

A Vision for High Volume Wind Energy Markets

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Robert Thresher

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Today 2006

**Bulk Power
Generator
5-8¢ at 13mph
With No PTC**

- Land Based
- Bulk Electricity
- Wind Farms

**Less than 1% of
Electricity Market**

Land-Based Electricity Path

**Land-Based LWST
Large-Scale
2-5 MW**

Transmission
Barriers

Tomorrow

LWST Turbines:
• 3.6¢/kWh at 13mph
• Electricity Market
2012

Offshore Electricity Path

**Offshore Turbines
5 MW and Larger**

Cost & Regulatory
Barriers

Offshore LWST Turbine:
• 5 cents/kWh
• Shallow/*Deep* water
• Electricity Market
• Higher wind Sites
2014 and Beyond

Advanced Applications
Path

• Hydrogen
• Clean Water
• Plug Hybrids

Cost & Infrastructure
Barriers

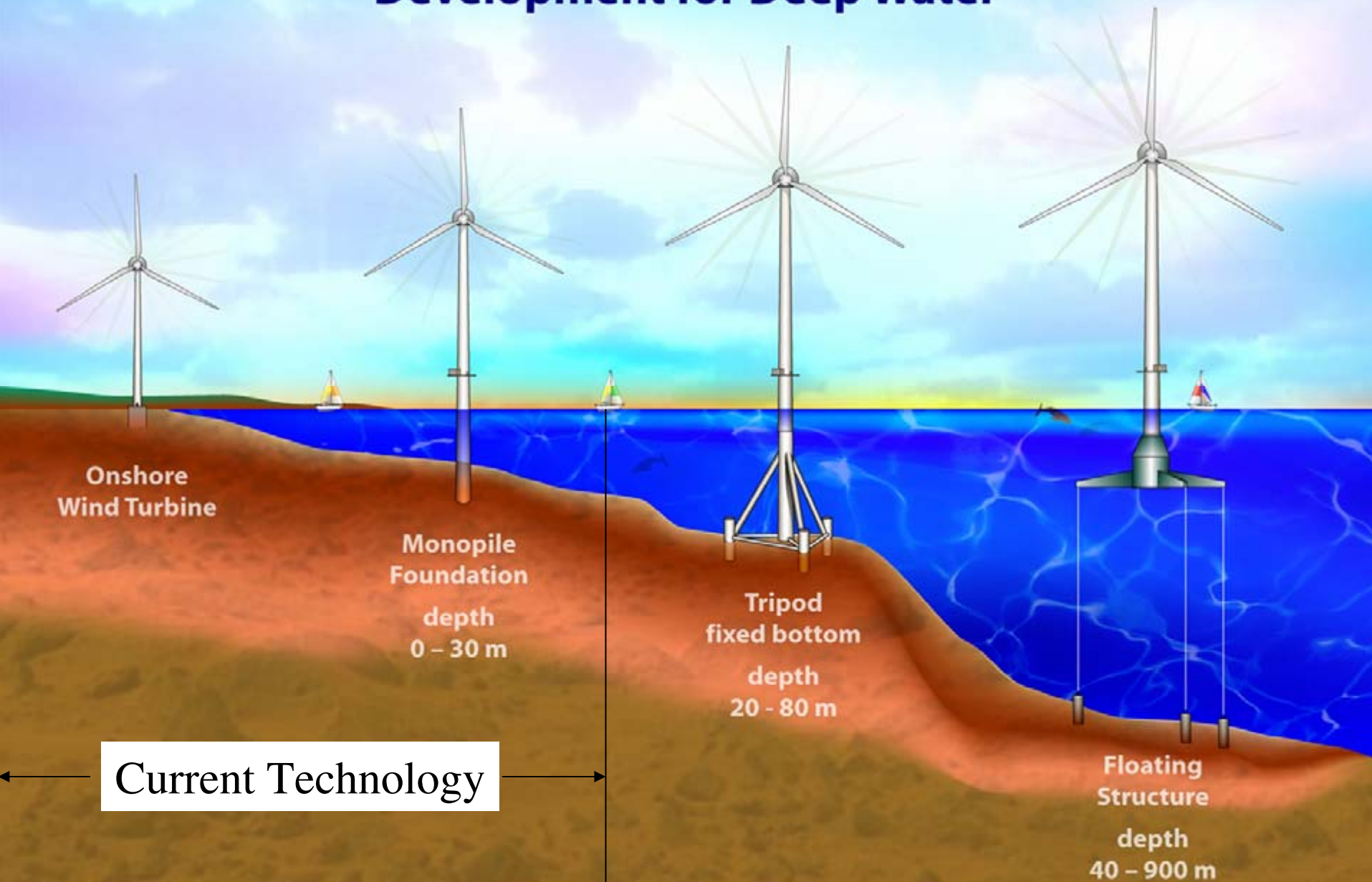
**Custom Turbines
for Multi-markets:**
• Electricity
• H2 production
• Desalinate water
• Transport & Storage
2020 and Beyond

Advanced Turbines Competitive without a PTC

- **Lifetime O&M cost reduction through innovation giving high reliability**
- **Condition monitoring to actively analyze the turbine condition and forecast maintenance**
- **Drivetrain innovation to reduce weight/cost while improving reliability**
- **Active rotor pitch and speed control for load reduction and more energy**
- **Lighter rotors with higher tip speeds and more flexible blades giving higher energy and lower loads**
- **Twist/flap coupling for passive load control during turbulence conditions**
- **Scaling to larger sizes with transport and installation constraints?**



Offshore Wind Turbine Development for Deep Water



Onshore
Wind Turbine

Monopile
Foundation
depth
0 - 30 m

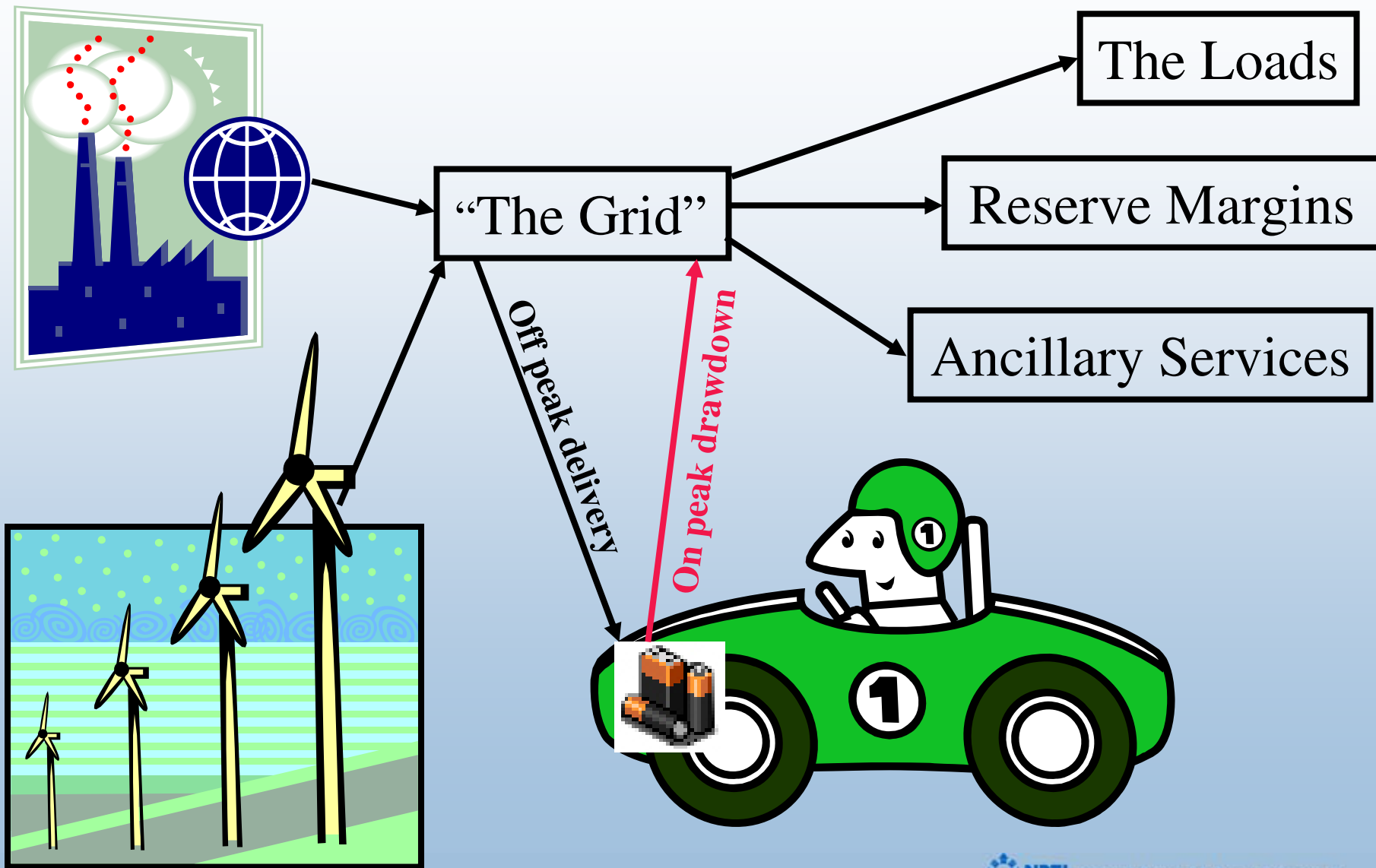
Tripod
fixed bottom
depth
20 - 80 m

Floating
Structure
depth
40 - 900 m

Current Technology

Plug Hybrid Electric Vehicles

(A Future Off-Peak Electricity Market with Storage)



Offshore Wind / Wave Synergy

- Long-term Possibility +20 Years
- Maximize Grid Interconnect Potential
- Reduce Intermittency & Increase Total Energy Output
- Increase System Reliability & Reduce Maintenance



Credit: GE Energy



Wind / Wave Integrated Platform
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