30 years
- $1 Billion revolving loan

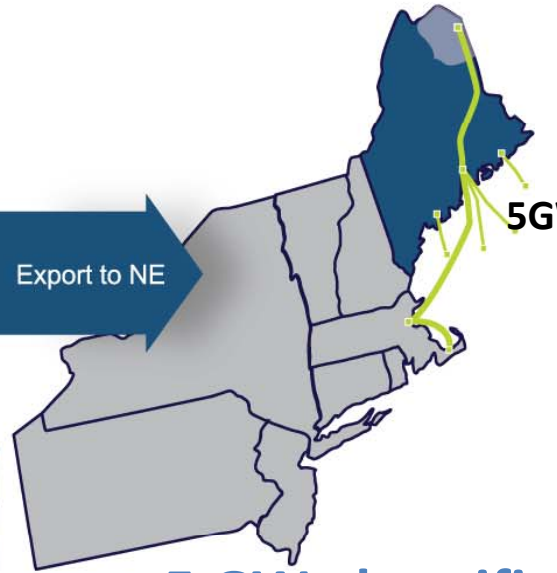
Smart Grid

Maine

Export to NE

3GW

5GW



LAND-BASED WIND
$7 Billion

3 GW

TRANSPORTATION
Save 40-60% PEHV, 30 years

5 GW electrifies heating and transportation

AEWC
Advanced Structures & Composites Center

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