Offshore Wind Technology

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Webinar: Offshore Wind Potential
for the Great Lakes

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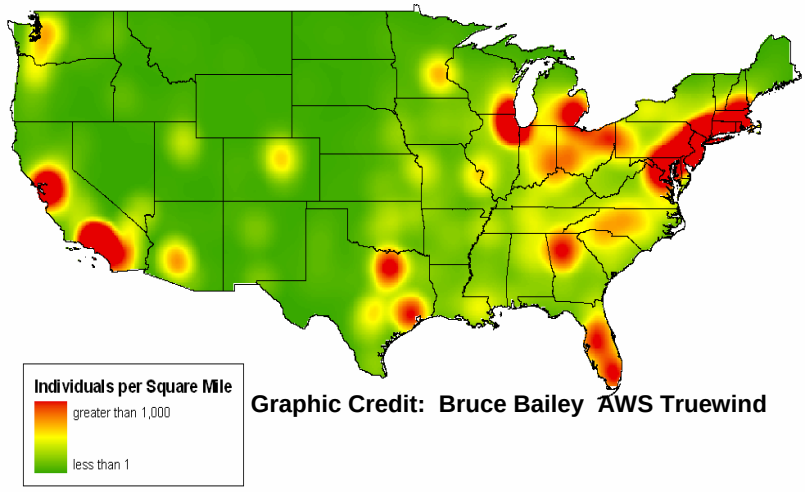
Why Offshore Wind?

28 coastal states use 78% of the electricity in US

Coastal load centers are transmission constrained and cannot be easily served by land-based wind.

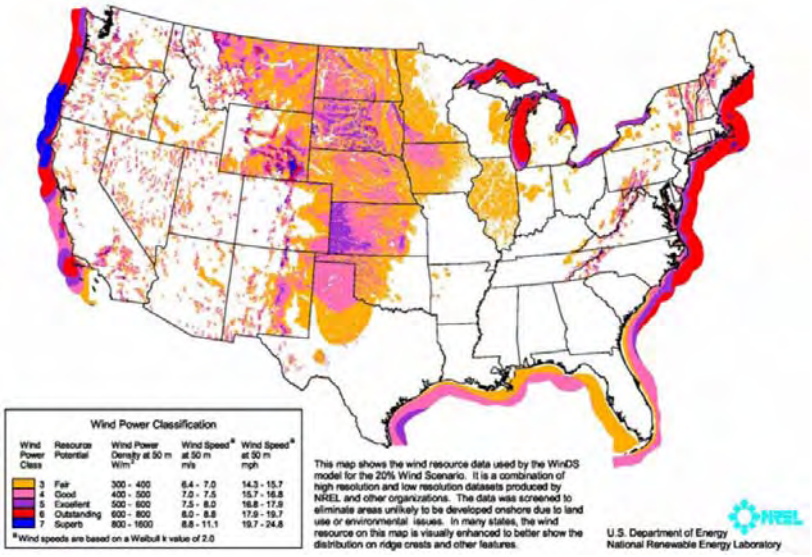
Wind energy goals cannot be achieved without offshore contributions

US Population Concentration

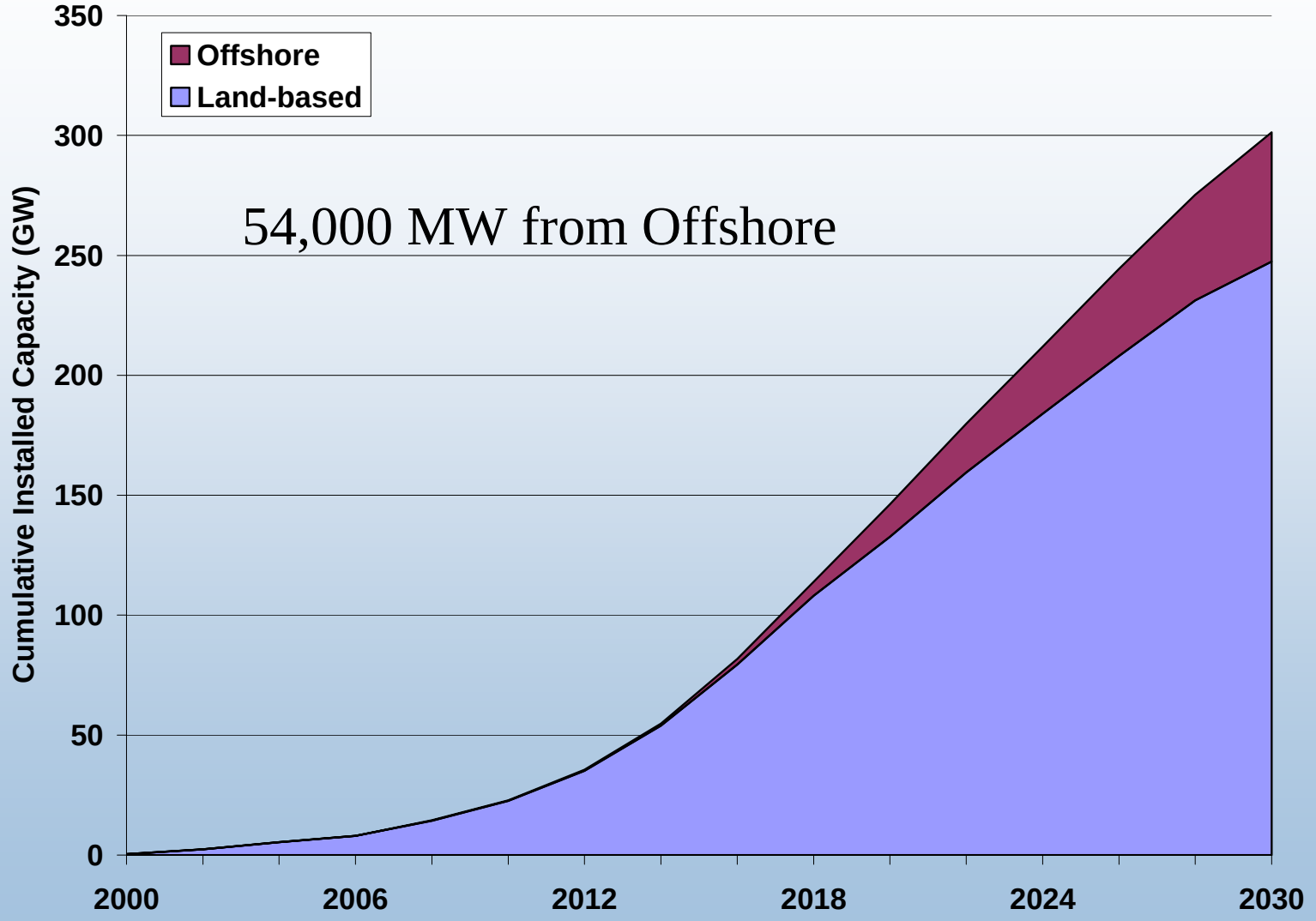


Graphic Credit: Bruce Bailey AWS Truewind

U.S. Wind Resource



20% US Electricity from Wind by 2030

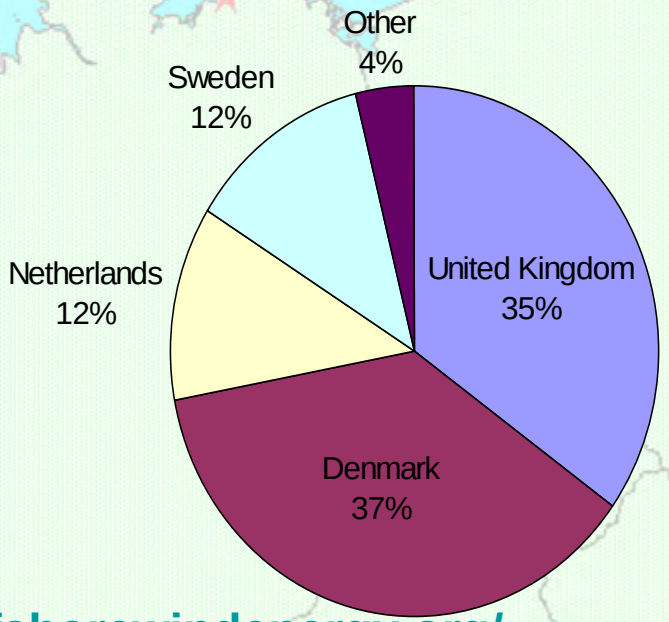


http://www1.eere.energy.gov/windandhydro/pdfs/41869.pdf

European Activity Offshore

Red = large turbines
Purple = small turbines
Blue = under construction
Grey = planned

1,135 MW installed

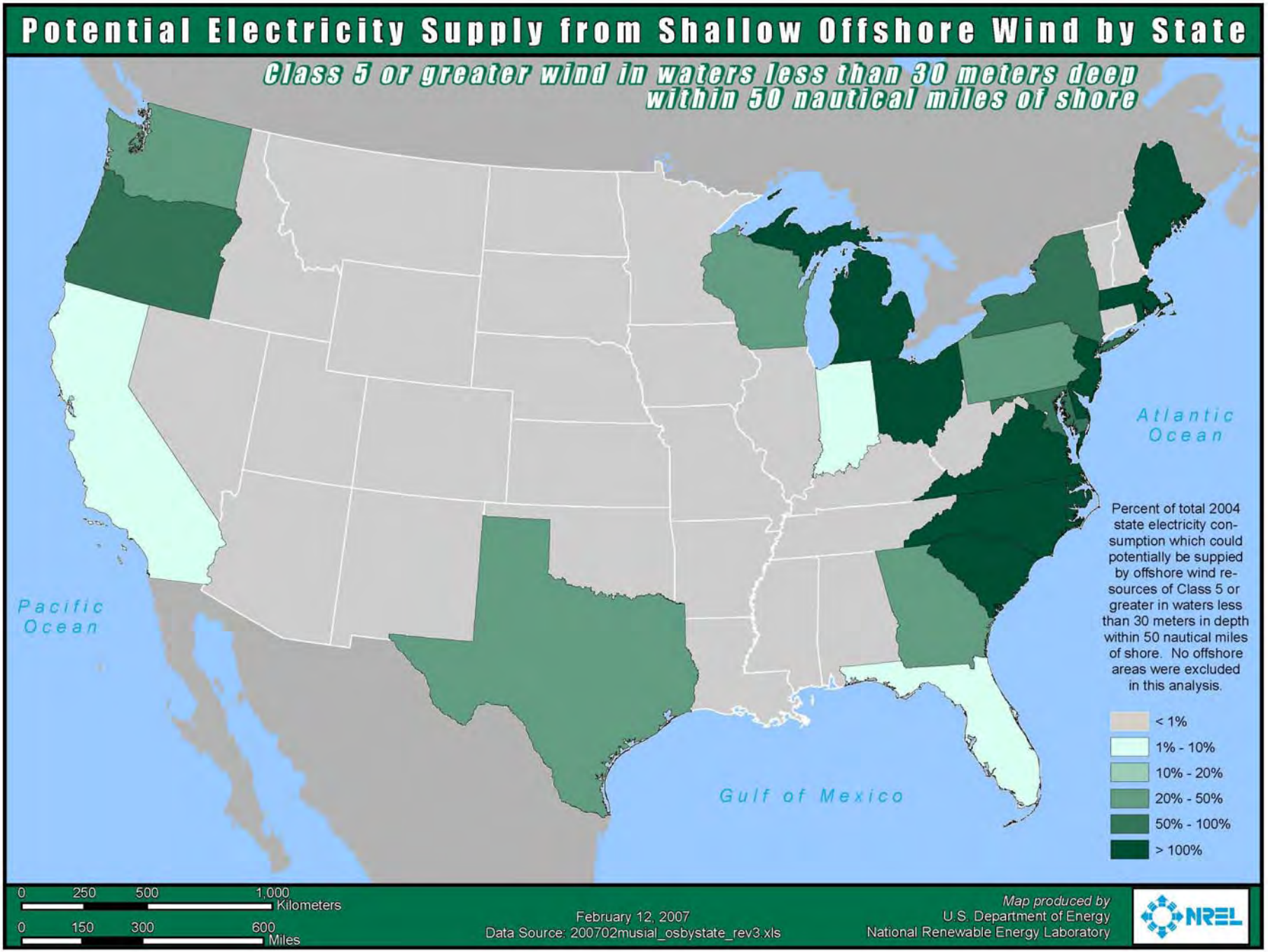


EU Offshore Wind Targets	
2010	5,000 MW
2015	15,000 MW
2020	40,000 MW
2030	150,000 MW

http://www.offshorewindenergy.org/
http://www.ewea.org/index.php?id=203

Offshore Wind

Horns Rev


Potential Electricity Supply from Shallow Offshore Wind by State
Class 5 or greater wind in waters less than 30 meters deep within 50 nautical miles of shore
Atlantic Ocean
Pacific Ocean
Gulf of Mexico
Percent of total 2004 state electricity consumption which could potentially be suppied by offshore wind resources of Class 5 or greater in waters less than 30 meters in depth within 50 nautical miles of shore. No offshore areas were excluded in this analysis.
< 1%
1% - 10%
10% - 20%
20% - 50%
50% - 100%
> 100%
0 250 500 1,000 Kilometers
0 150 300 600 Miles
February 12, 2007
Data Source: 200702musial_osbystate_rev3.xls
Map produced by
U.S. Department of Energy
National Renewable Energy Laboratory
NREL

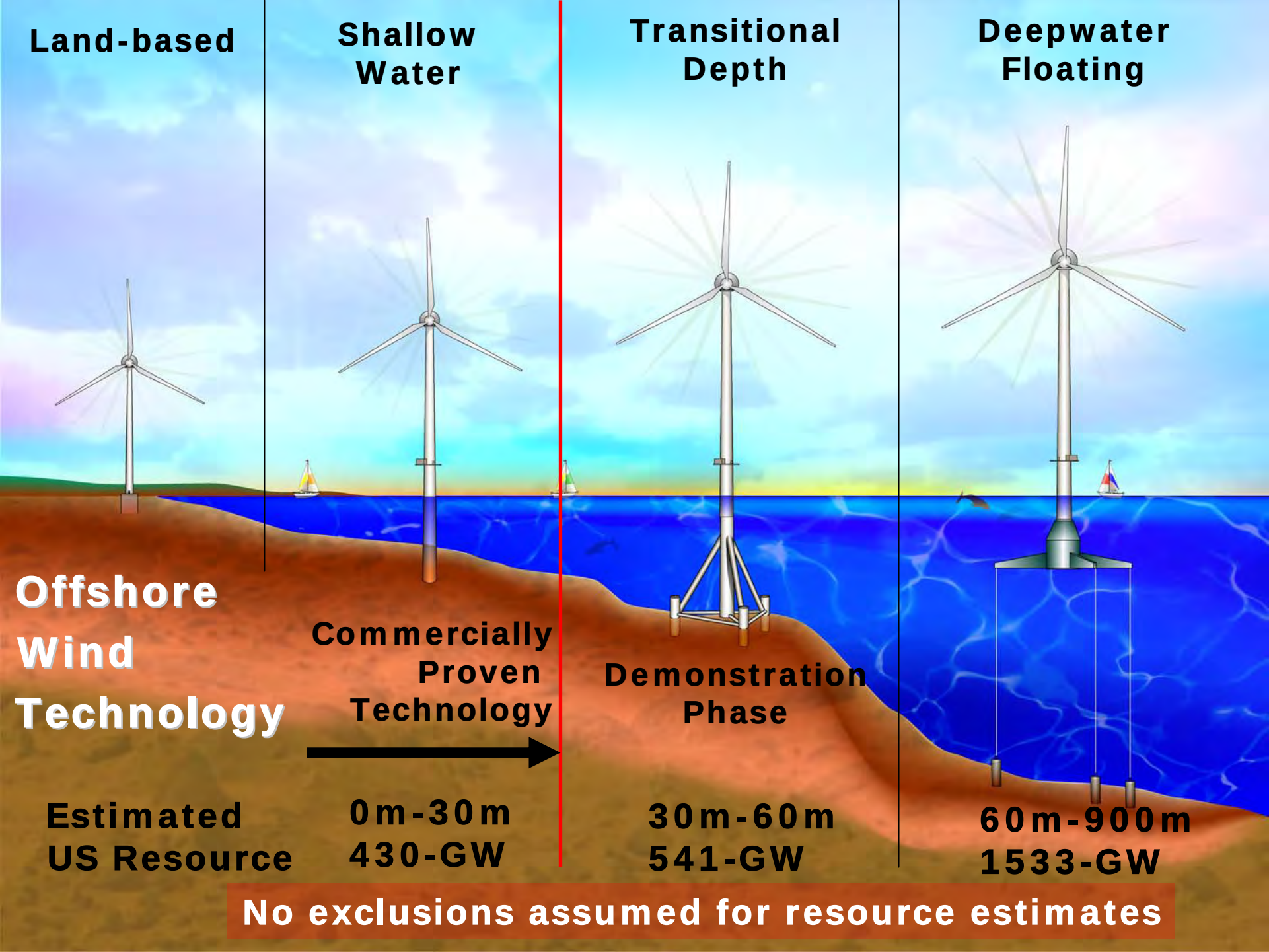
US Offshore Wind Projects Proposed

US Offshore Wind Initiatives		
Project	**State**	**MW**
Cape Wind	MA	468
Hull Municipal	MA	15
Buzzards Bay (Patriot)	MA	300
RI OER (Deepwater)	RI	400
Winergy	NY	10
NJ BPU (Garden State)	NJ	350
Delmarva (Bluewater)	DE	450
Southern Company	GA	10
W.E.S.T.	TX	150
Cuyahoga County	OH	20
Total MW		2173

No Offshore Wind Projects Installed In U.S. Yet

Offshore Wind Turbine Suppliers

Turbine Manufacturer	Turbine model & rated power	Date of availability	Offshore Operating Experience
Vestas	V90 - 3 MW	2004	Commercial
Siemens	SWT-3.6 - 3.6 MW	2005	Commercial
Siemens	SWT-2,3 - 2.3 MW	2003	Commercial
Vestas	V80 - 2 MW	2000	Commercial
RePower Systems	5M - 5 MW	2005	Offshore Demo 2006 Borkum West pilot
Multibrid	M5000 - 5 MW	2005	Onshore 2005 Borkum West Pilot
General Electric	GE – 3.6-MW	2003	Commercial inactive
Bard Engineering	VM - 5 MW	2008-09	Onshore prototype 2008
Nordex	N90 - 2.5 MW	2006	Offshore Demo 2003
Clipper Windpower	Liberty 2.5 MW	NA	Not yet offshore ready
Clipper Windpower	Britannia 7.5 MW	NA	Drawing board


Land-based
Shallow Water
Transitional Depth
Deepwater Floating
Offshore Wind Technology
Commercially Proven Technology
Demonstration Phase
Estimated US Resource
0m-30m
430-GW
30m-60m
541-GW
60m-900m
1533-GW
No exclusions assumed for resource estimates

Offshore Wind Technology Today


Vestas 2.0 MW Turbine
Horns Rev, DK


Talisman Energy:
Repower 5-MW
Beatrice Fields,
Scotland


GE 3.6 MW Turbine
Arklow Banks


Seimens 2.3 MW Turbines
Middlegrunden, DK

- Initial development and demonstration stage; 22 projects, 1135 MW installed
- Fixed bottom shallow water 0 - 30 m depth
- 2 – 5 MW upwind rotor configurations
- 70+ m tower height on monopoles and gravity bases
- Mature submarine power cable technology
- Existing oil and gas experience is essential
- Reliability problems and turbine shortages have discouraged early boom in development
- Cost are not well established in the US

Offshore Wind Energy Cost Factors

↑ **Upward Cost Pressures**

↑ Turbine Supply Shortages

↑ Steel and copper price increases

↑ Regulatory Uncertainty

↑ Euro/$ Currency Exchange Rates

↑ Project Risk Uncertainty (public acceptance, reliability issues, insurance, unstable policy)

↑ Increasing fossil prices

↓ **Downward Cost Drivers**

- Deployment
  - ↓ Learning Curve Effects
  - ↓ Mass production
  - ↓ Infrastructure development
  - ↓ Experience lowers uncertainty
- Technology Improvements
  - ↓ Land-based learning
  - ↓ High reliability components
  - ↓ Multi-megawatt turbines
  - ↓ Optimized offshore systems

Monopile Foundations

Pile Hammer
Credit: DONG Energy

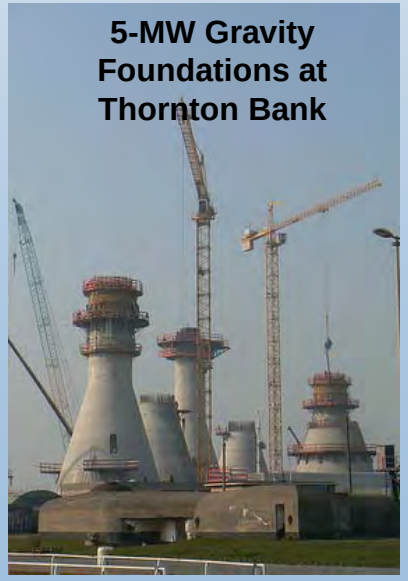
- Most common type
- Driven or drilled 25 - 30 m embedment
- Stiff soils only (e.g. sand)
- 4.5 - 6 m diameter steel tube typical
- Wall thickness 30 - 60 mm
- Minimal footprint
- Water depth experience to 25 m

Transition Pieces
Credit: DONG Energy

Credit: GE Energy

Gravity Base Foundations

- Steel or concrete
- Relies on weight of structure to resist overturning
- Ballast added after placement
- Shallow water with proper seabed preparation essential
- Examples: Siemens turbines at Nysted and Samso.
- New project underway at Thornton Bank in Belgium.



5-MW Gravity Foundations at Thornton Bank

5-MW Gravity Foundations at Thornton Bank

Multi-Pile Foundations

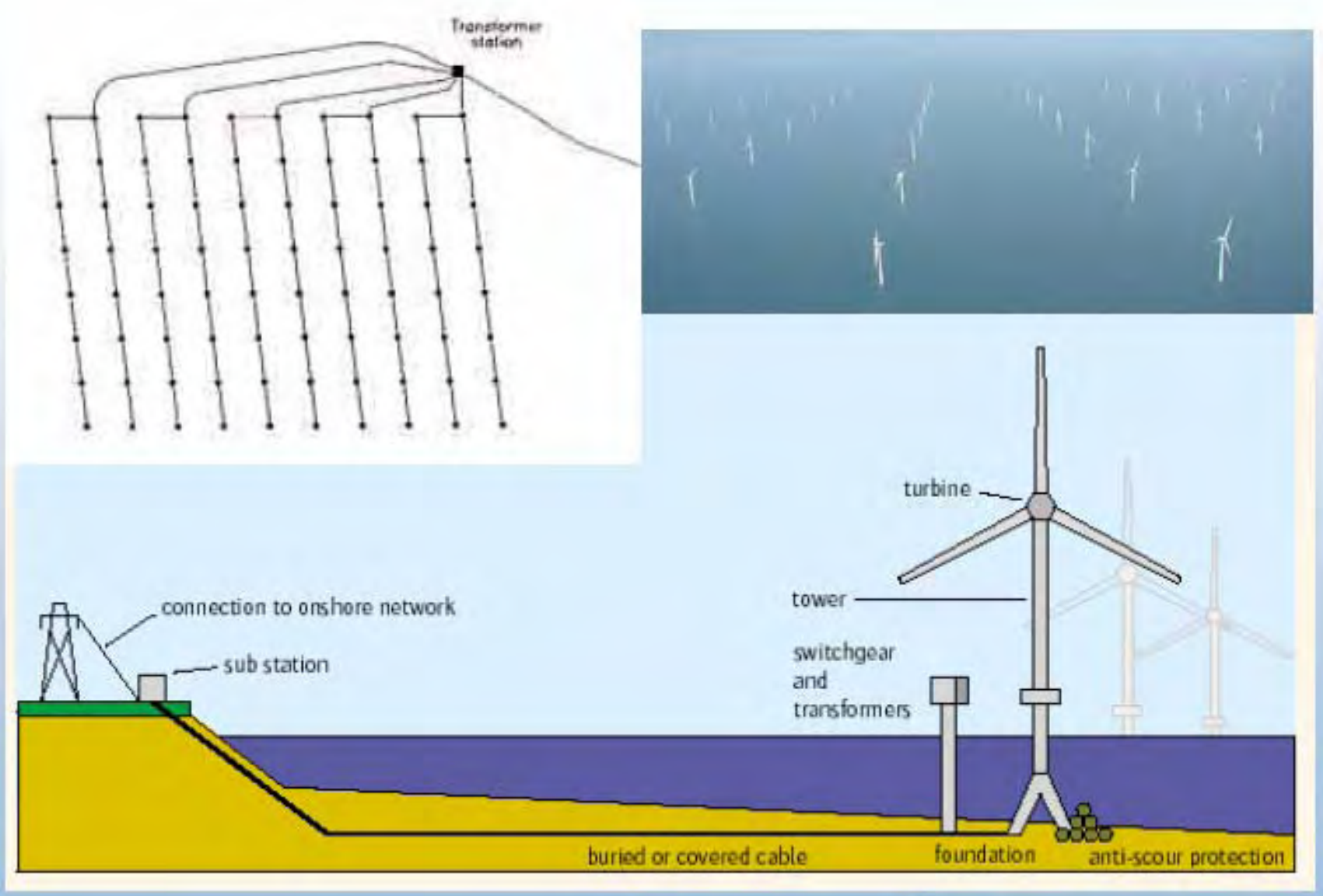
Wind Industry Experience is Limited
Jackets (welded truss towers) are the Oil and Gas Standard
Applicable in Softer Soils and Deeper Waters

Bard Engineering Tripod Variation

Multibrid M5000 Prototype on Tripod

Repower 5MW Demonstration at Beatrice Four-pile jacket

Offshore Wind Electric Distribution



Offshore Wind Turbines Accessibility is a Challenge

Credit: GE Energy

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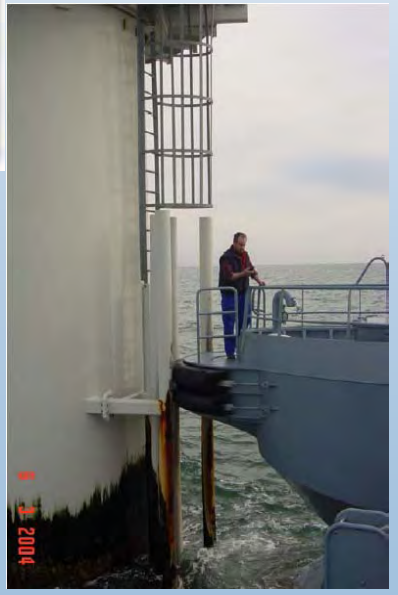

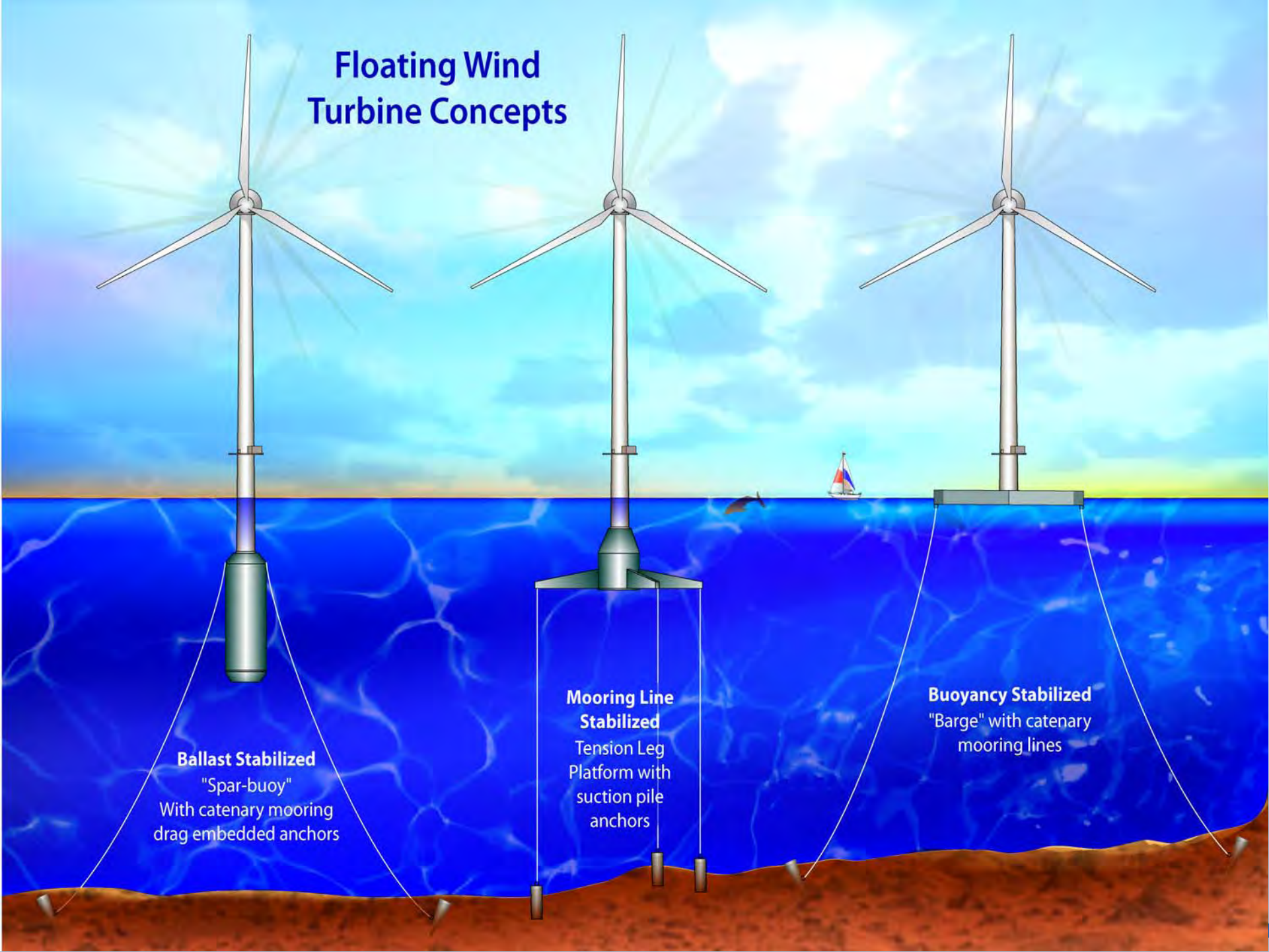
Floating Wind
Turbine Concepts
Ballast Stabilized
"Spar-buoy"
With catenary mooring
drag embedded anchors
Mooring Line
Stabilized
Tension Leg
Platform with
suction pile
anchors
Buoyancy Stabilized
"Barge" with catenary
mooring lines

Floating Wind Turbine Projects

- HyWind is under development by StatoilHydro – Norway
- Spar-buoy needs 100+ m depth to operate.
- Announced a $78MM demonstration project in North Sea.
- Partnering with Siemens using their 2.3MW turbine.
- Costs estimated about where solar is today.
- Expectations to compete with conventional wind energy long term.

- BlueH is the first company to claim “in-the-water” floating wind turbine status.
- Deployed tension leg concept with an 80kW turbine near Italy in summer 2008.
- Currently building a 2MW unit for deployment in 2009.
- Is receiving funding from the Energy Technology Institute (ETI) for UK-based projects.

Offshore Technology Summary

- Over 1000-MW deployed in Europe but none yet in the USA.
- Offshore wind resources are abundant in the USA.
- Over 2100-MW of offshore projects are underway in USA.
- Transmission-constrained load centers are beginning serious development.
- Demand for turbines is exceeding supply as land-based markets flourish, and projects await regulatory process development.
- Shallow water wind (<30m) will evolve first due to siting advantages.
- Deeper water wind energy has many advantages but will require new technology.

Thank you!

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Photo credit: http://www.owen.eru.rl.ac.uk/images/seaside.jpg