

NextEra Energy Resources Generation Repair & Service Overview

November 15, 2013

NextEra Energy is a premier U.S. power company primarily comprised of two strong businesses



- Fortune 200 company
- 42,179 MW in operation
- \$64 billion in total assets



- One of the largest U.S. electric utilities
- Vertically integrated, retail rate-regulated
- 4.6 million customer accounts
- 24,626 MW in operation



- Successful wholesale generator
- U.S. leader in renewable generation
- Assets in 26 states and Canada
- 17,771 MW in operation

A growing, diversified, and financially strong company

For the 7th consecutive year, NextEra Energy, Inc. is ranked No. 1 on Fortune's list of "Most Admired Companies" among gas and electric utilities



It's a hard hat to fill.

And the 13,341 employees at FPL Group fill it with pride every day with a focus on continuous improvement, excellence and hard work. FPL Group proudly serves those men and women who make up the FPL Group companies in 26 states - Florida Power & Light Company and FPL Energy. Their commitment to excellence and dedication to serving customers, who always strive to get better, have earned the company top honors.

IT'S A HARD HAT TO FILL. And We've Done It Again!

For the second year in a row, FPL Group was named #1 among electric and gas utility companies in the "Most Admired Companies" issue of Fortune magazine. The magazine's evaluation of these and other utility companies was based on the companies' financial performance, customer satisfaction and employee satisfaction. FPL Group's success in these areas is a testament to the company's commitment to excellence and dedication to serving customers, who always strive to get better. FPL Group's success in these areas is a testament to the company's commitment to excellence and dedication to serving customers, who always strive to get better.



This is our version of a hat trick.

For the third consecutive year, FPL Group is ranked No. 1 among electric and gas utility companies.



It's a Grand Slam.



High Five!

For the fifth consecutive year, NextEra Energy, Inc. is ranked No. 1 on Fortune's "Most Admired Companies" among electric and gas utilities.



Sixcess!

For the sixth consecutive year, NextEra Energy, Inc. is ranked No. 1 on Fortune's "Most Admired Companies" among electric and gas utilities.

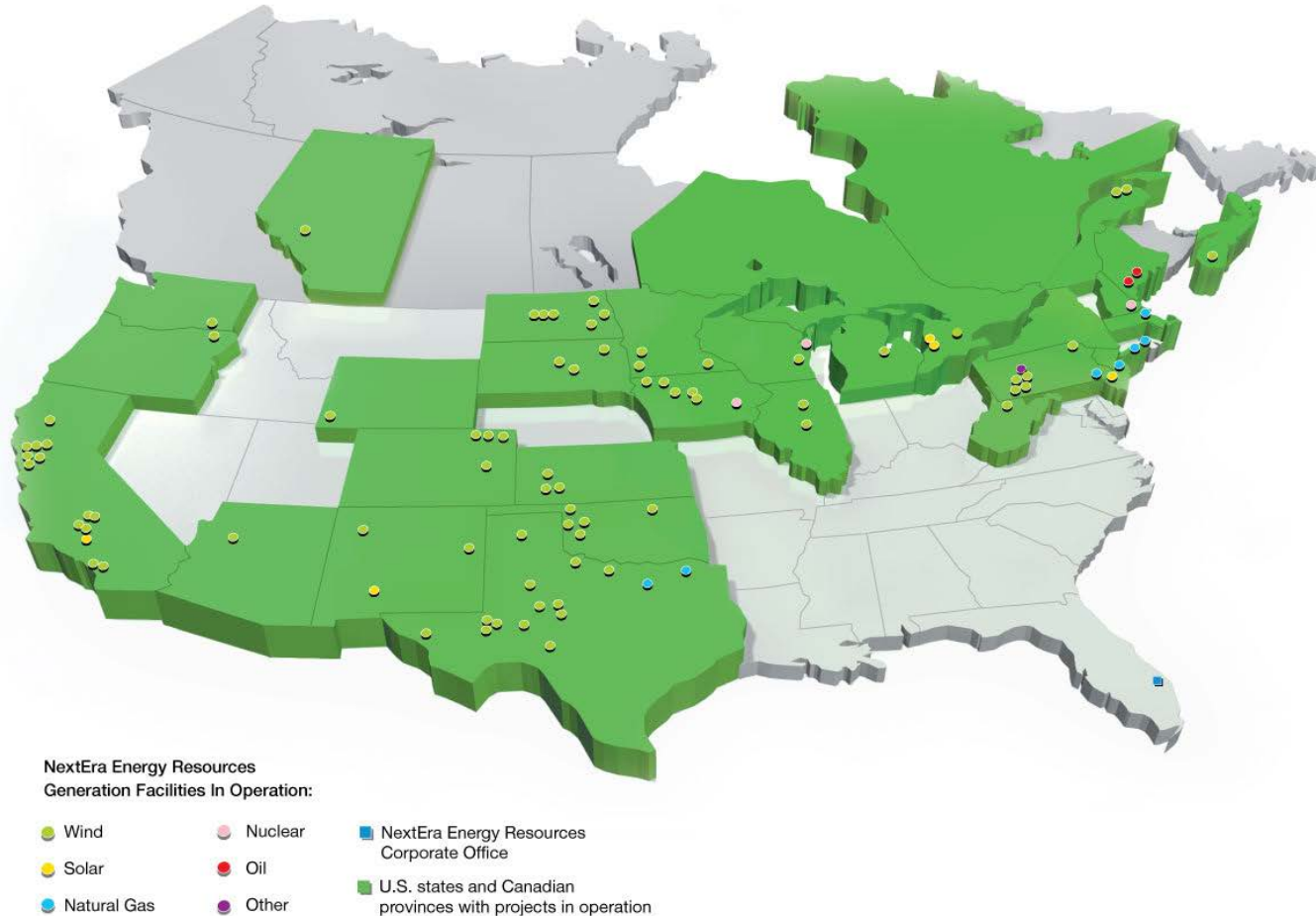


Seventh Heaven

For the seventh consecutive year, NextEra Energy, Inc. is ranked No. 1 on Fortune's "Most Admired Companies" among electric and gas utilities.

NextEra Energy Resources is the largest wind and solar energy provider in North America

NextEra Energy Resources Facilities



17,771 MW⁽¹⁾ located across 24 states and Canada

NextEra Energy Resources is the largest wind owner operator in North America

Cumulative Wind Energy Portfolio at NextEra Energy Resources
Megawatts

Top North America Wind Plant Owners
Cumulative capacity in megawatts – 2012

NextEra Energy Resources	10,057
Iberdrola Renewables	5,650
MidAmerican Energy Holdings Co.	3,697
EDP Horizon Wind Energy	3,554
E.ON Climate & Renewables	2,723
Invenergy	2,403
EDF-RE / EDF-EN	1,789
Edison Mission Group	1,687
Duke Energy Renewables	1,625
BP Wind Energy	1,584

Source: For other companies, IHS Emerging Energy Research



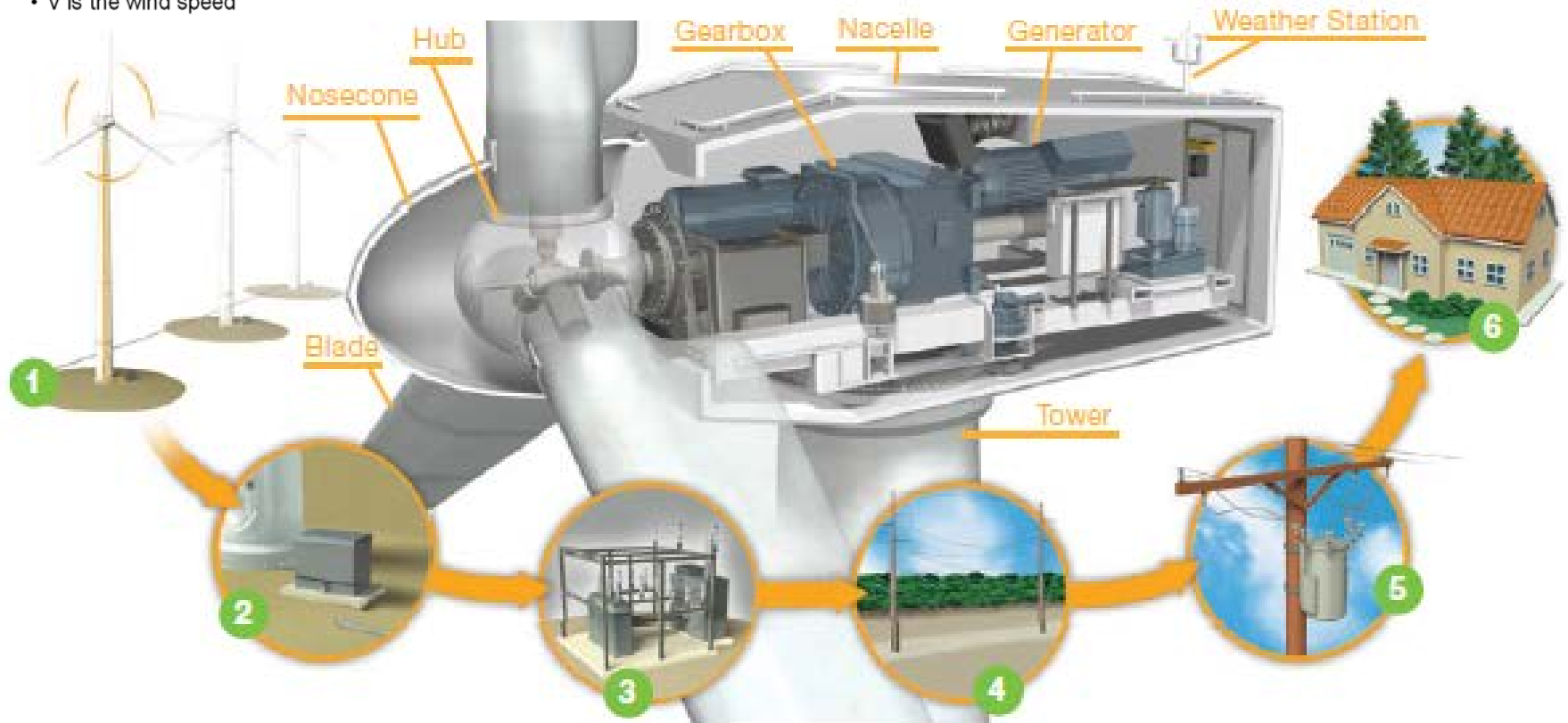
Wind has grown quickly and repairing components is a big effort

Wind power from energy capture to your home

$$P = \frac{1}{2} C_p \rho A V^3$$

- Where C_p is the power coefficient
- ρ is the air density
- A is the rotor swept area
- V is the wind speed

1 Turbine powers
about 300 homes

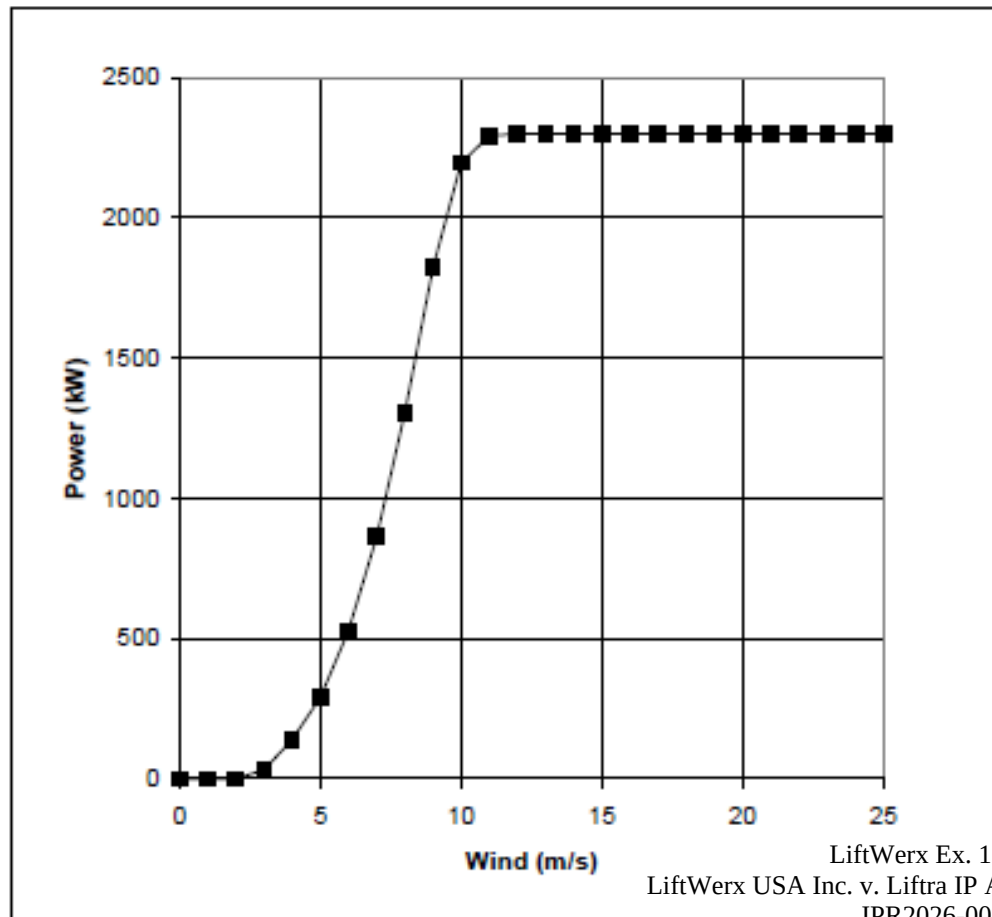


Wind turbines produce power on a design power curve

Standard Power Curve Rev 1

The calculated power curve data are valid for standard air density conditions of 15 deg.C air temperature, 1013 hPa air pressure and 1.225 kg/m³ air density, clean rotor blades, substantially horizontal, undisturbed air flow, normal turbulence intensity and normal wind shear.

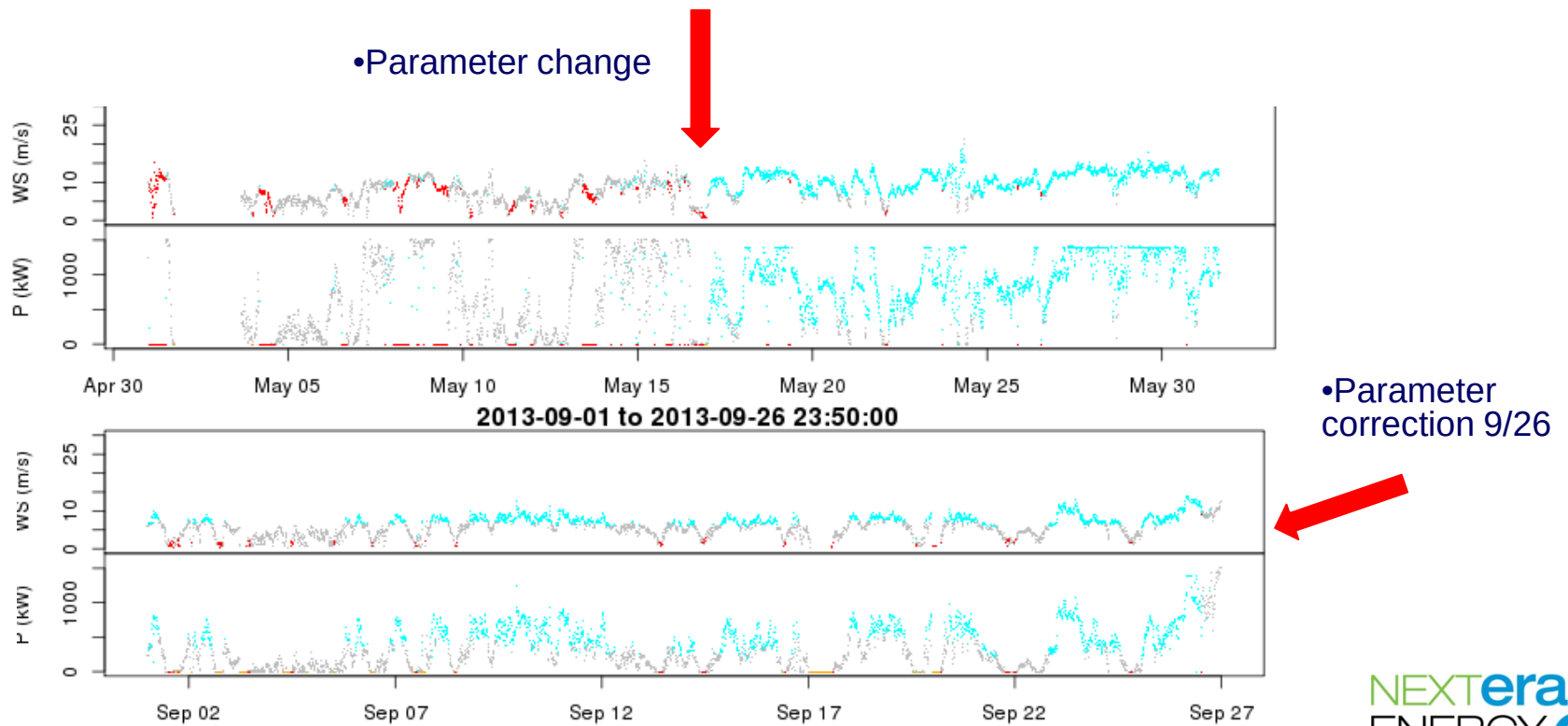
Wind [m/s]	Power [kW]
0	0
1	0
2	0
3	32
4	139
5	290
6	529
7	862
8	1305
9	1822
10	2196
11	2292
12	2300
13	2300
14	2300
15	2300
16	2300
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22	2300
23	2300
24	2300
25	2300



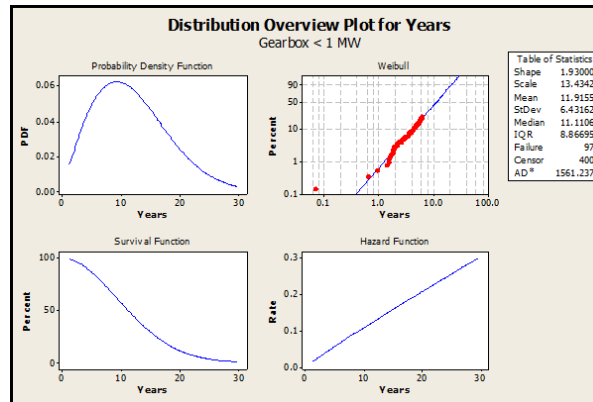
LiftWerx Ex. 1037
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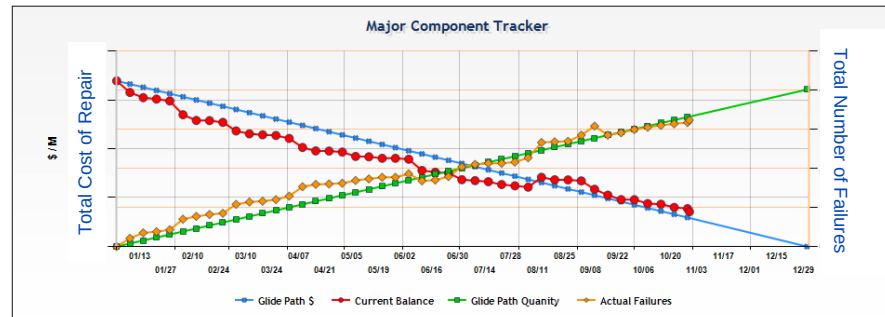
- Underperformance Example
 - Callahan Divide: Parameter change caused underperformance.



Weibull data is used to forecast the annual failures of gearboxes for the year based on failures and aging



We repair 33 different gearbox models and there are 67 in our wind fleet



Display Transaction Details: ☒ Totals ☐ 56-100 ☐ Clipper ☐ GE ☐ KVS 33 ☐ Micon ☐ Mitsubishi ☐ Siemens ☐ Vestas ☐ Zond

Gearbox	Budget Qty	Transfer Qty	Actual Qty	Remaining Qty fav / (unfav)	%	Budget \$	Transfer \$	Actual \$	Remaining \$ fav / (unfav)	%
56-100										
Clipper										
Danwin										
GE										
KVS 33										
Micon										
Mitsubishi										
Nordex										
Siemens										
Vestas										
Zond										
Total										

Confidential Information

Experienced technicians operate and maintain our 100+ wind sites in the United States and Canada.

- Experienced technicians on site
- On-going training and mentoring programs
- Supported by 24/7 fleet monitoring and diagnostic center



NextEra Energy Resources Iowa Service Business Units



Generation Repair & Service

- 27 Employees
- \$20 MM Investment
- \$30 MM Inventory

North American Parts & Services

- \$2 MM Investment
- \$17 MM Inventory



Local Sourcing \$2 MM in 2011

Our Story City, Iowa location is a critical component of our North American wind fleet operations

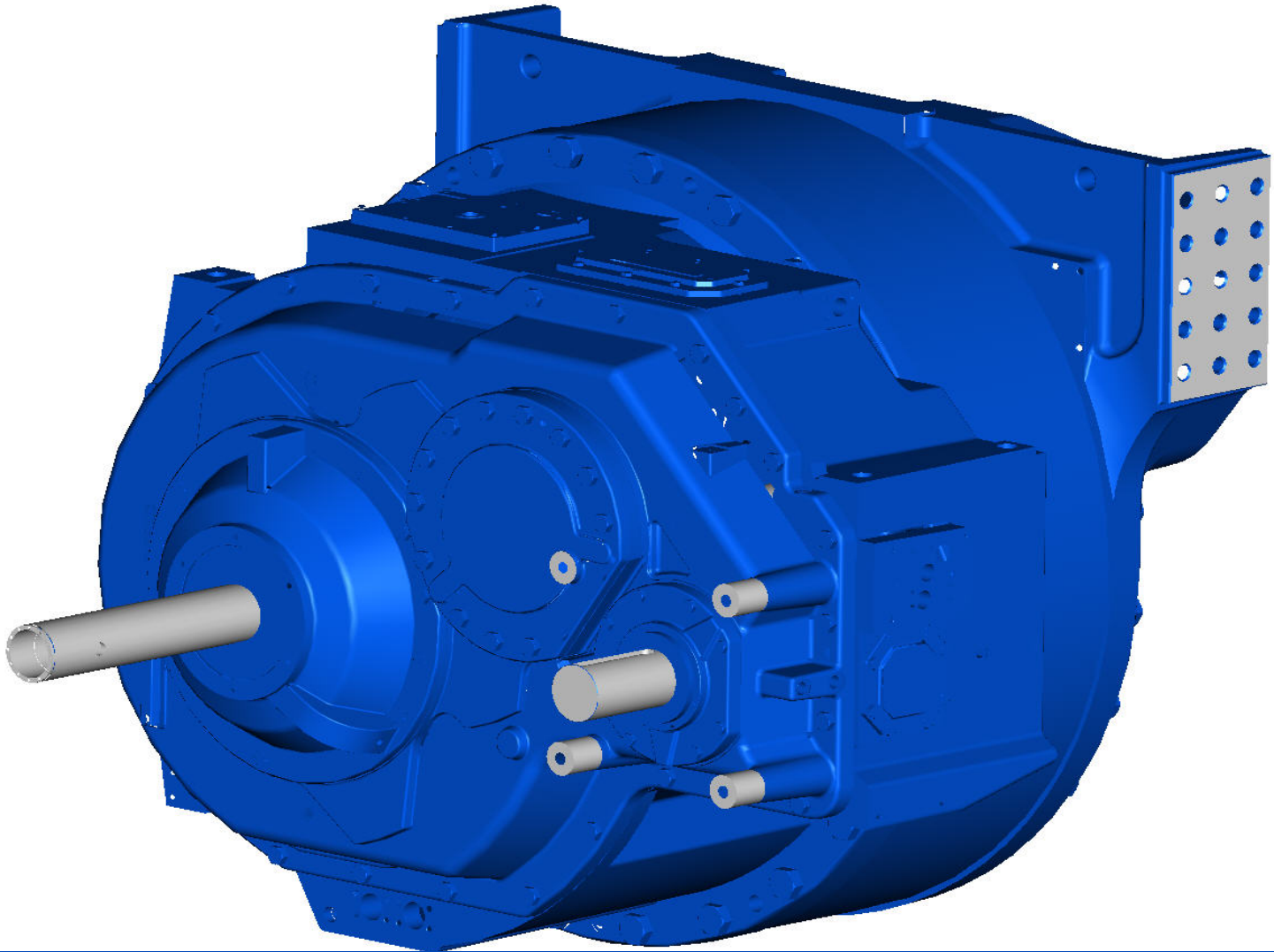
- **Fleet Gearbox Repairs**

- 254 gearboxes repaired, 150 annually by 2015
- 33 technologies - proprietary procedures and techniques developed in-house
- Regenerative Test Stand
- Repair cycle reduce from 118 to 34 days
- Up-tower Repair Center of Excellence

- **Fleet Part & Services**

- Supports NextEra's fleet of approximately 10,000 wind turbines
- Significant increase to inventory capacity and processing over the next 5 years

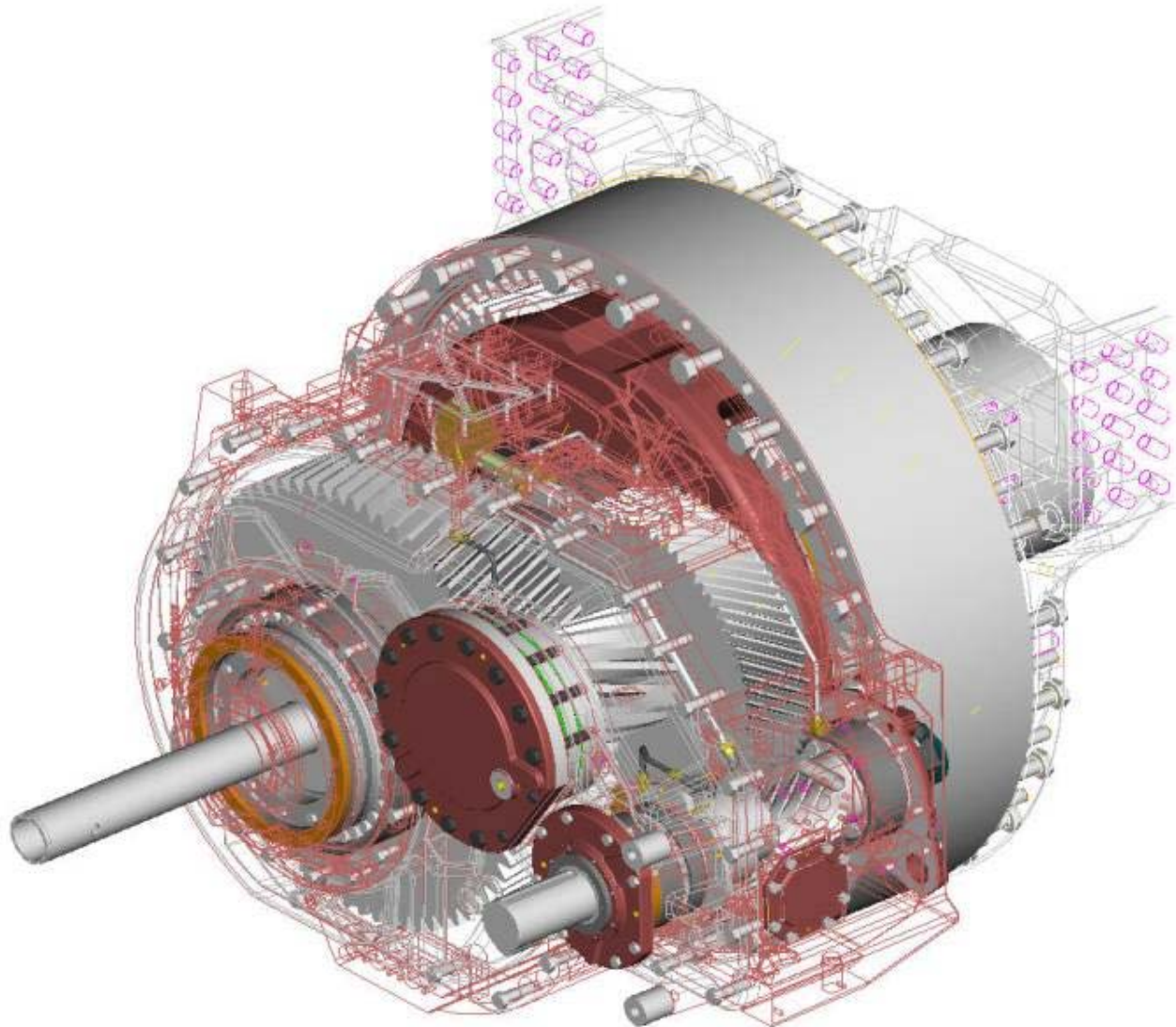
GRS looks at gearboxes from all angles



Exterior casing and auxiliary equipment (brakes, oil pumps, instrumentation and case deflection)

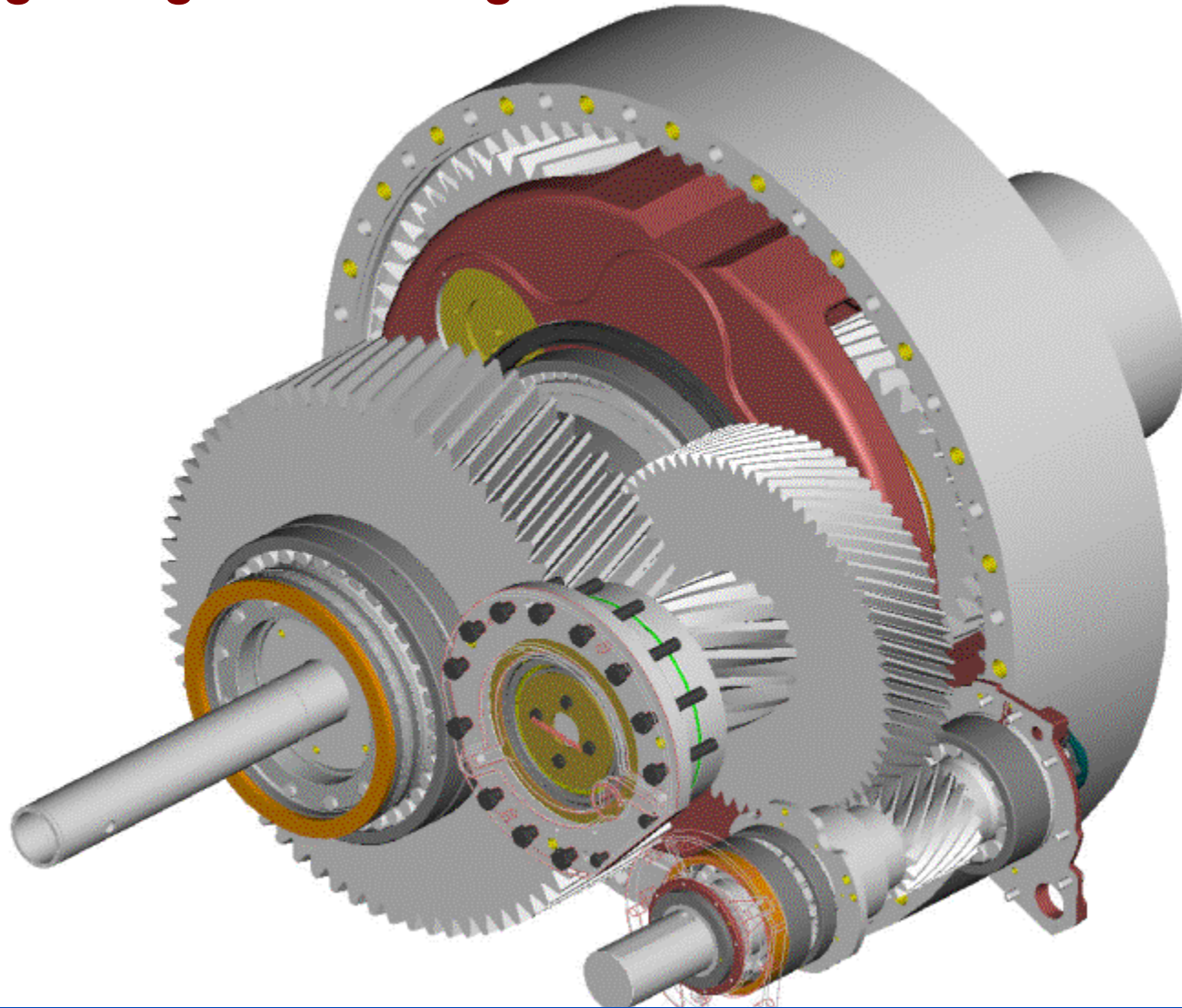
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Look at bolting, cover and inspection plates



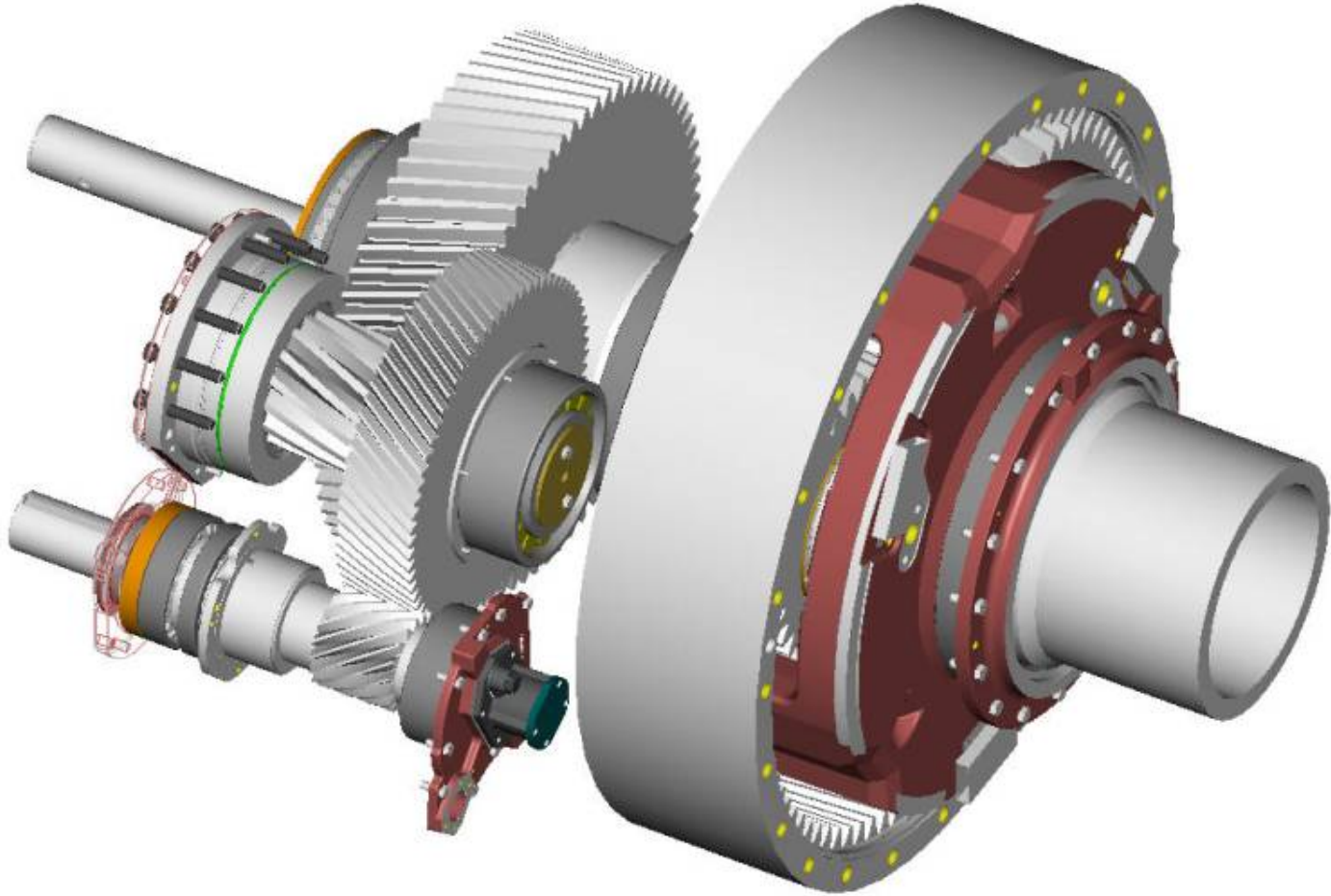
Borescoping is critical to seeing inside a gearbox prior to failures

Look at gearing and bearings



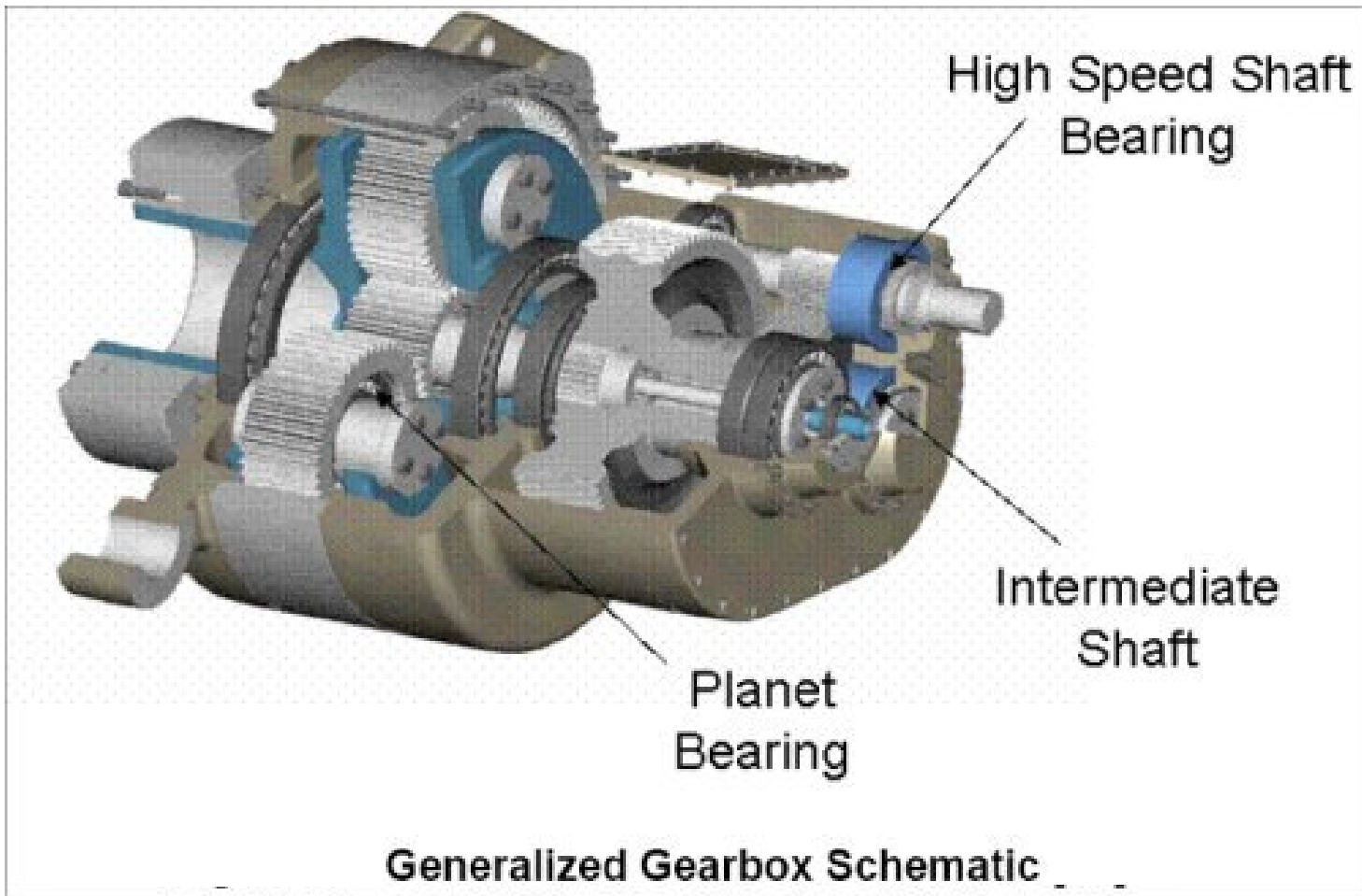
Inspect loading patterns, wear patterns and lubrication performance

Look at disassembly and reassembly processes



What is the most efficient, low cost way to repair failed gearboxes? NextEra uses quality tools -Kaizen events, 6 sigma, and lean- 5S techniques to understand the root cause of failures and implement proper countermeasures

Effective Gearbox maintenance is based on maximizing the “ 5R “ Concepts



5R's - Replace, Reuse, Reverse, Regrind, Repair, are all steps in the assessment of a gearbox overhaul

Reviews for bills of materials, specifications, and dimensions

NEXTERA[®]
ENERGY 
RESOURCES

AGMA (American Gear Manufacturers Association) standards are used

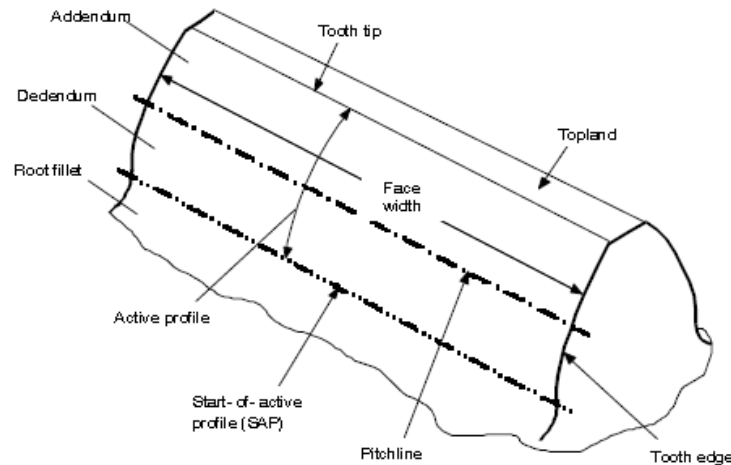


Figure G1 - Gear nomenclature

The following table shows the difference in manufacturing tolerances between gearing.

Old 90's vintage wind gearboxes were class 8. New gearboxes are at least class 12.

Gear Tolerances - Fine Pitch Spur and Helical Gears

AGMA Quality No.	Number of Teeth and Pitch Diameter	Diametral Pitch Range	Tooth-to-Tooth Composite Tolerance	Total Composite Tolerance
5	Up to 20 teeth inclusive	20 to 80	0.0037	0.0052
	Over 20 teeth, up to 1.999"	20 to 32	0.0027	0.0052
	Over 20 teeth, 2" to 3.999"	20 to 24	0.0027	0.0061
	Over 20 teeth, 4" and over	20 to 24	0.0027	0.0072
	Up to 20 teeth inclusive	20 to 200	0.0027	0.0037

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Failure forensic analysis. Why did it fail?

Forensics of failures is caused by up 2,210 BHP of energy



Overloaded
High cycle fatigue
Low cycle fatigue
Material inclusion
Grind temper
Heat treating error

Ring gear pinion secondary damage from previous slide



Fig.2 View of the sun pinion gear mesh. Note, only secondary fractures were observed.

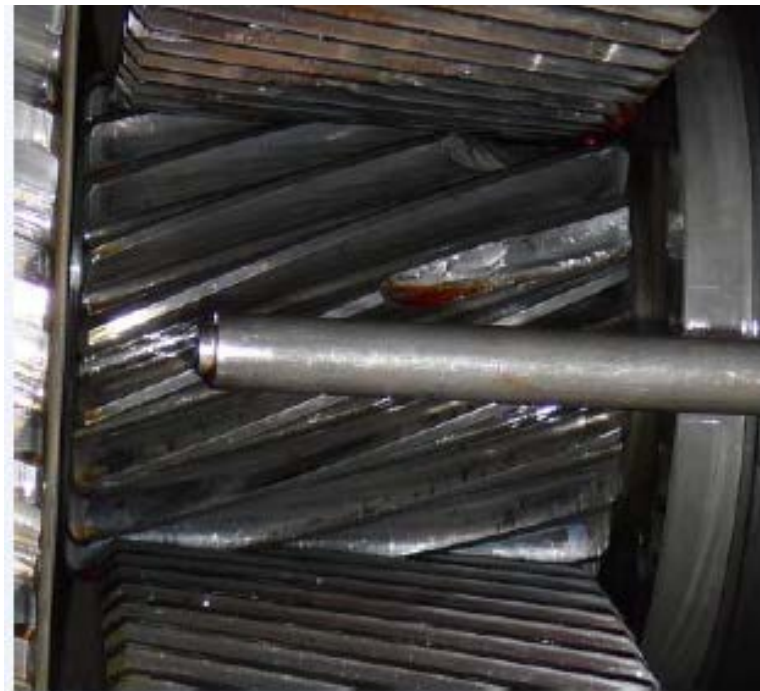
Macro pitting of a spherical roller planet gear bearing race



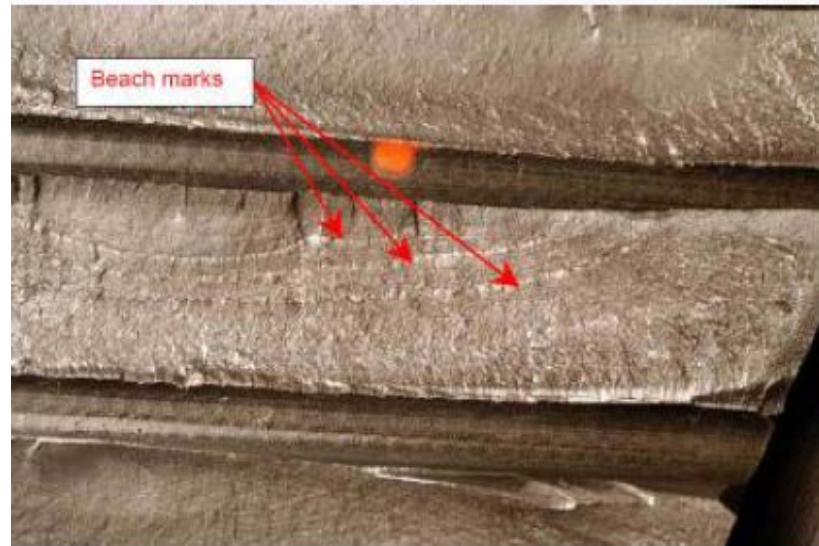
Spalling
of
inboard
races

Typical bearing analysis, indications of overloaded bearing due to higher loads than expected. Bearing selections that work in other industry do not work in wind.

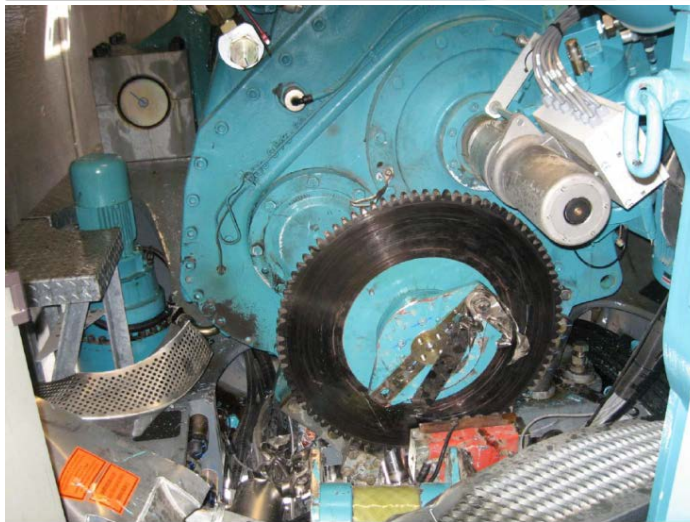
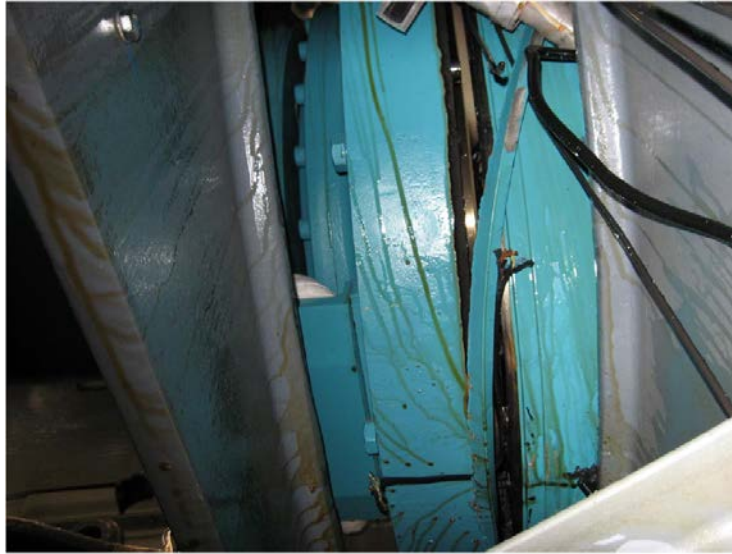
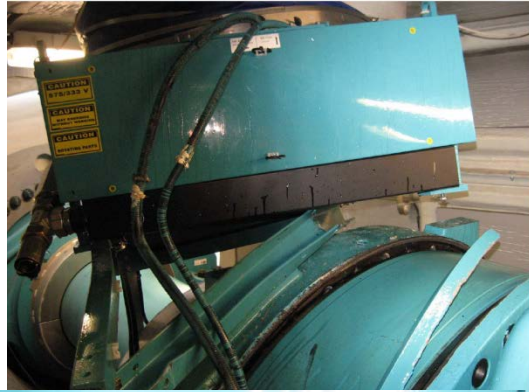
Gear tooth overloading associated with a tolerance problem



High cycle fatigue – wear over life of the component



Catastrophic Failure



Salvage some gearing and send gearbox to scrap vendor

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Plastic deformation of a pair of tapered roller bearings



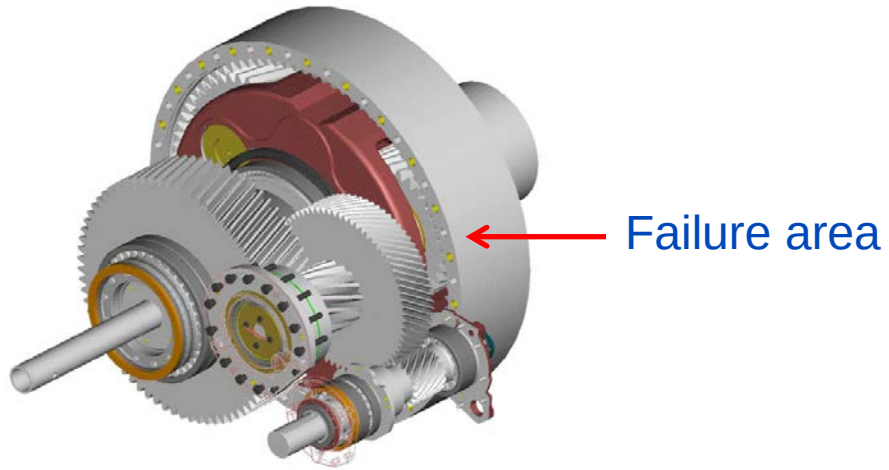
Bearing race white etching prior to spalling of race



Root Cause is the transient vibrational loading seen in high speed bearings

Up tower repair was perfected in the GRS shop then deployed to the field

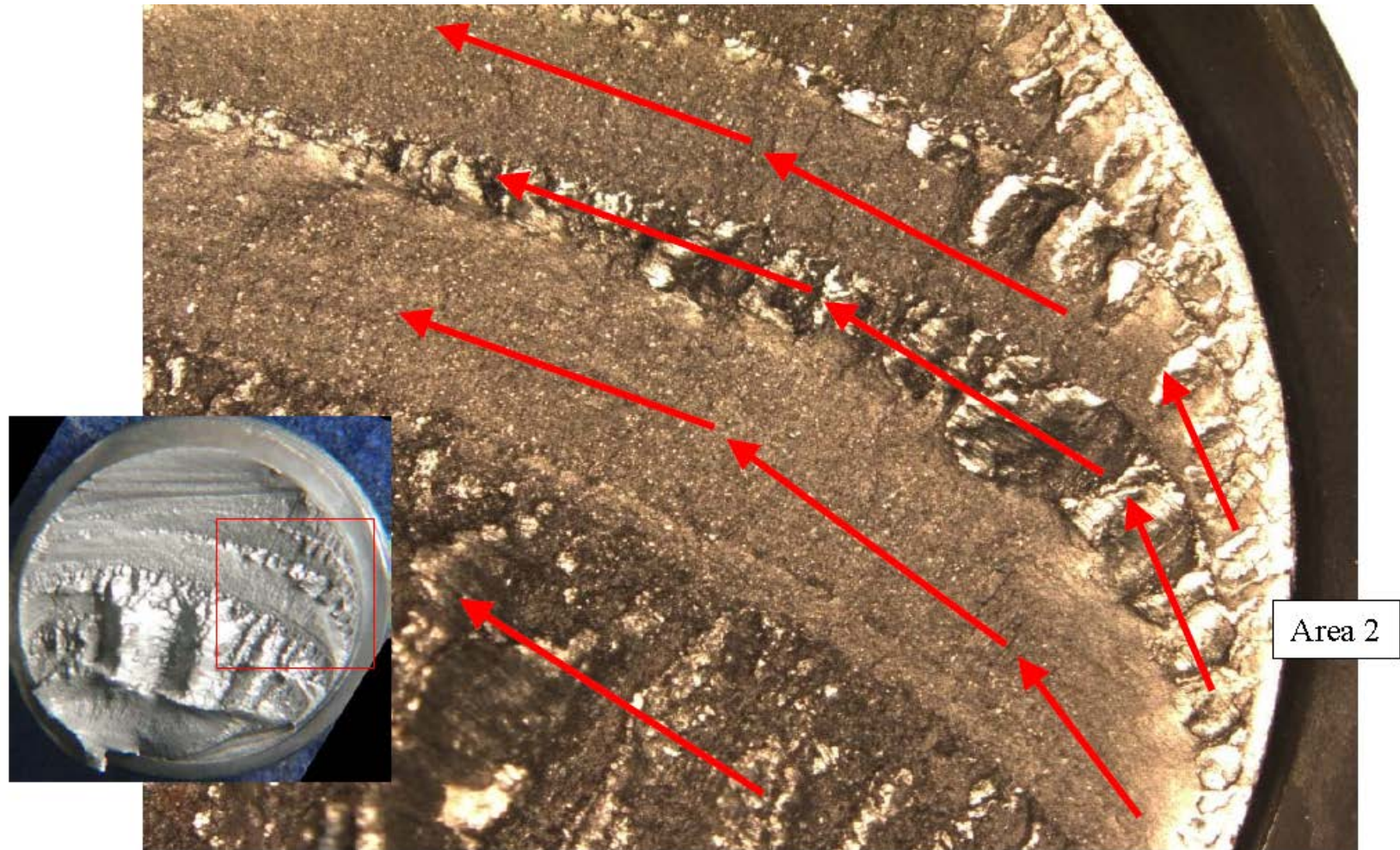
Failure pictures



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Gearbox case bolt failure after about 50% of the diameter was cracked the bolt sheared off causing a failure



Broken Gear and Ring Gear – cracked in two pieces

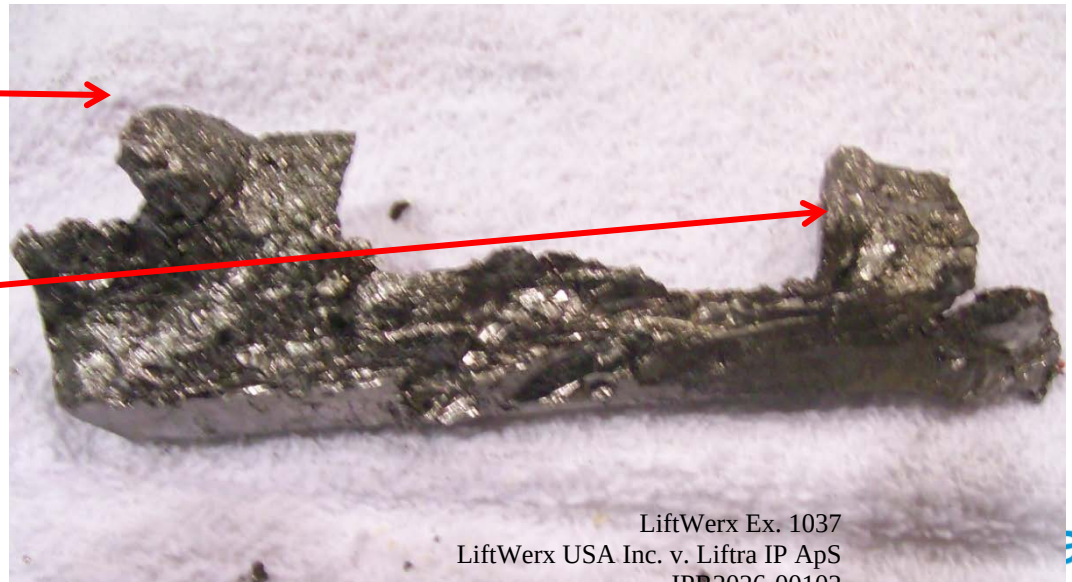


Failure debris pictures

Planet gear tooth



2 ring gear teeth
cold welded
together due to the
energy of the failure



Intermediate pinion – Double helix or herringbone design



Overloading failure



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Inclusion failure



Non metallic inclusion usually
aluminum or silica

Macro spalling

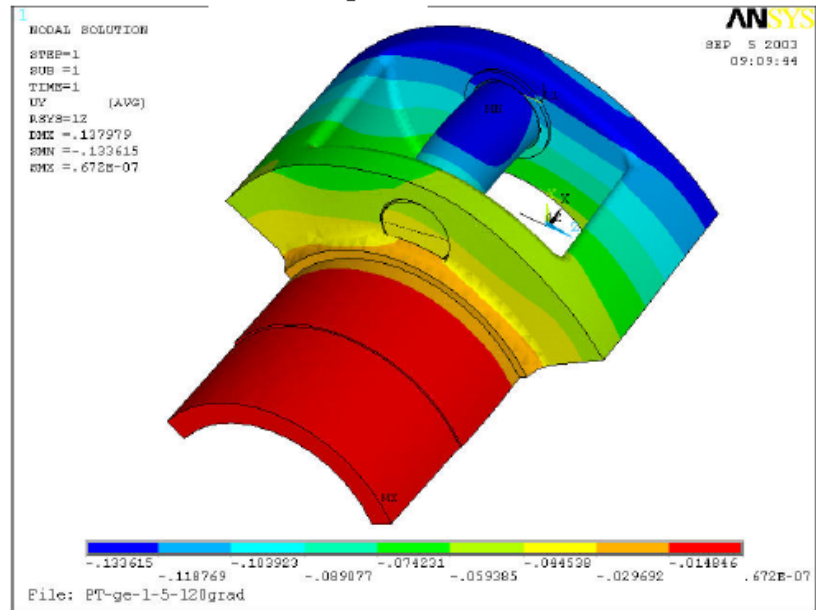
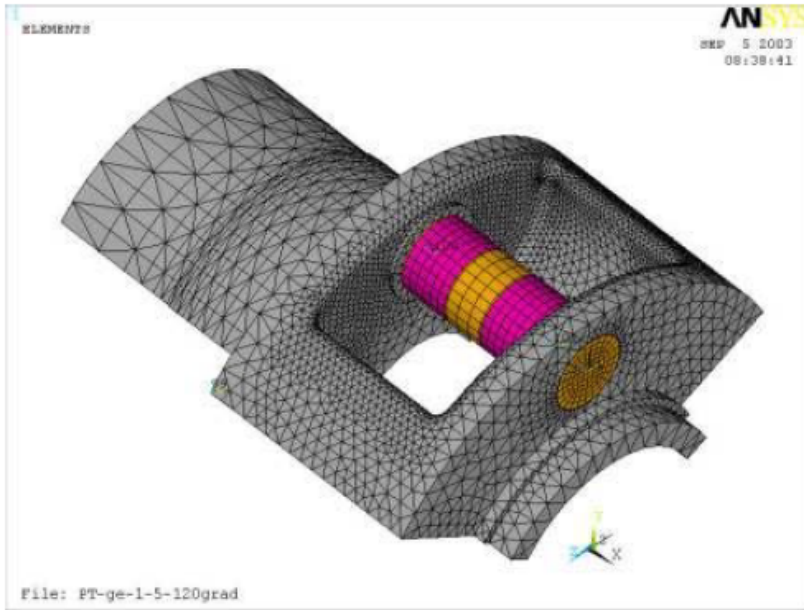
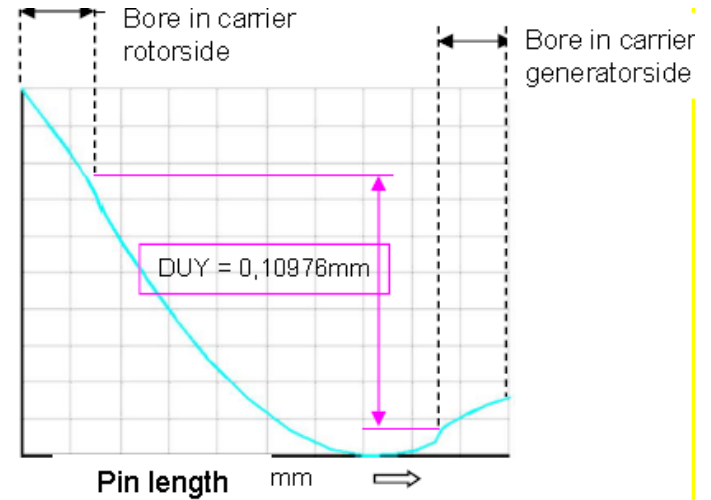
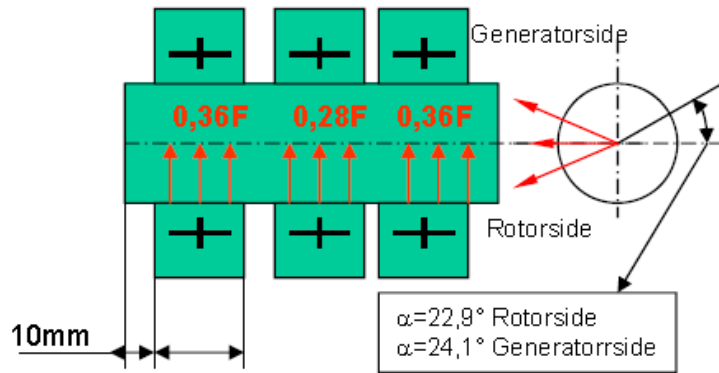


One sided spalling can suggest an alignment issue

Planet carrier with 5 planet gears Wind turbines commonly have 3 planets



Load modeling for analysis



Design Calculations

	gear ratio	center distance	No. of teeth	phase displacement	Normal module	profile shift coeff	face width	helix angle	tip diameter	contact ratio		spec. sliding		b/sun diameter or b/pinion diameter	b/annulus diam. or b/center distance	load distribution		safety factor		safety factor scuffing		
	i	a	z	Delpe	m	x	b	β	da	σ _H	σ _F	itp	root	b/dw	b/dwa	flank	root	flank	root	integral	contact	FVA 166
	i	a	z	Delpe	m	x	b	β	da	σ _H	σ _F	itp	root	b/dw	b/dwa	KH8	KF8	SH	SF	SintS	SB	SS
KAH/KAF=1,15/1,31 KV=1,0 Lh=175200 Kg=1,0																						
sun	6,529	390,5	17	0,667	13,5	0,5200	300	8,75	273,5	1,413	1,076	0,53	-1,55	1,245	0,229	1,15	1,13	1,37	2,19	3,81	5,24	1,93
3 planets			38	3		0,7249			565,6			0,61	-1,13					1,43	1,63			
annulus			-94	0,333		-1,3644			1291,5	1,598	1,055	0,16	-0,19									
RMS = 0 (AGMA rec.)																						
GE Wind Energy 1,5 60Hz i=71,76595 planetary stage T-Rotor = 790000 Nm n-Rotor = 20,065 rpm n-Gen = 1440 rpm Pel/mech = 1500/1660 kW Oil: synthetic CLP320 FZG-LS: 12 SKS in GFT: 10 Oil temperature: 65°C Gearwheel material: 18CrNiMo7-6 (1.6587) SigHlim = 1510 N/mm² Sig Flim = 520 N/mm²																1,11	1,10	1,40	2,26	3,86	5,43	1,96
																		1,45	1,68			
																1,18	1,16	1,83	1,98	(FVA45 I/II)		
																RMS = 0 (upgrade)						
																1,23	1,20	1,33	2,06	3,71	4,90	1,88
																		1,38	1,53			
																1,17	1,15	1,84	1,99	(FVA45 I/II)		
RMS = +91 (upgrade)																						
																1,24	1,21	1,32	2,04	3,69	4,85	1,87
																		1,37	1,52			
																1,36	1,31	1,71	1,75	(FVA45 I/II)		
RMS = -91 (upgrade)																						
																1,40	1,35	1,20	1,83	3,16	3,65	
																		1,25	1,36			
																1,99	1,84	1,34	1,25	(FVA45 I/II)		
As of 1999																LiftWery Ex. 1037						

Limits (AGMA) (2003)

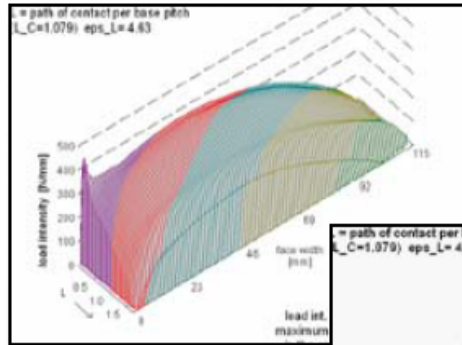
KH8	SH	SF
1,15	1,25	1,56

K.5.42004

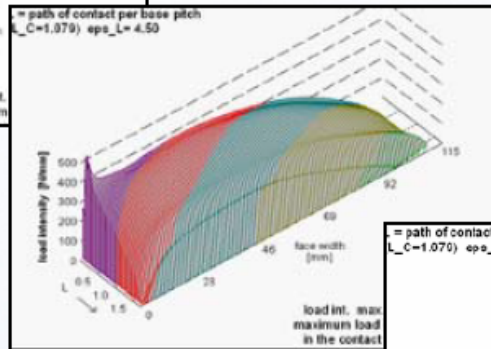
Limits (AGMA) (2003)		
KH8	SH	SF
1,15	1,25	1,56

K.5.4.2004

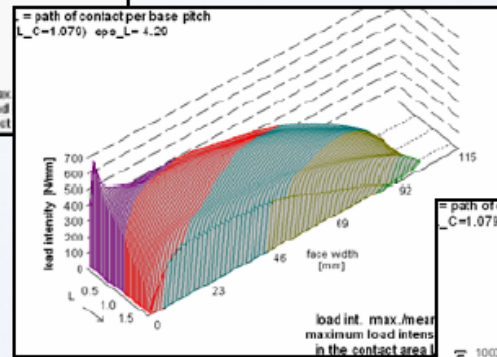
Design calculations associated with load sharing of multiple gears



0.005" Timing Error



0.010" Timing Error



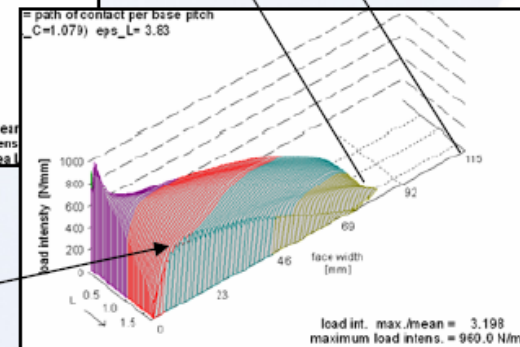
0.020" Timing Error

Region of elevated tooth bending stress



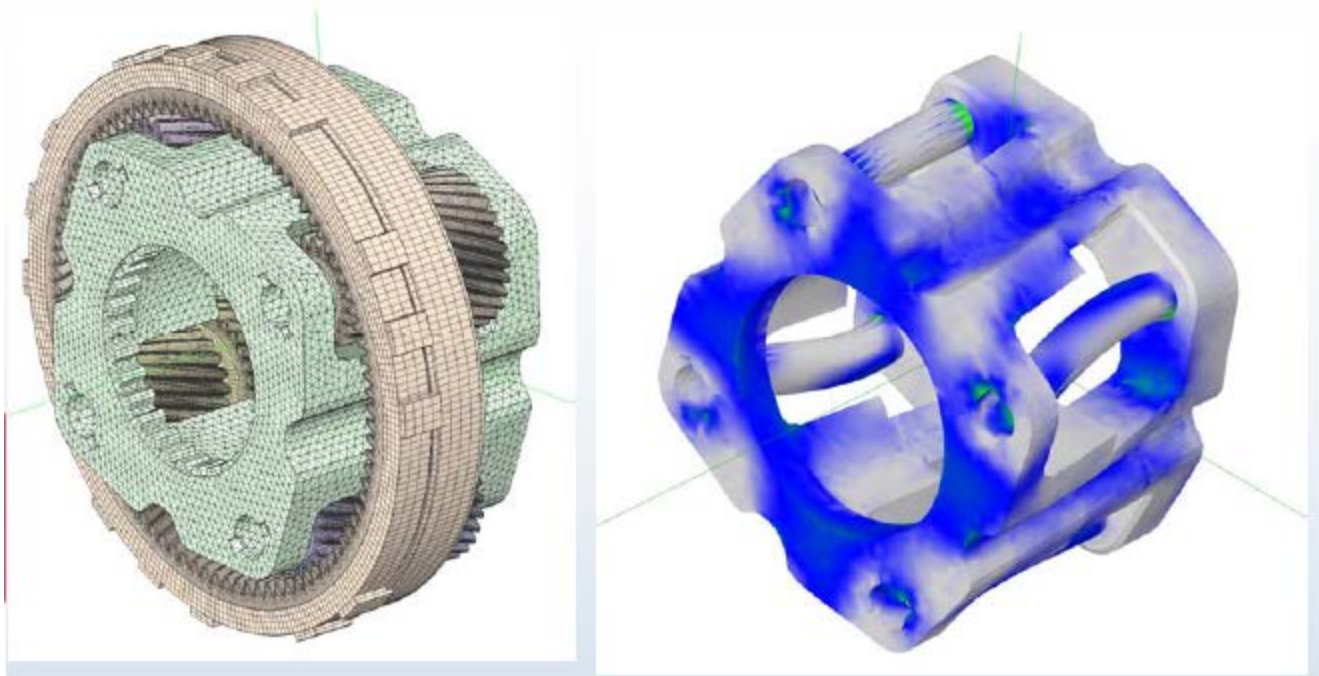
Region of elevated tooth bending stress

Region of no contact



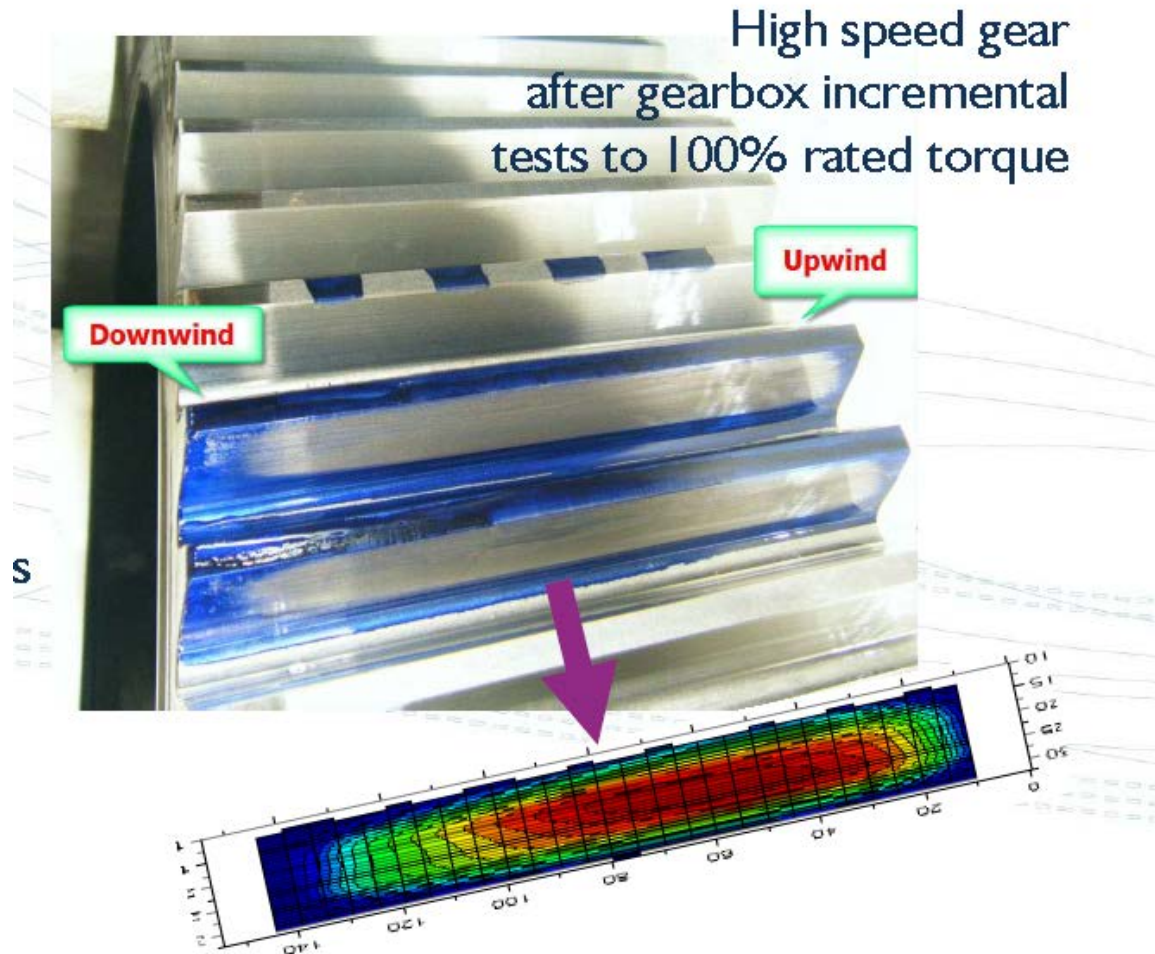
Timing of gears is critical to some gear train designs

Design Calculations for deformation



GRS engineers use many contractors to assist in failure analysis

Design Calculations for contact stress after operation at full load



Bluing is often used to check tooth contact for rebuilt gearboxes

Typical jobs around the shop



Assembly/
Disassembly



Flipping



Measuring

Cleaning



Freezing



Heating



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All > 1MW gearboxes get load tested at the shop

Torque Feedback Test Stand

Test Gearbox

Location
where
Consolidation
gearbox is
installed

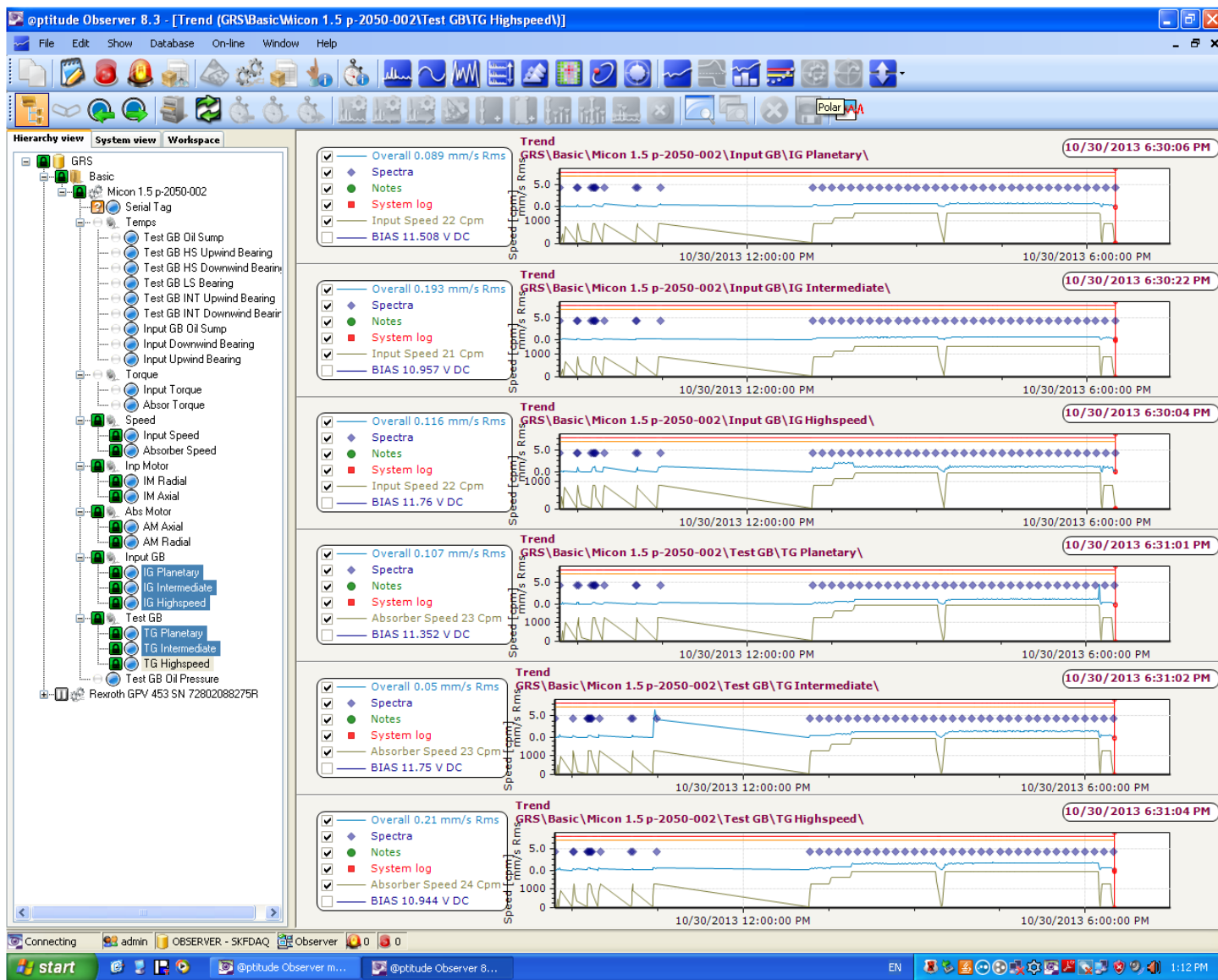
Absorber



Drive Motor

Drive Gearbox

All > 1MW gearboxes must pass the load test prior to installation



All bearing vibrations and oil flows are monitored

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Electronic repairs will start at the facility next year



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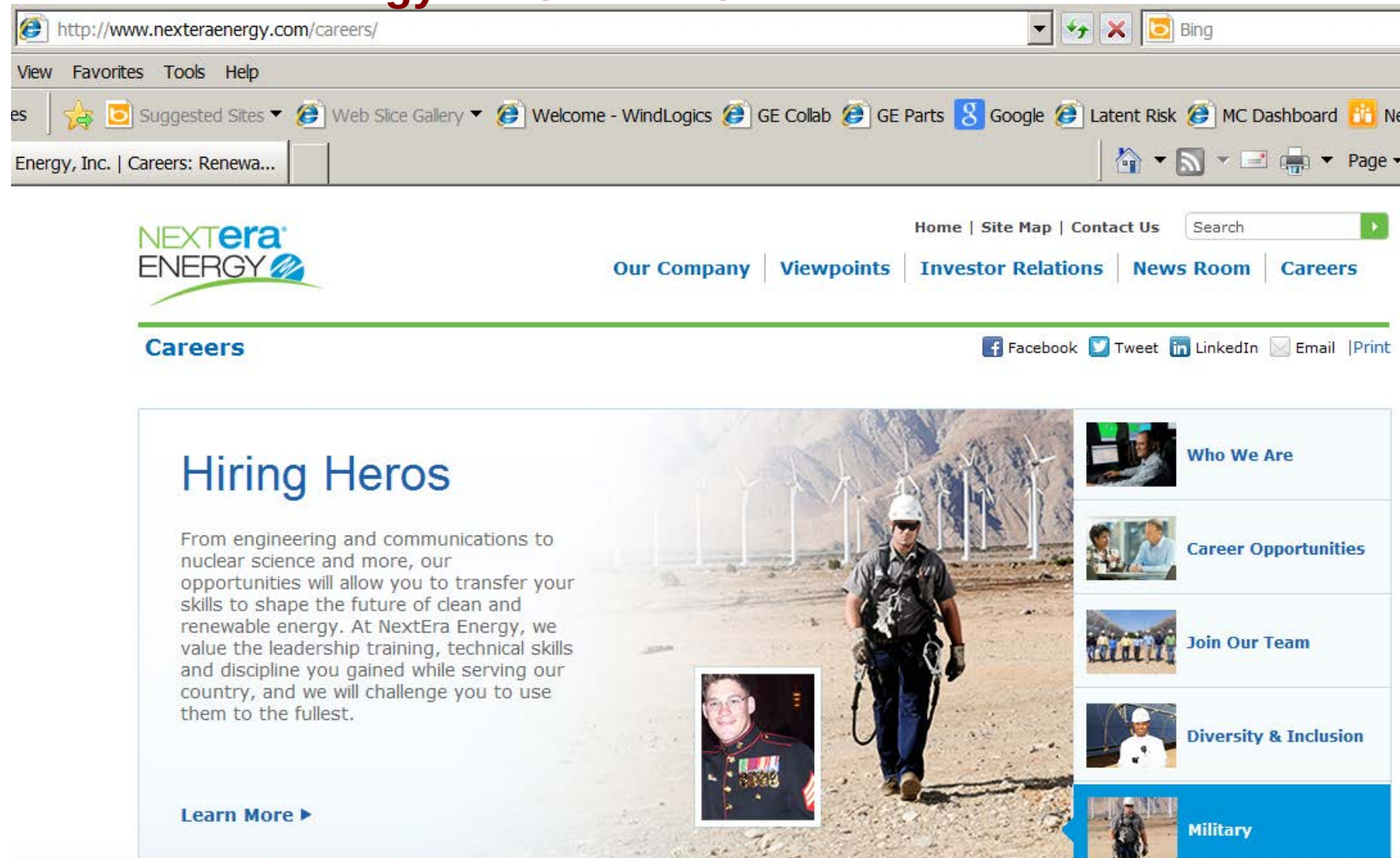
Motor and pump repairs will also start at the facility next year



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Job opportunities with NextEra can be found at

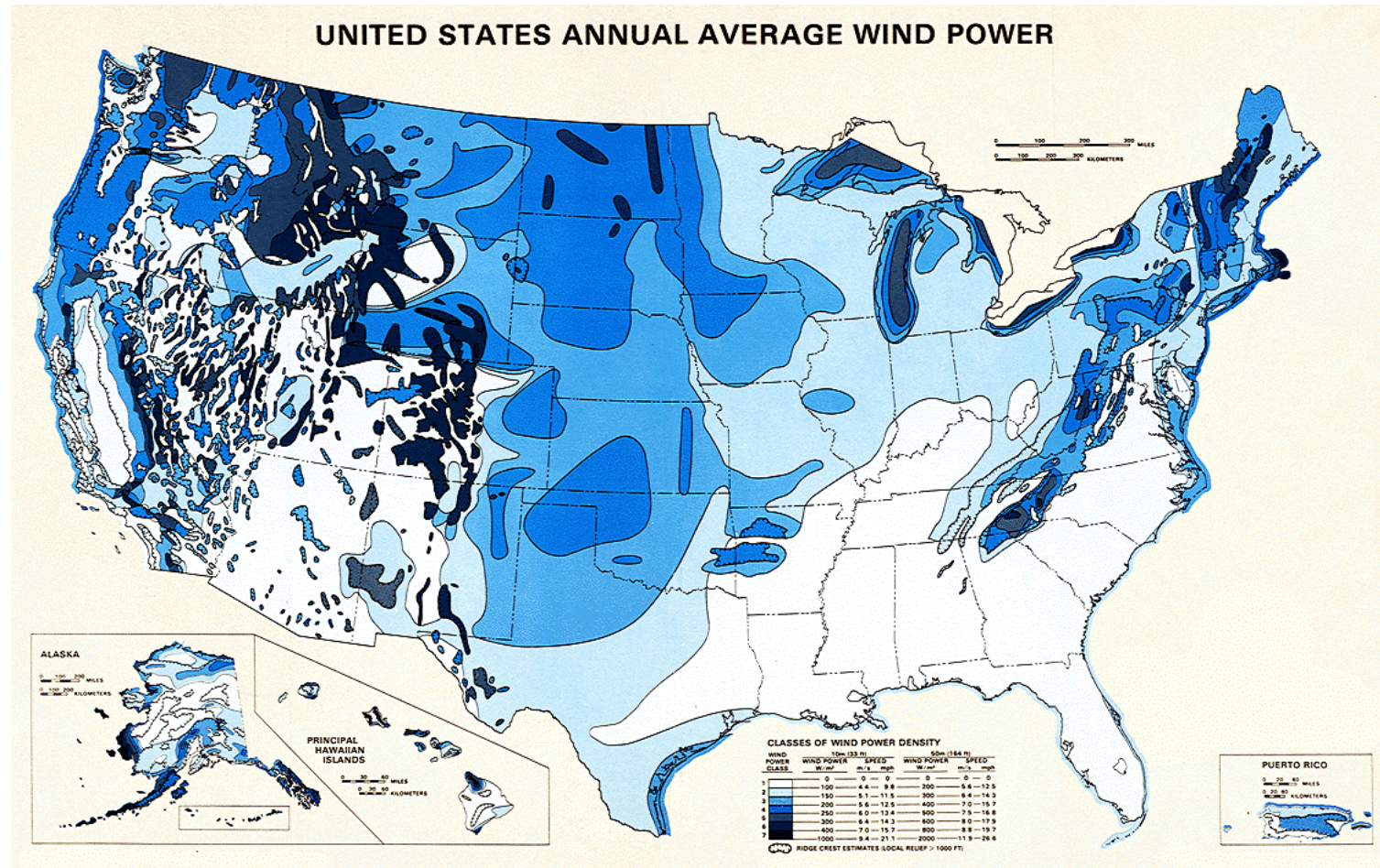
www.nexteraenergy.com/careers/

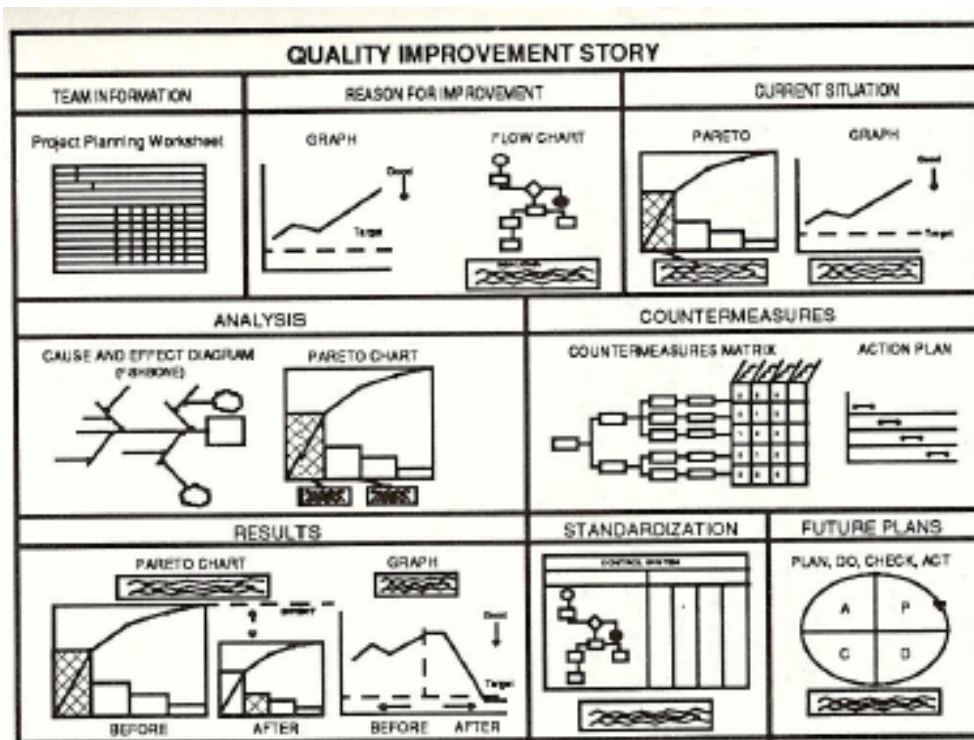


Questions?

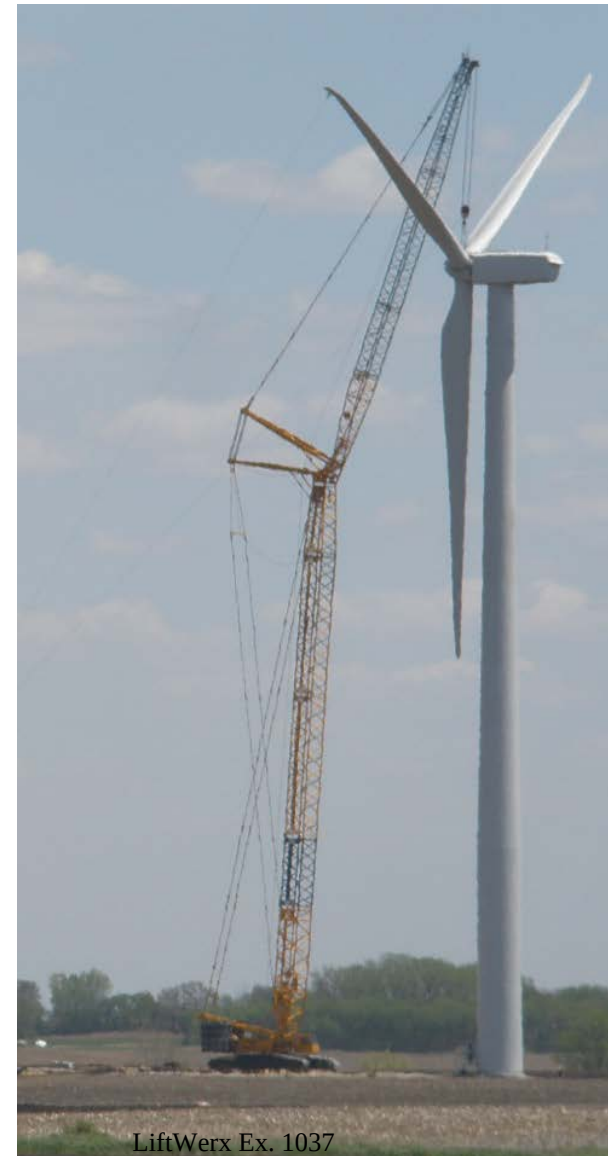


UNITED STATES ANNUAL AVERAGE WIND POWER





Some Assembly Required

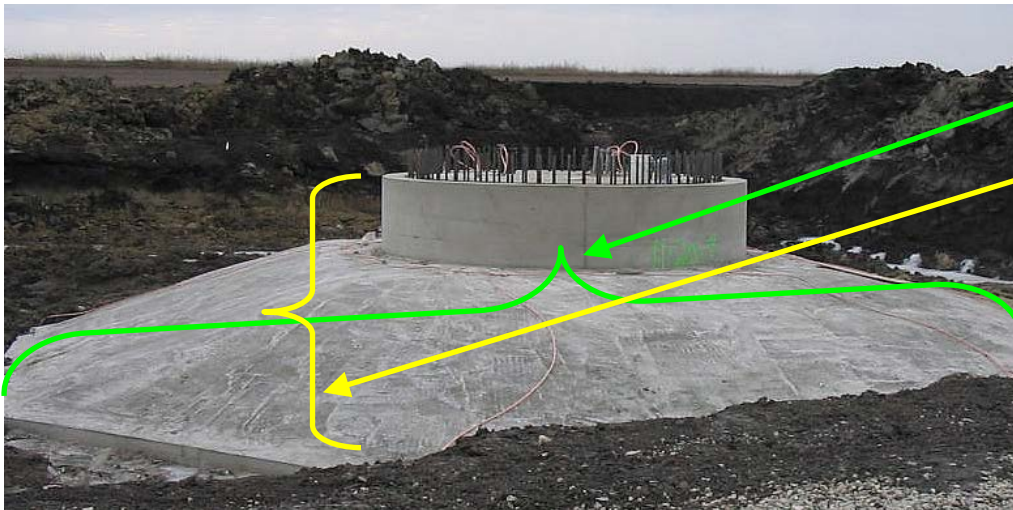


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Installing Foundations



- 54 feet, 6 inches wide
- 8 feet deep
- 330 cubic yards of concrete
- 53,200 pounds of rebar
- Foundation above ground is about 14 feet in diameter