Kinetik Partners

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Innovative Manufacturing and Supply Chain Concepts

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Sandia National Laboratories – Wind Turbine Reliability Workshop

Kinetik Partners

Business and Technology Innovation

Experienced consulting firm specialized in wind technology commercialization and manufacturing innovation

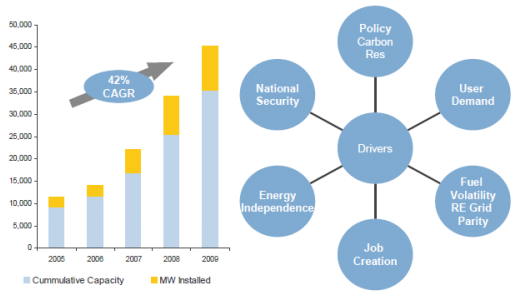
- Technology and Business Development Strategy
  - Market entry options
  - Value chain analysis
  - Technology road mapping and futuring
  - Commercialization and R&D strategy
  - Cost modeling and profit pool analysis
  - Business model innovation
- Strategic Brokering
  - Strategic partnerships: teaming agreements, technology transfer, JV, JDA, licensing product rights, go-to-market partners
  - Corporate venturing
  - Collaborative R&D program development
  - Financing strategy (state, federal, private investment)

Approach – Kinetik Innovation Process

KIP Allows Industry and Regions to Develop Competitiveness Programs

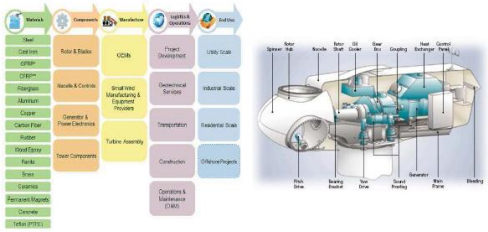
Market Intelligence

Market growth
Forecasts and Drivers



Market and Product Segmentation

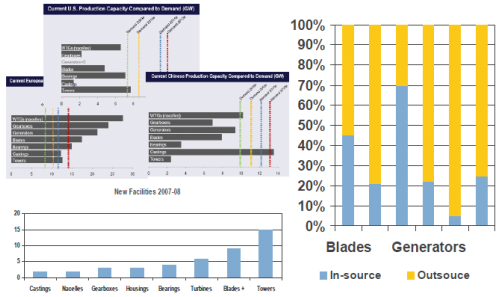
Product Segmentation
Detailed value chain analysis



SOURCE: Center on Globalization, Governance & Competitiveness

Supply Chain Dynamics

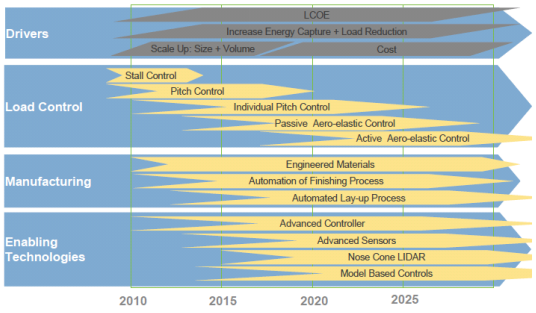
Supply Chain Analysis
Production & new planned capacity and sourcing dynamics



Technology Evolution

Technology Road Maps

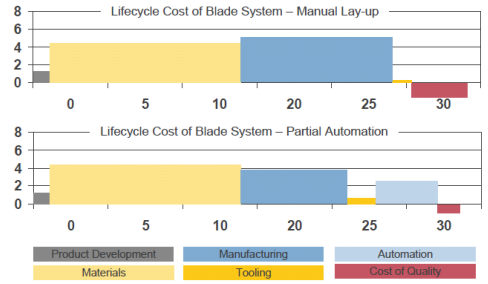
Illustrative



Present and Future Value Chain

Cost and Profit Pool Analysis
Effects of new technology on revenue and margins

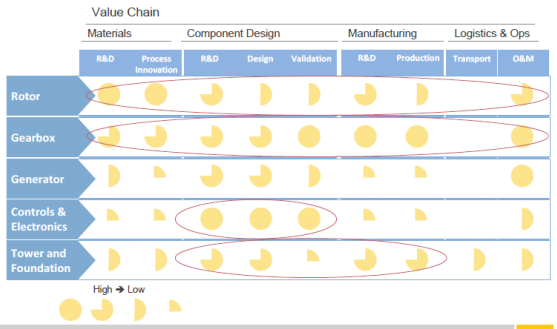
Illustrative - Disguised Client Example



Strategy Development and Execution

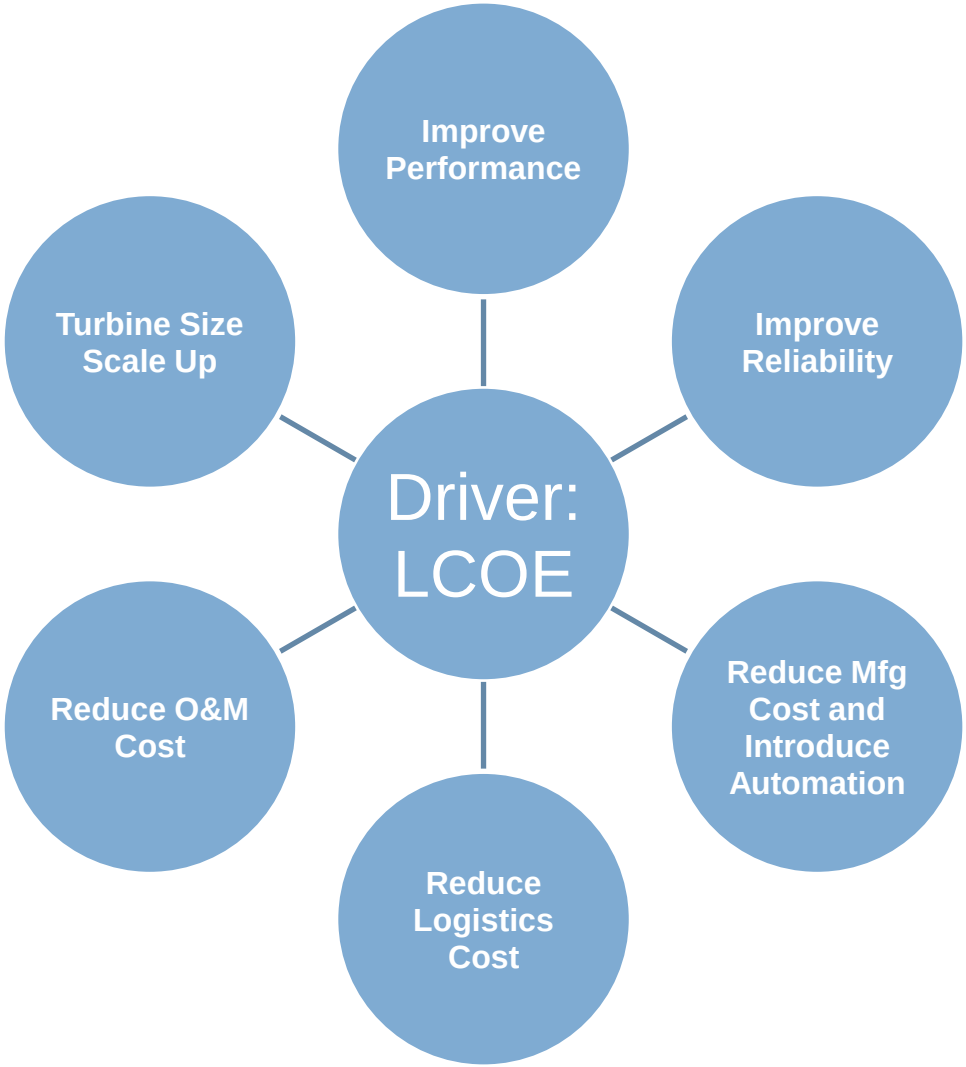
Corporate or Regional Capability Analysis
Regional capability analysis example

Illustrative

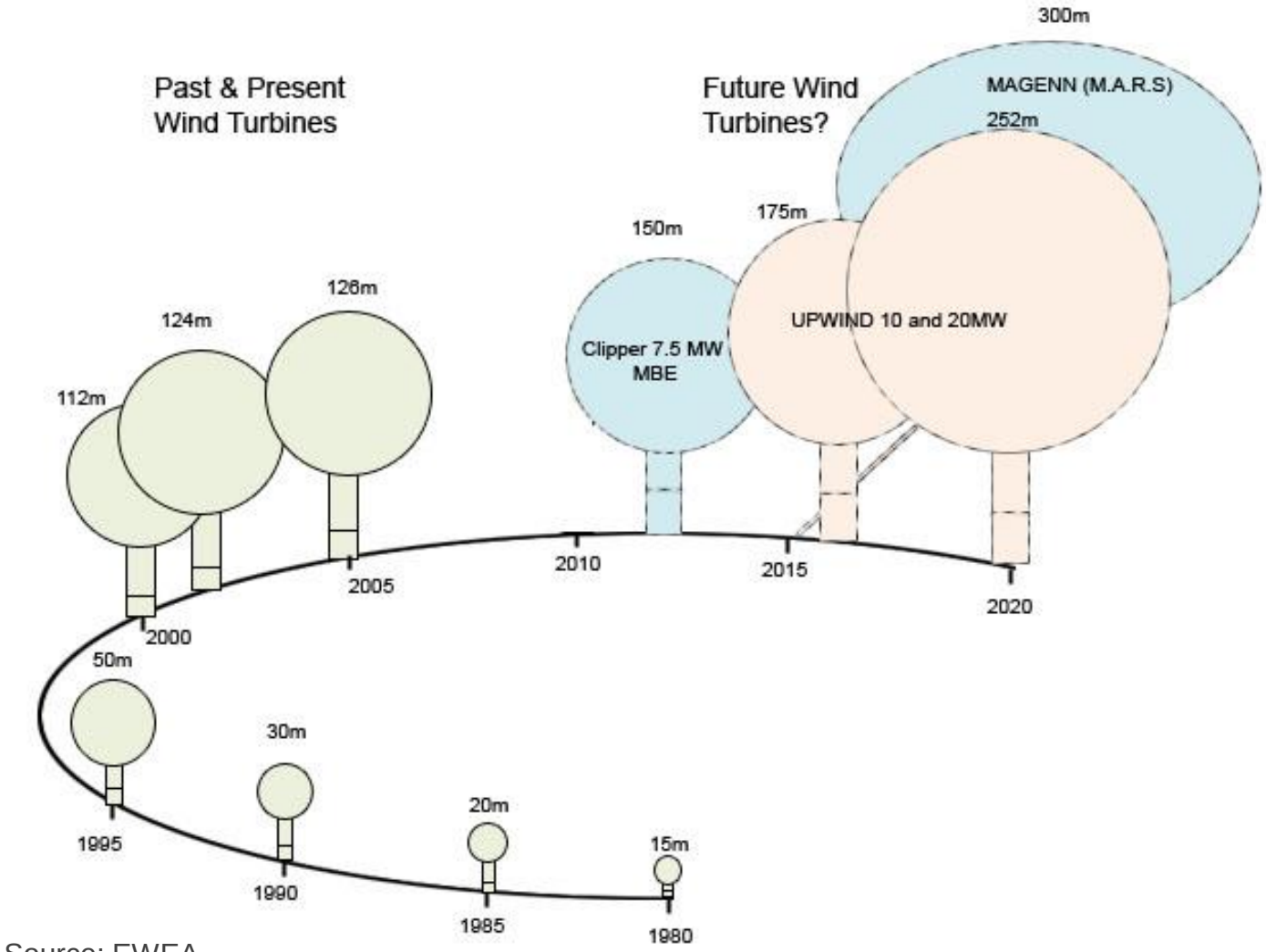


Wind Turbine Product Development Drivers

What is Driving Innovation?



Utility Wind Turbines – Scaling up in Size
Industry Trends



Source: EWEA

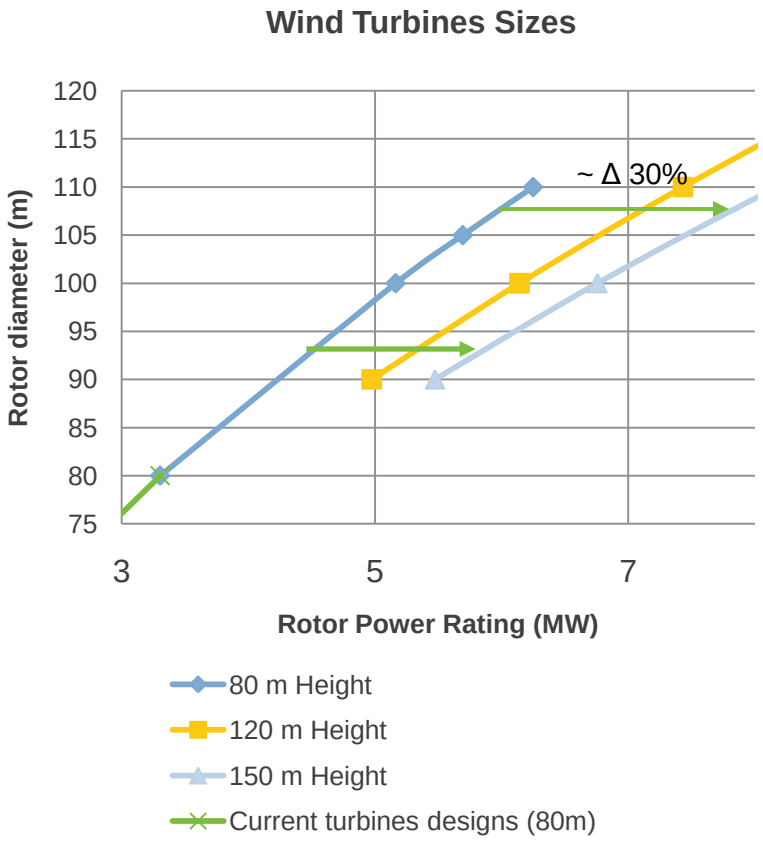
Turbine Technology Offer Overview

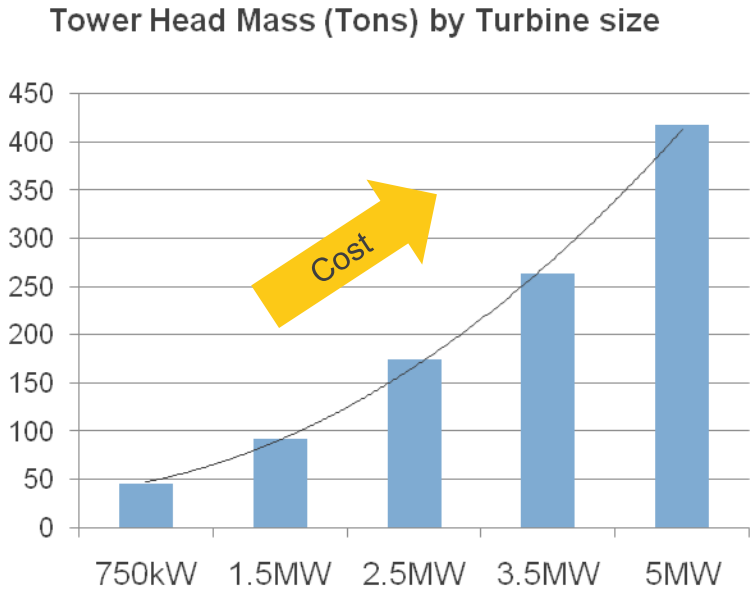
Driver Cost → Driver Efficiency-Reliability

OEM	Sub-2 MW Segment (MW)	2 MW to 3 MW Segment (MW)	3 MW and Above (MW)	Offshore Segment (MW)
Vestas	V52 (.85), V82 (1.65)	V80 (2.0), V90 (1.8 and 2.0)	V112 (3.0), V90 (3.0)	V90 (3.0), 6.0, 7.0
GE Wind	1.5s,1.5sl, 1.5sle (1.5),1.6	2.5xl(2.5)		4.0
Gamesa	AE-59 (.8), G52 and G58 (.85), G66 (1.65)	G80 (2.0), G87 (2.0), G90 (2.0)	GX (4.5-6)	5.0
Enercon	E-33 (.33), E-48 and E-53 (.8), E-44 (.9)	E-82 (2.0), E-70 (2.3)	E-112 (4.5), E-126 (6.0)	7.5
Suzlon	S52 (.6), S64 and S66 (1.25)	S82 (1.5), S88 (2.1)		
Siemens	SWT-1.3-62 (1.3)	SWT-2.3-82 VS (2.3), SWT-2.3-93 (2.3)	3.0 DD	SWT-3.6-107 (3.6)
Sinovel	70 and 77 (1.5)		3000 (3.0)	3000 (3.0)
Acciona	AW 1500 (1.5), AW-82 1500 (1.5)		AW 3000 (3.0)	
Goldwind	S43 (.6), S48 (.75), S62 (1.2), S70 and S77 (1.5), S82 (1.5)	2.5	3.0	3.6
Nordex	S70 (1.5)	N90 (2.3), N80 (2.5), N90 HS (2.5), N90 LS (2.5), N100 (2.5)		N90 offshore (2.5)
Dongfang	70 and 77 (1.5)		3.0	10.0

Source: EERE & Kinetik Partners

Wind Turbine Scaling – Innovation Driver

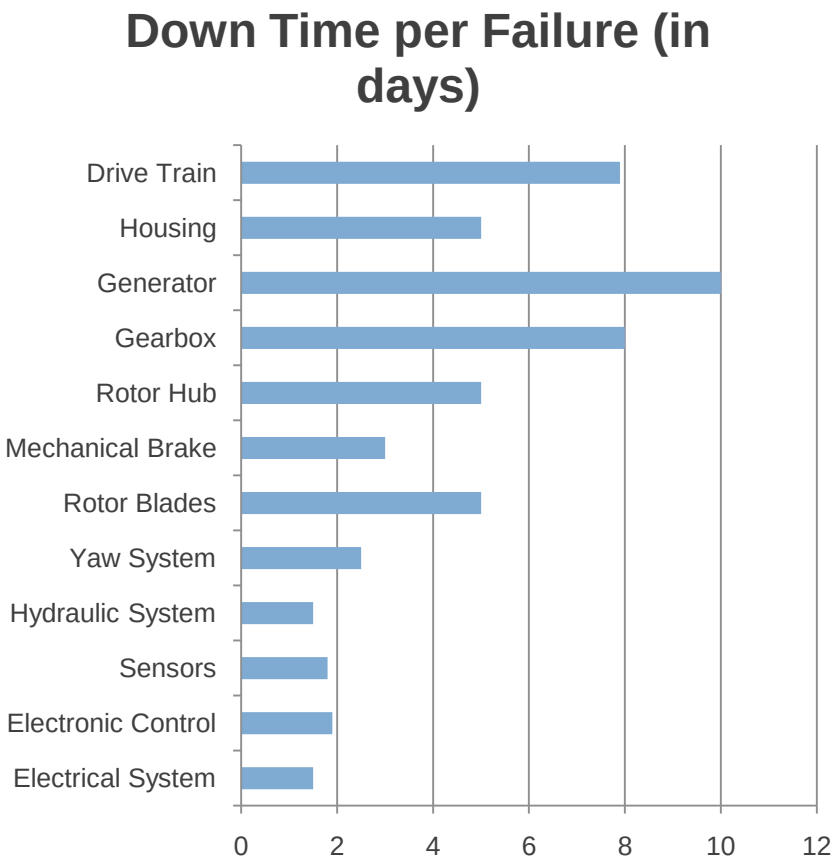


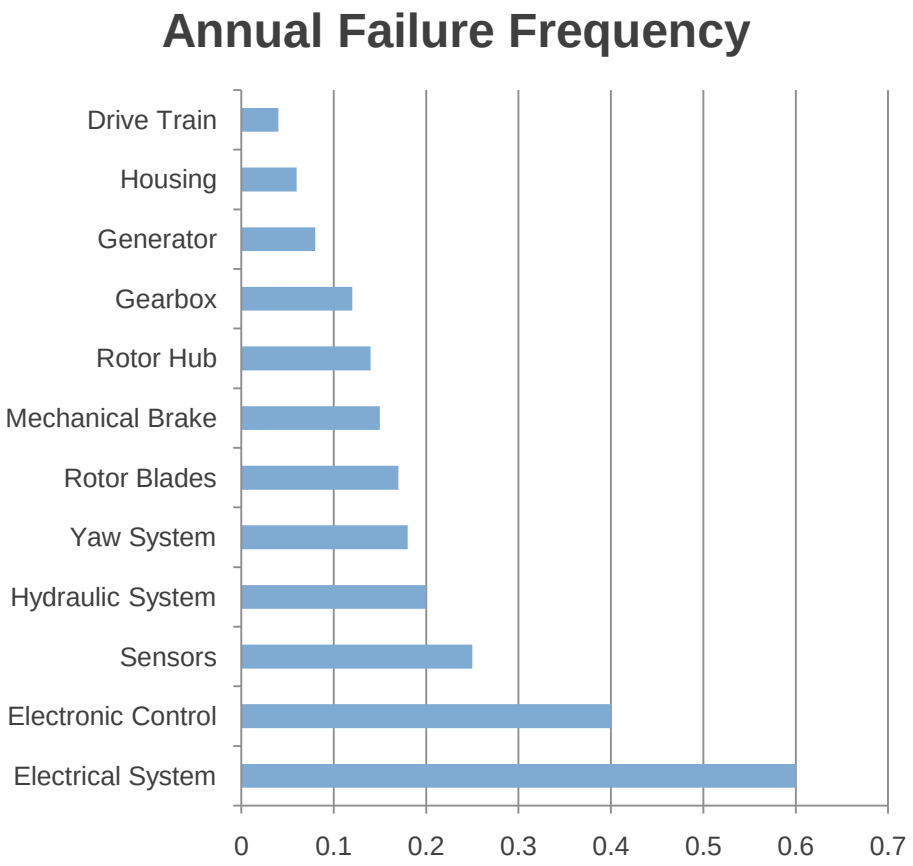


$M = 2.2692 (D^{2.5318})$
M = Tower Head Mass (kg)
D = Rotor Diameter (m)

Source: NREL

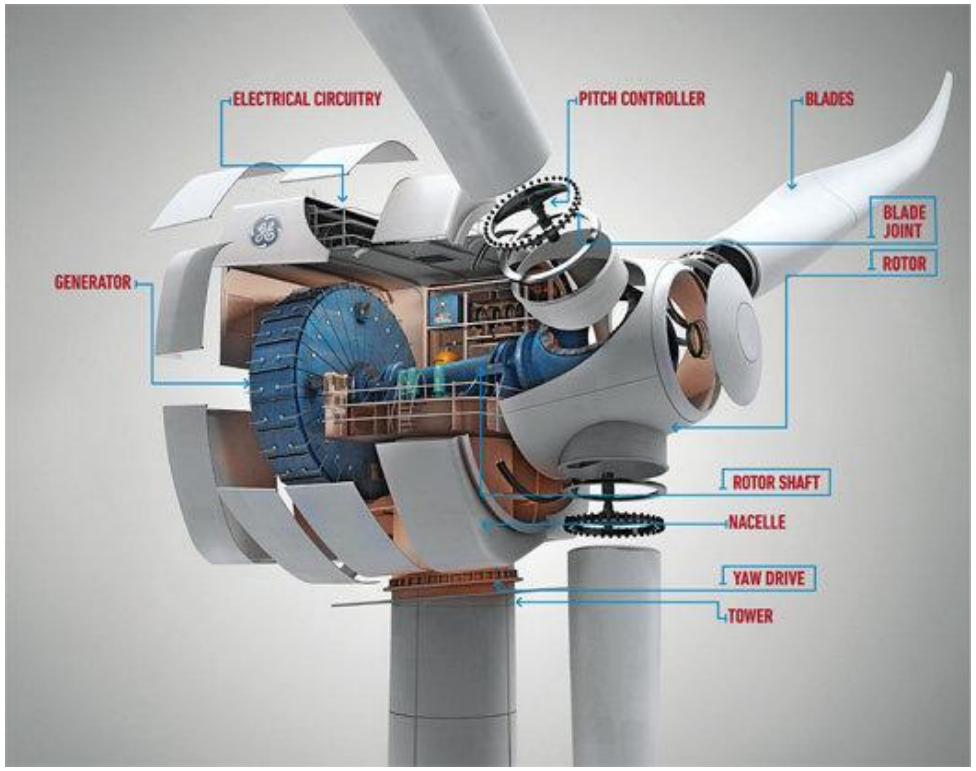
Reliability of Wind Turbine Components – Innovation Driver



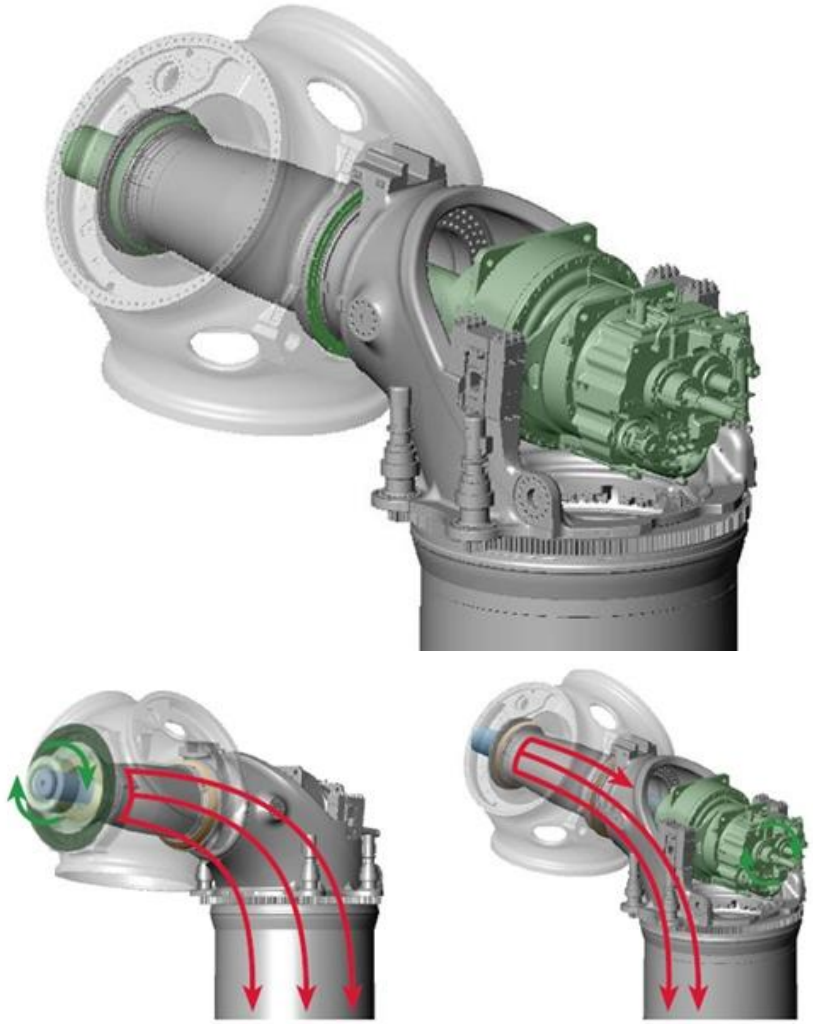


Source: Historical European Experience – Paul Kuhn, ISET

Wind Turbine System Design Innovation



GE 4.0MW Direct Drive



Alstom Load Mitigating Design

Source: GE, Alstom

Wind Turbine System Design Innovation

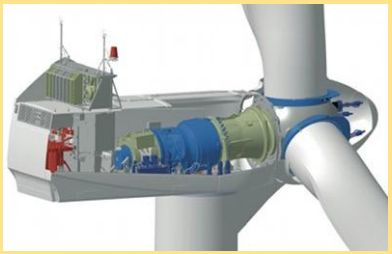
Drivetrain Architecture Evolution

Geared Systems

Vestas

Clipper

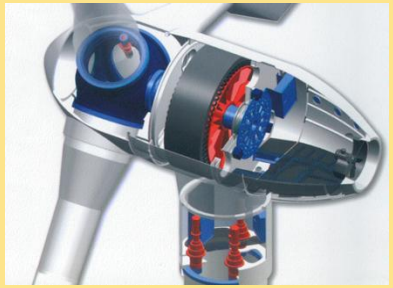
Gamesa



Direct Drive Systems

Enercon

M-Torres



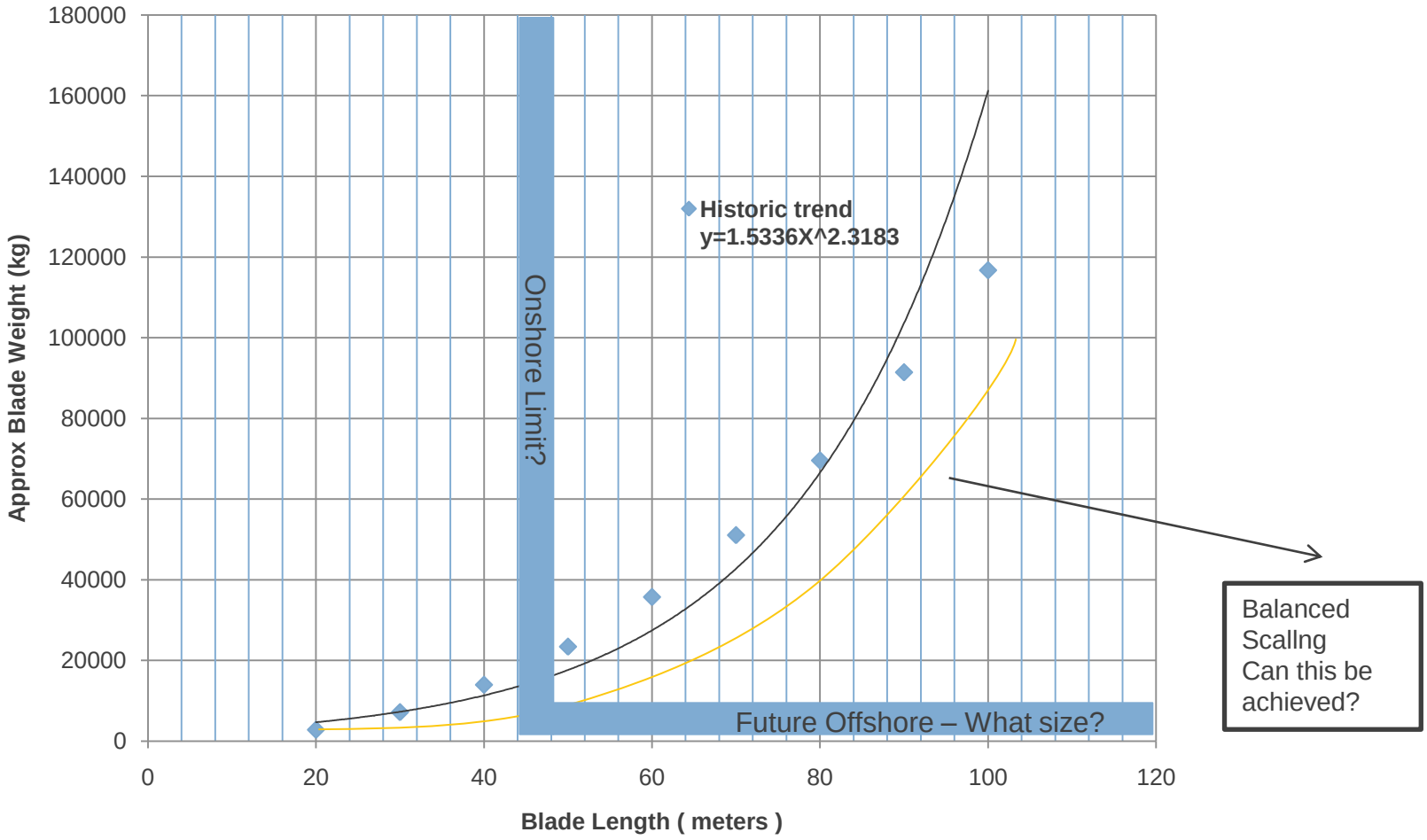
NPS

DFIG + Partial Converters

Integrated Gearbox + Multi-pole & PM Mid-Speed Generators + Full Converters

Blade Scaling – Innovation Drivers

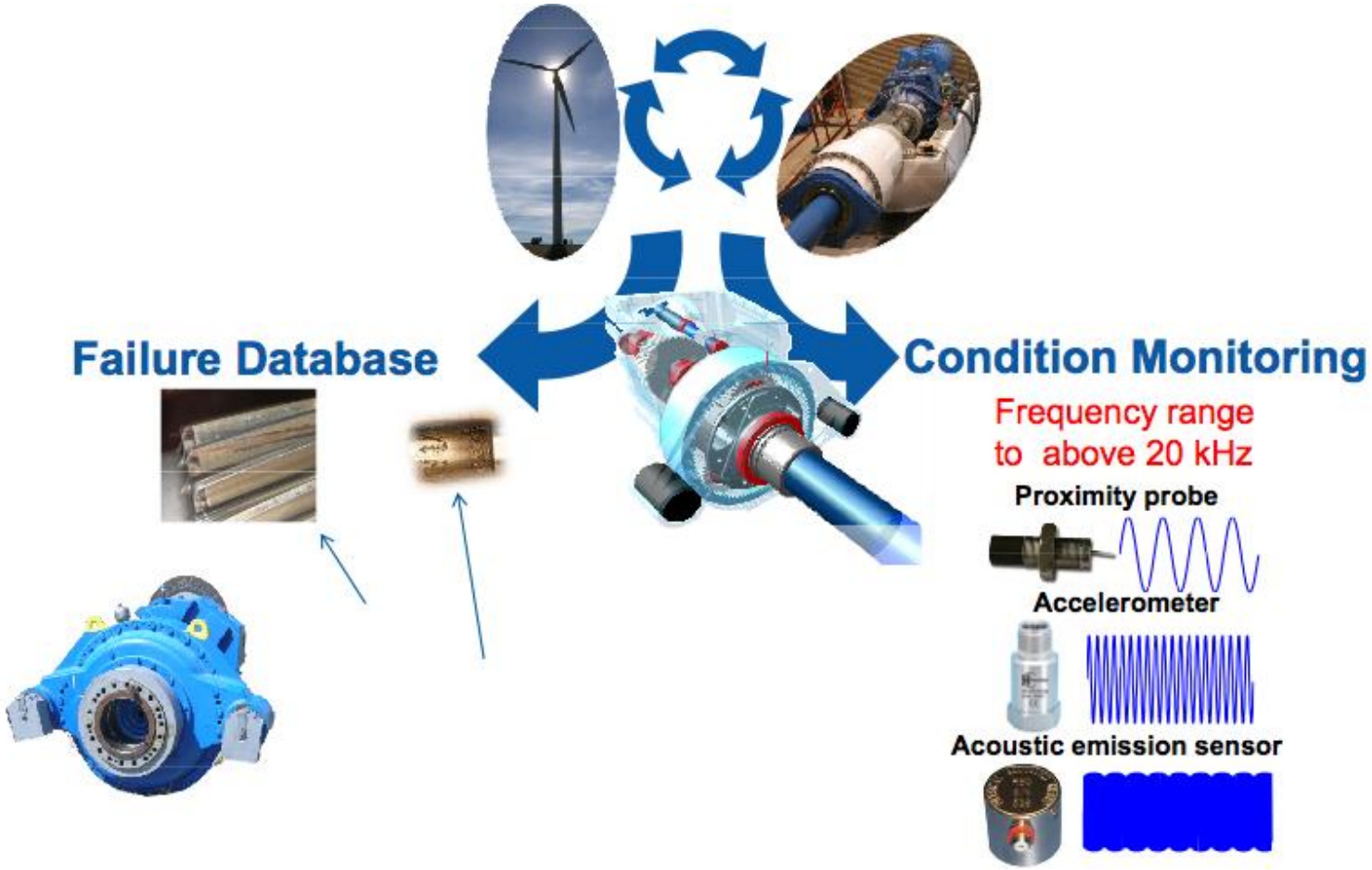
Larger blade design drives advanced manufacturing and design innovation



Gearbox Reliability – Innovation Driver

A significant amount of R&D is currently going into gearbox reliability

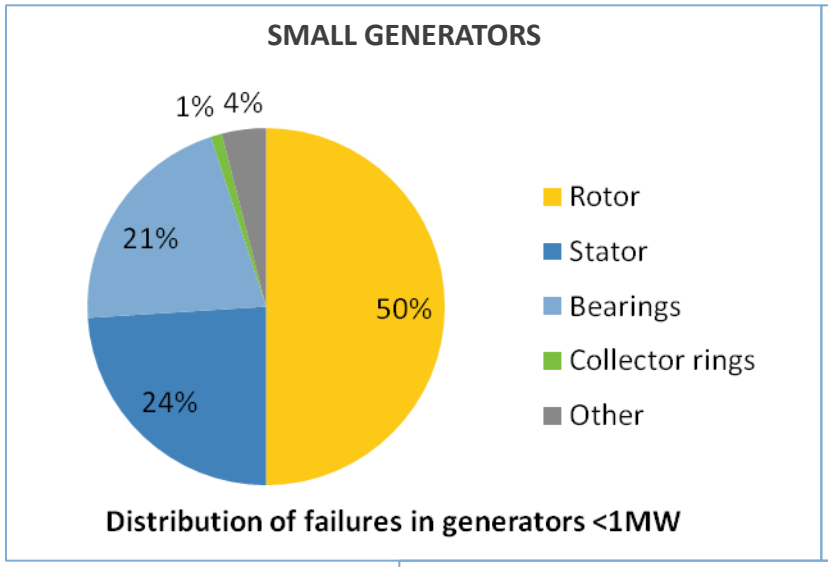
Current gearbox life is 6-8 years of operation versus 20 year of design expectancy

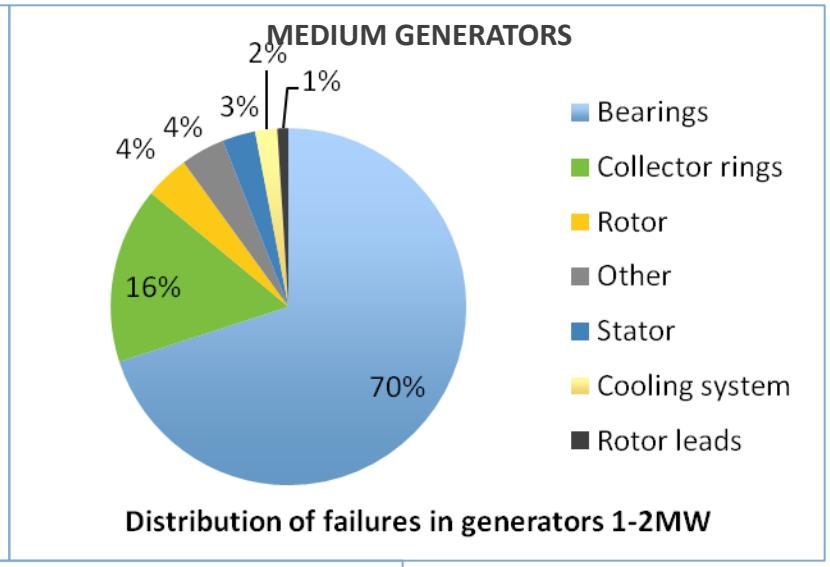


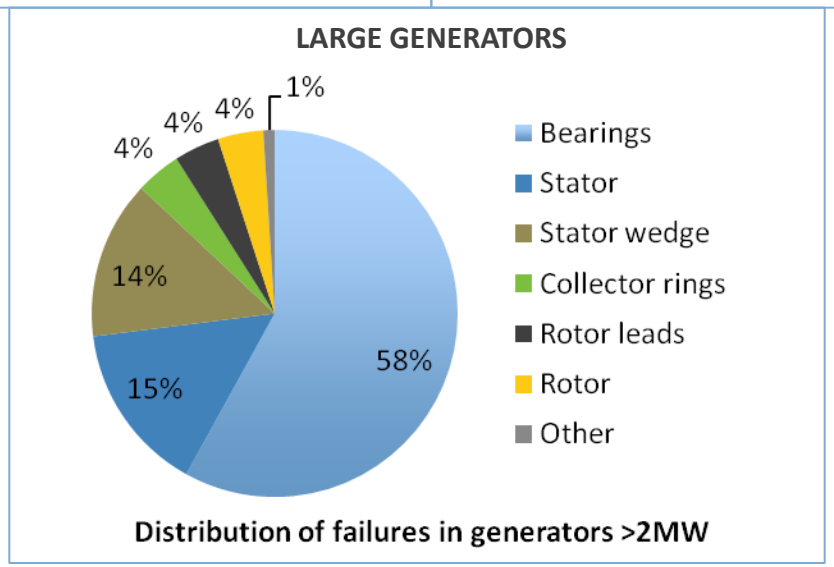
Source: NREL

Wind Turbine Generator Reliability - Innovation Driver

Statistics were collected from 1,200 repair operations





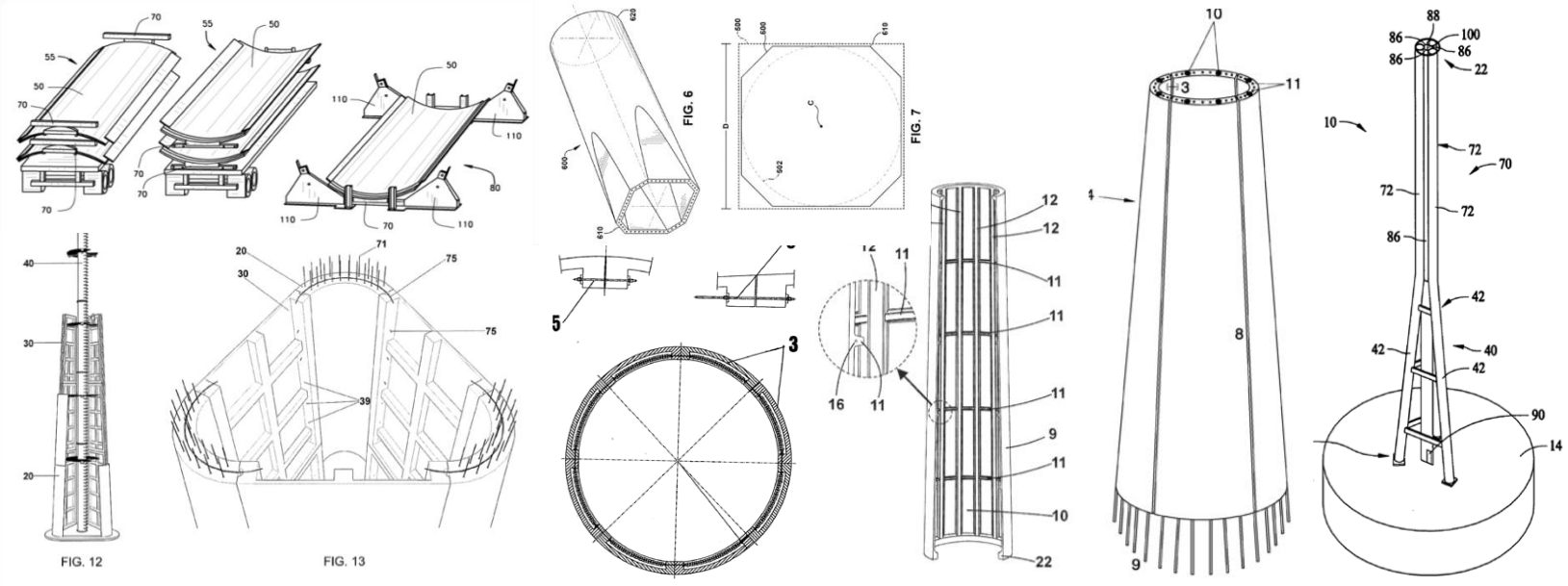


Represents most current utility scale turbine designs

Source: Shermco

Wind Tower Innovation Drivers

Cost Drivers		Governing Equations
Materials Manufacturing Transportation Assembly	+	Mass Reduction Section Modulus Improvement



Wind Turbine Transportation & Logistics Innovation

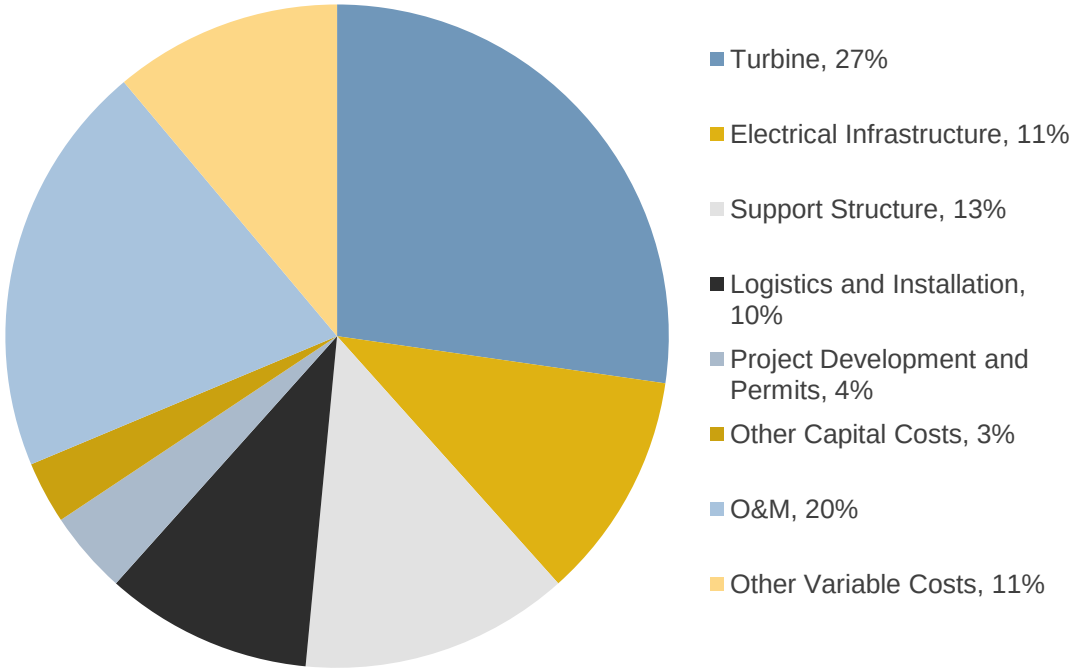
Next Gen Blade & Tower Transportation &
Material Handling Systems

Source: Vestas, LM

Offshore Wind Innovation Drivers - Cost

DOE 20% by 2030 Goal:
305 GW total includes 54 GW of offshore wind

54 GW at 7-9 ¢/kWh by 2030
(10 GW at 10 ¢/kWh by 2020)



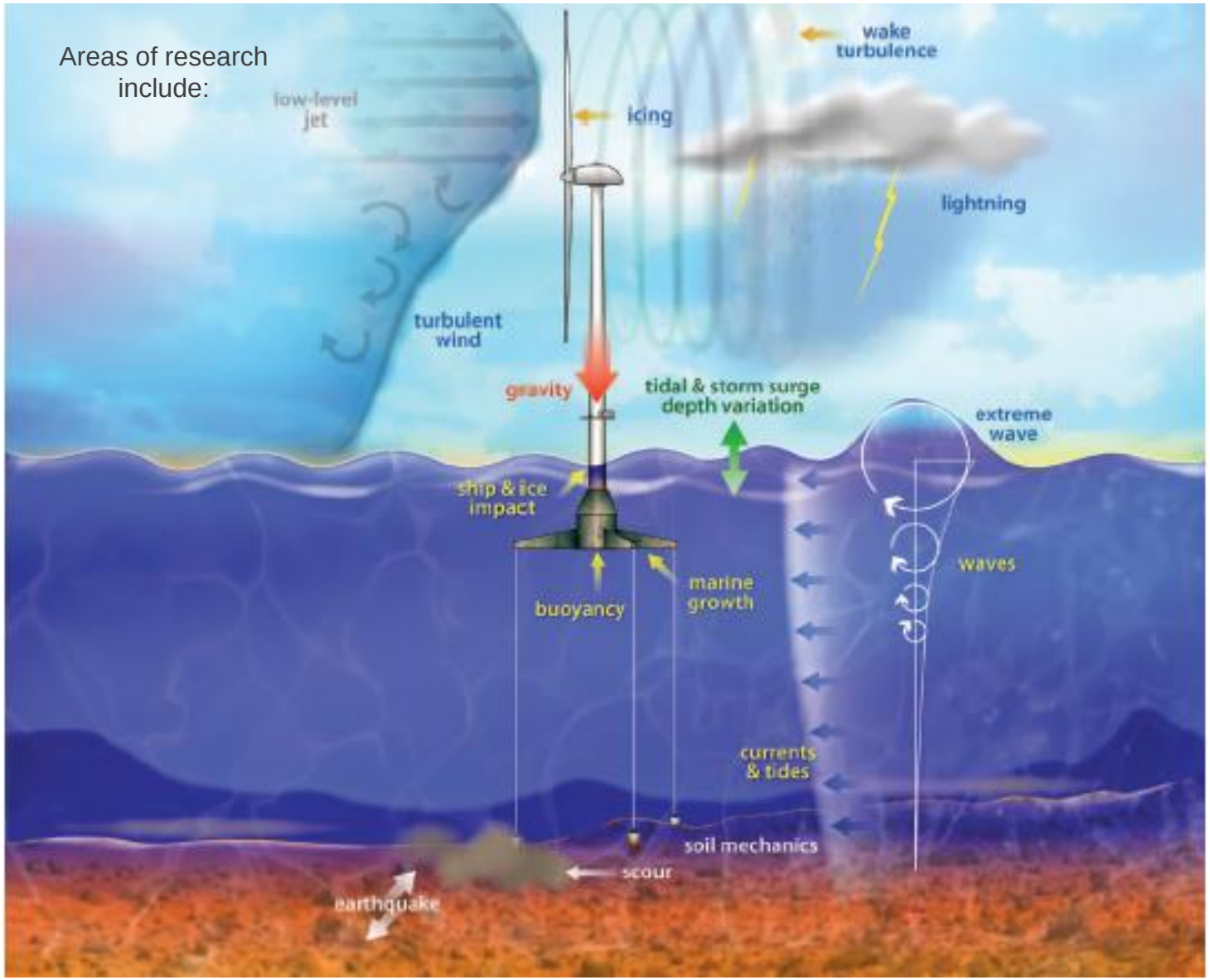
Key Points

- Turbine hardware is only 1/4 of offshore capital costs
- Lack of deployment and experience in U.S. waters drives up risk premiums
- Balance-of-system, installation, and O&M are key opportunities for lowering costs
- Cost structures favor larger turbines per platform

Source: DOE

Offshore Wind Turbine Challenges

Areas of research include:



Source: NREL

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