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

FPL

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

NEXTera ENERGY RESOURCES

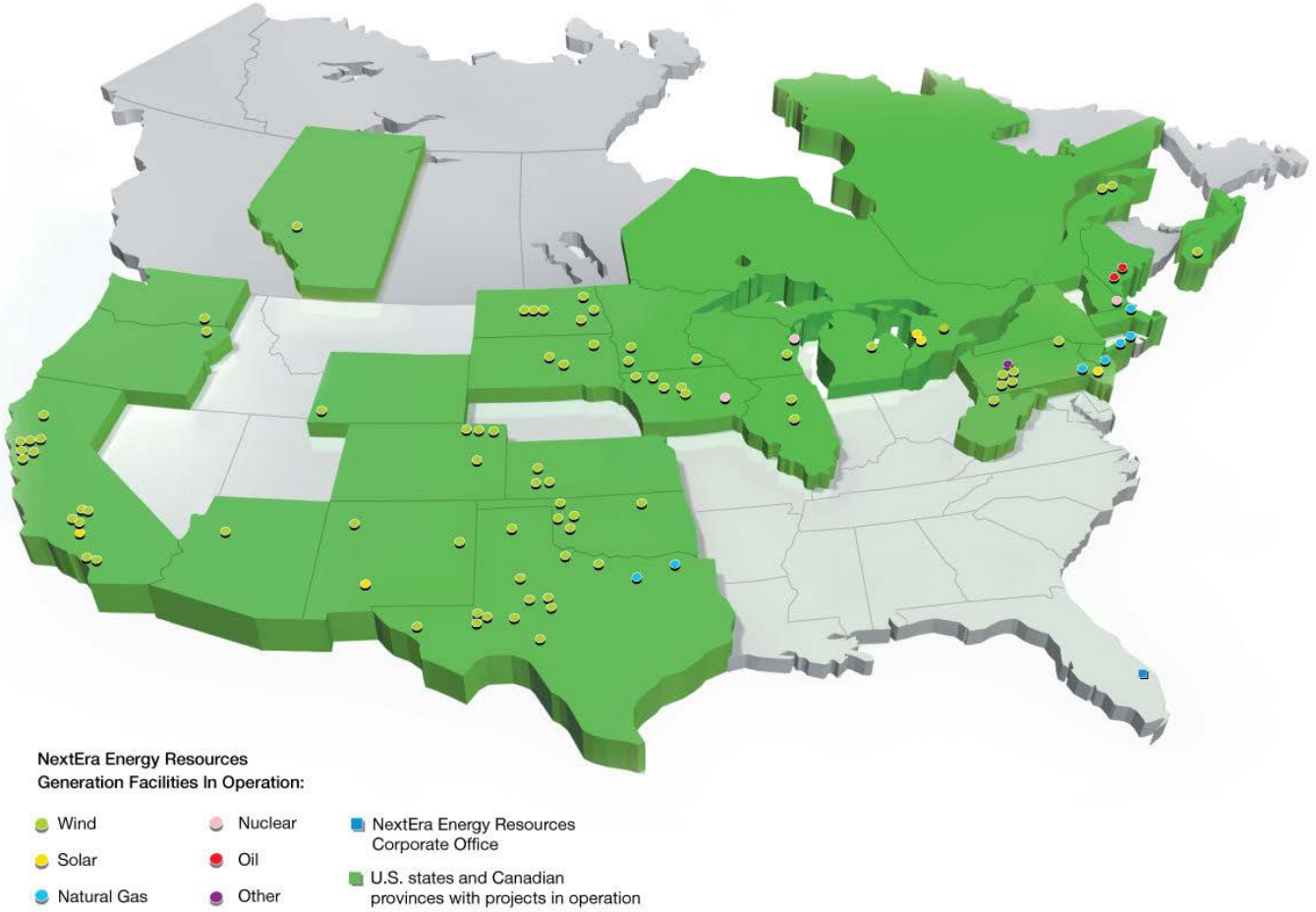
- Successful wholesale generator
- U.S. leader in renewable generation
- Assets in 26 states and Canada
- 17,771 MW in operation

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

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

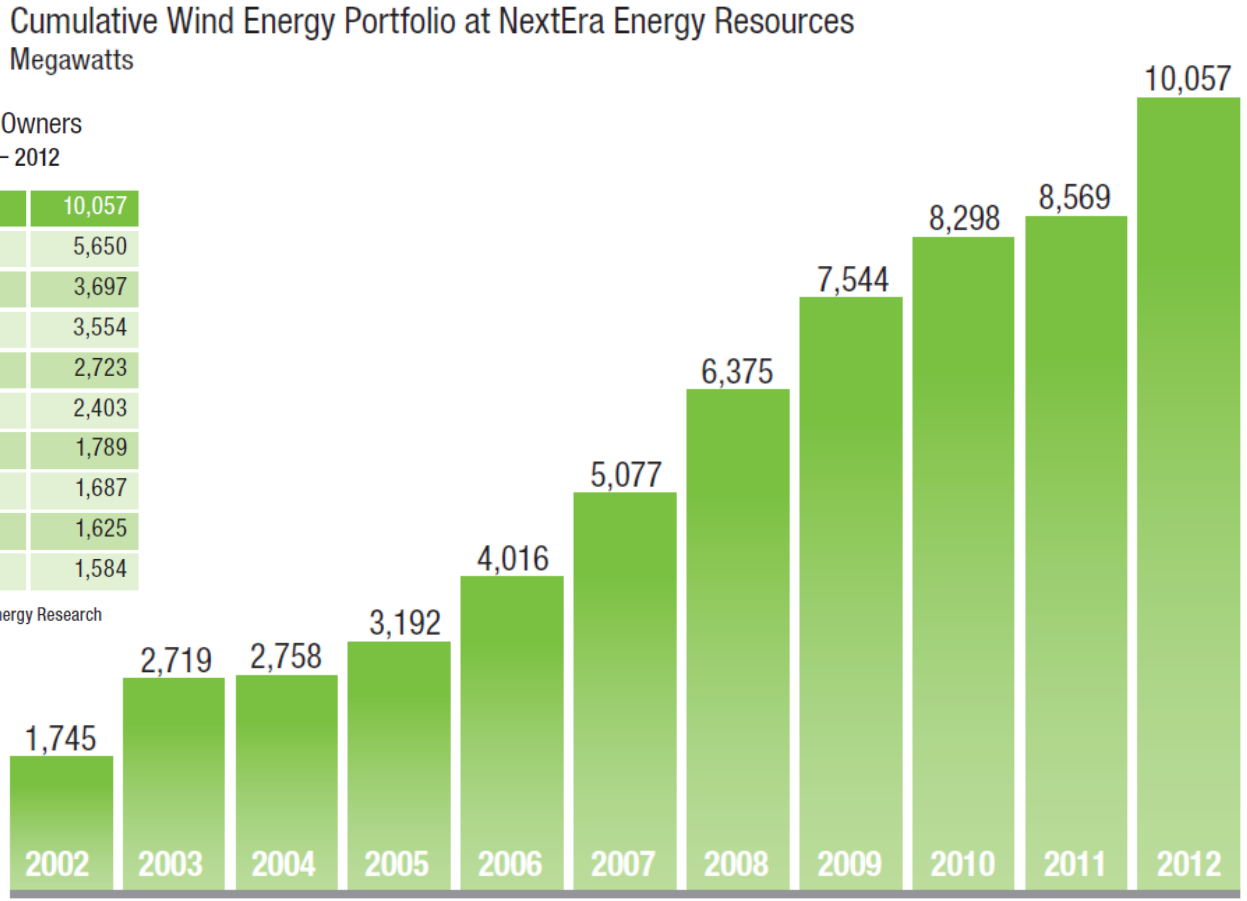
1) As of March 1, 2013

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

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



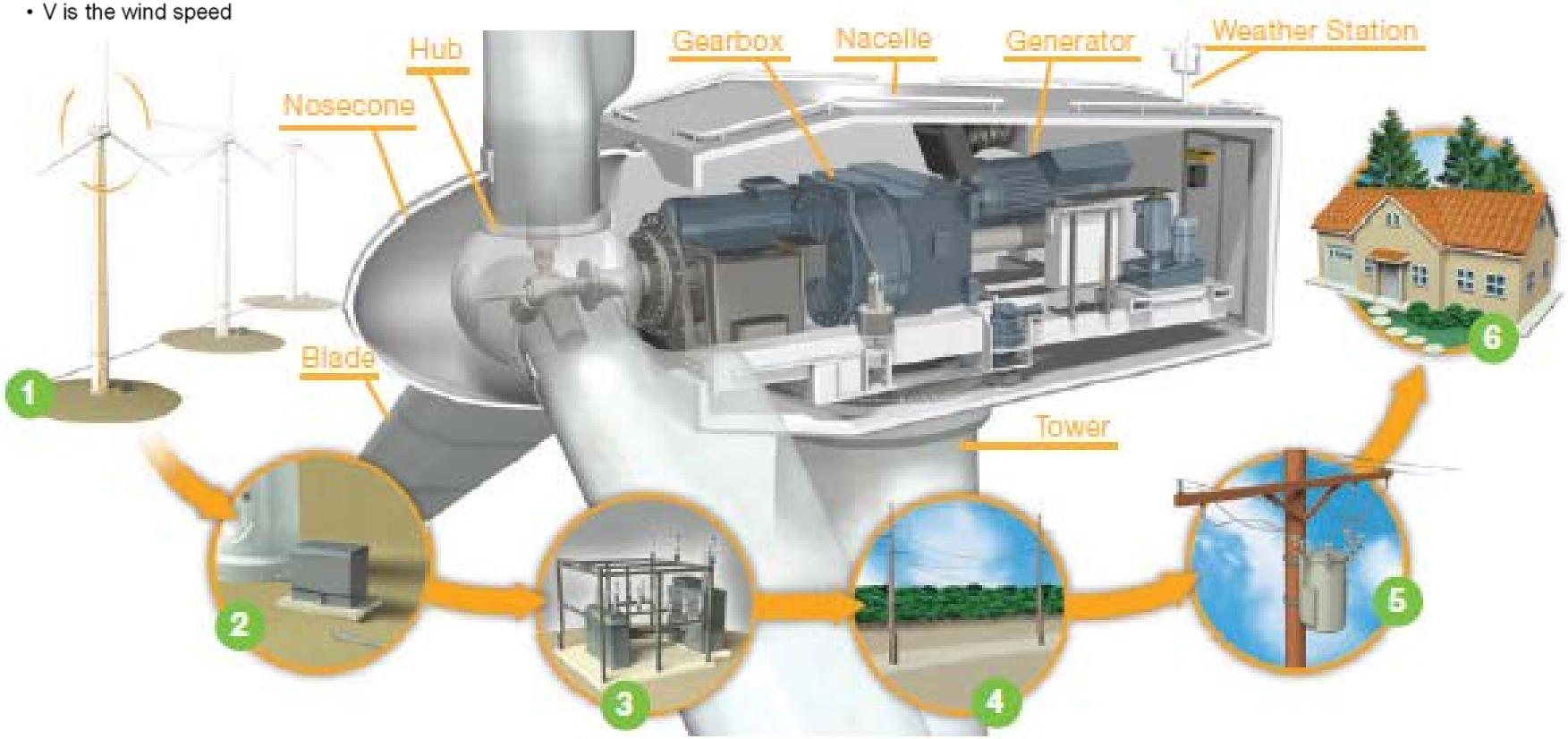
Wind has grown quickly and repairing components is a big effort

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

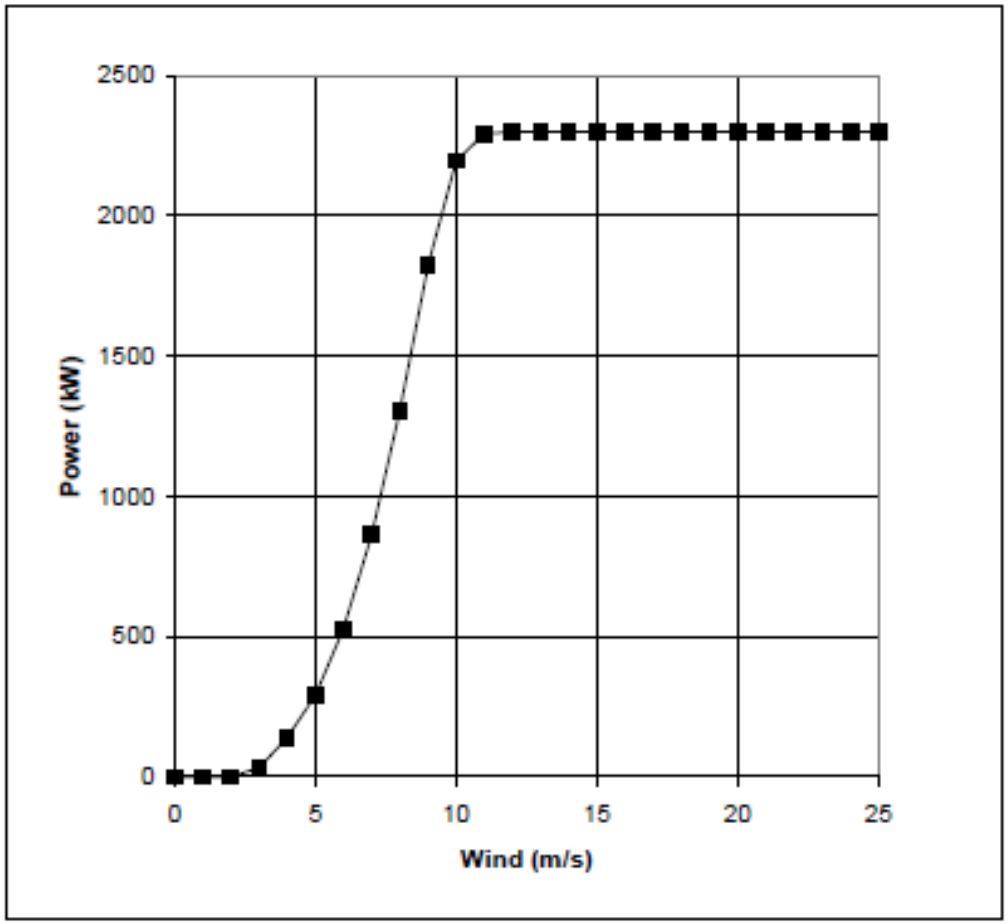


Wind turbines produce power on a design power curve

Standard Power Curve Rev 1

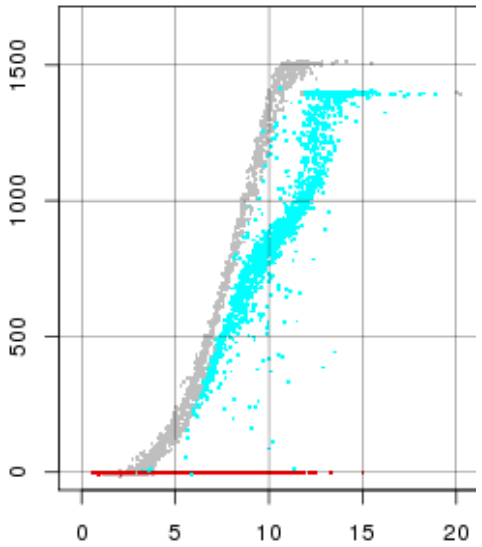
The calculated power curve data are valid for standard air density conditions of 15 deg.C air temperature, 1013 hPa air pressure and 1.225 kg/m3 air density, clean rotor blades, substantially horizontal, undisturbed air flow, normal turbulence intensity and normal wind shear.

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
17	2300
18	2300
19	2300
20	2300
21	2300
22	2300
23	2300
24	2300
25	2300

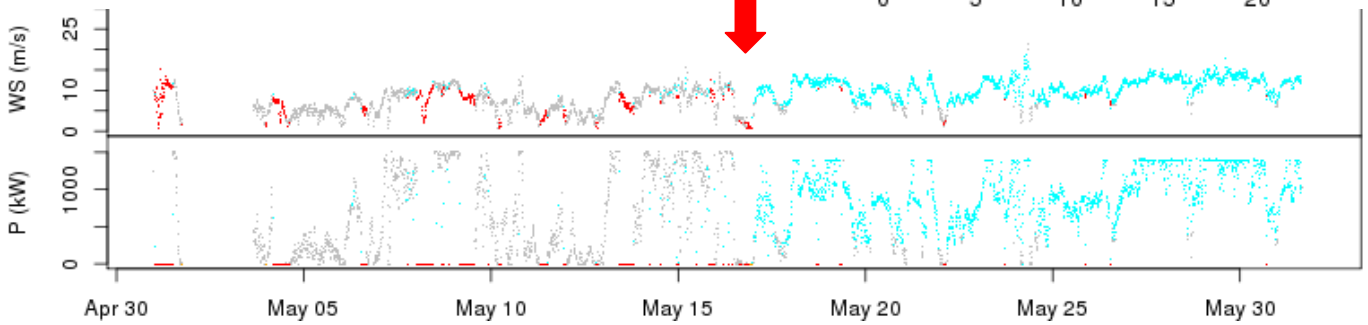


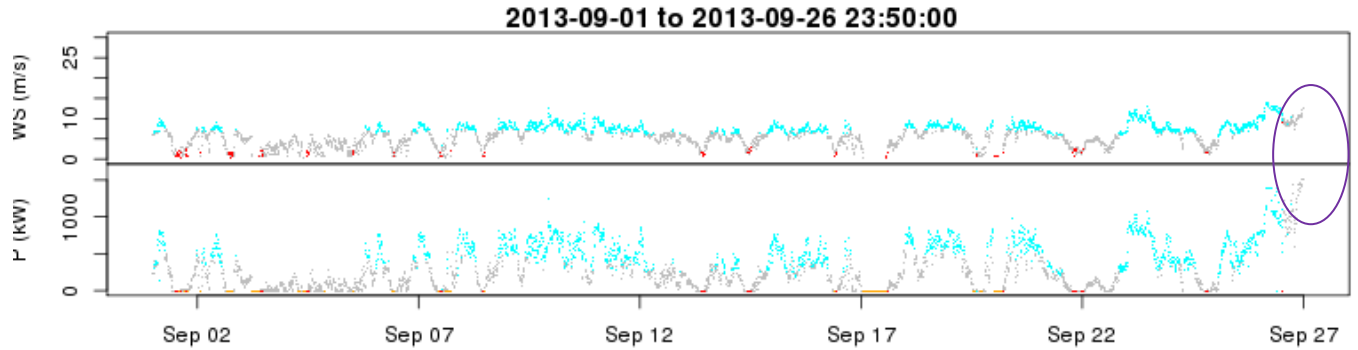
In reality the power has a lot of variability and this data is used to pick out troubled turbines

- Underperformance Example
  - Callahan Divide: Parameter change caused underperformance.



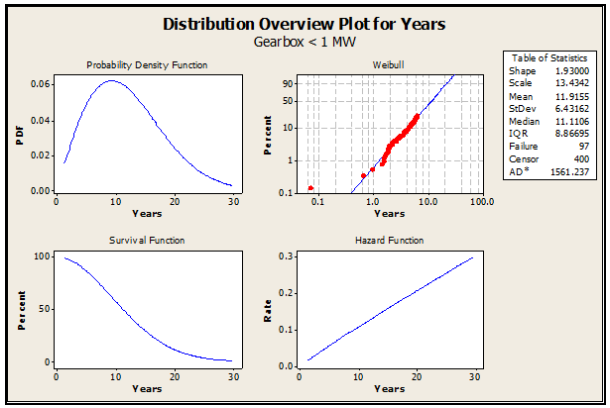
- Parameter change



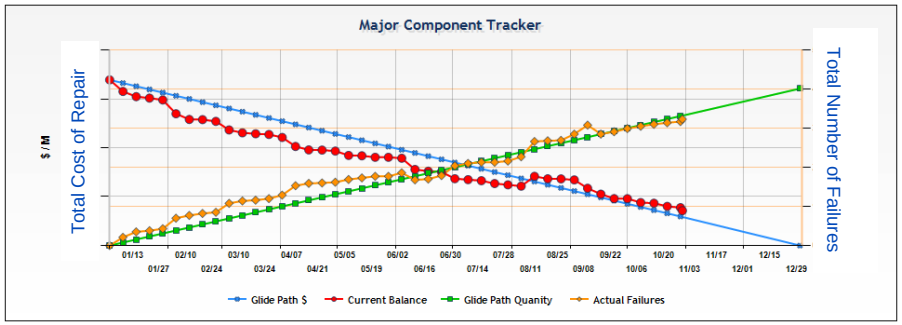


- Parameter correction 9/26

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

RESOURCES

NextEra Energy Resources Iowa Service Business Units

Generation Repair & Service

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

North American Parts & Services

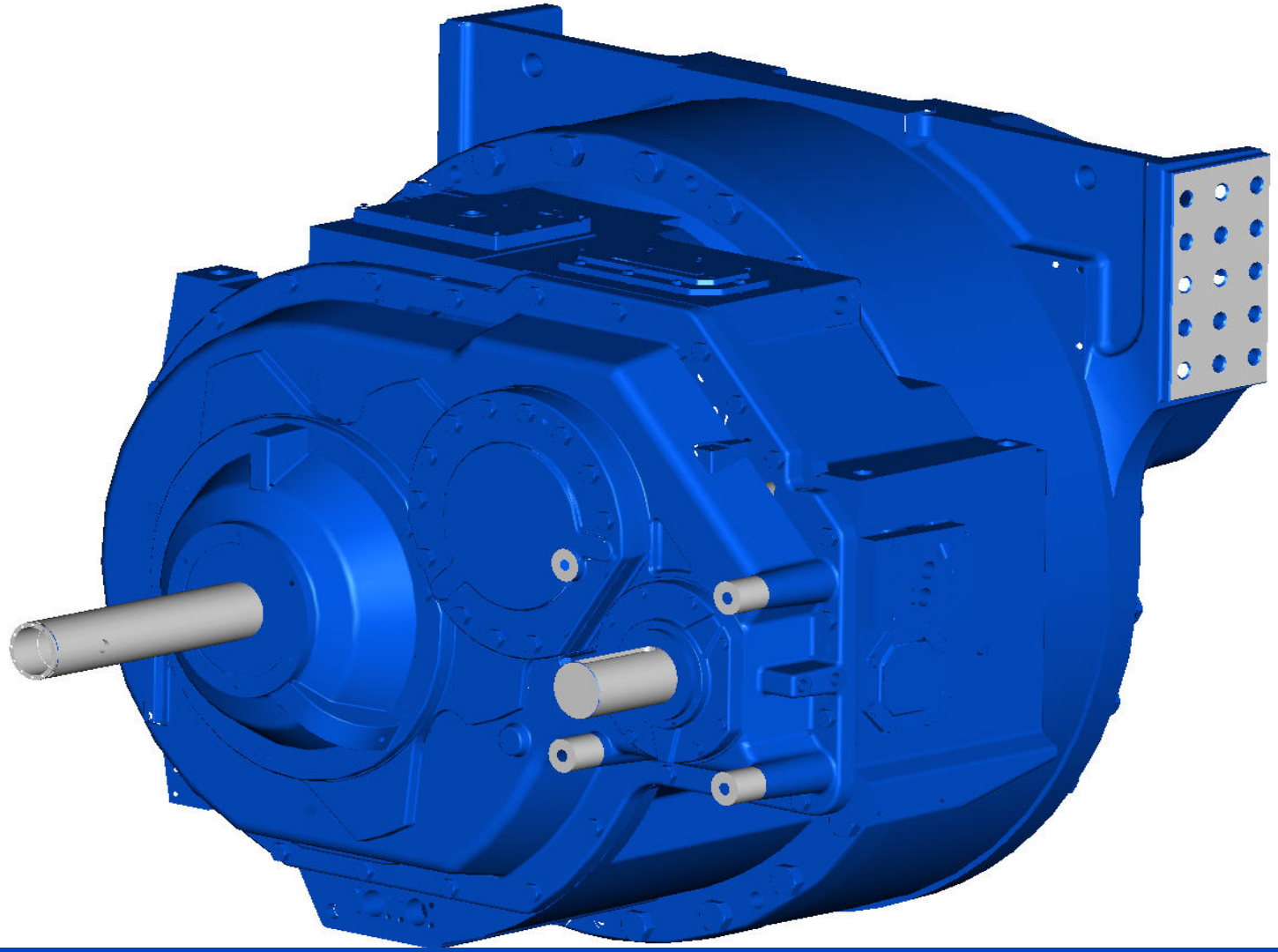
- $2 MM Investment
- $17 MM Inventory

Local Sourcing $2 MM in 2011

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

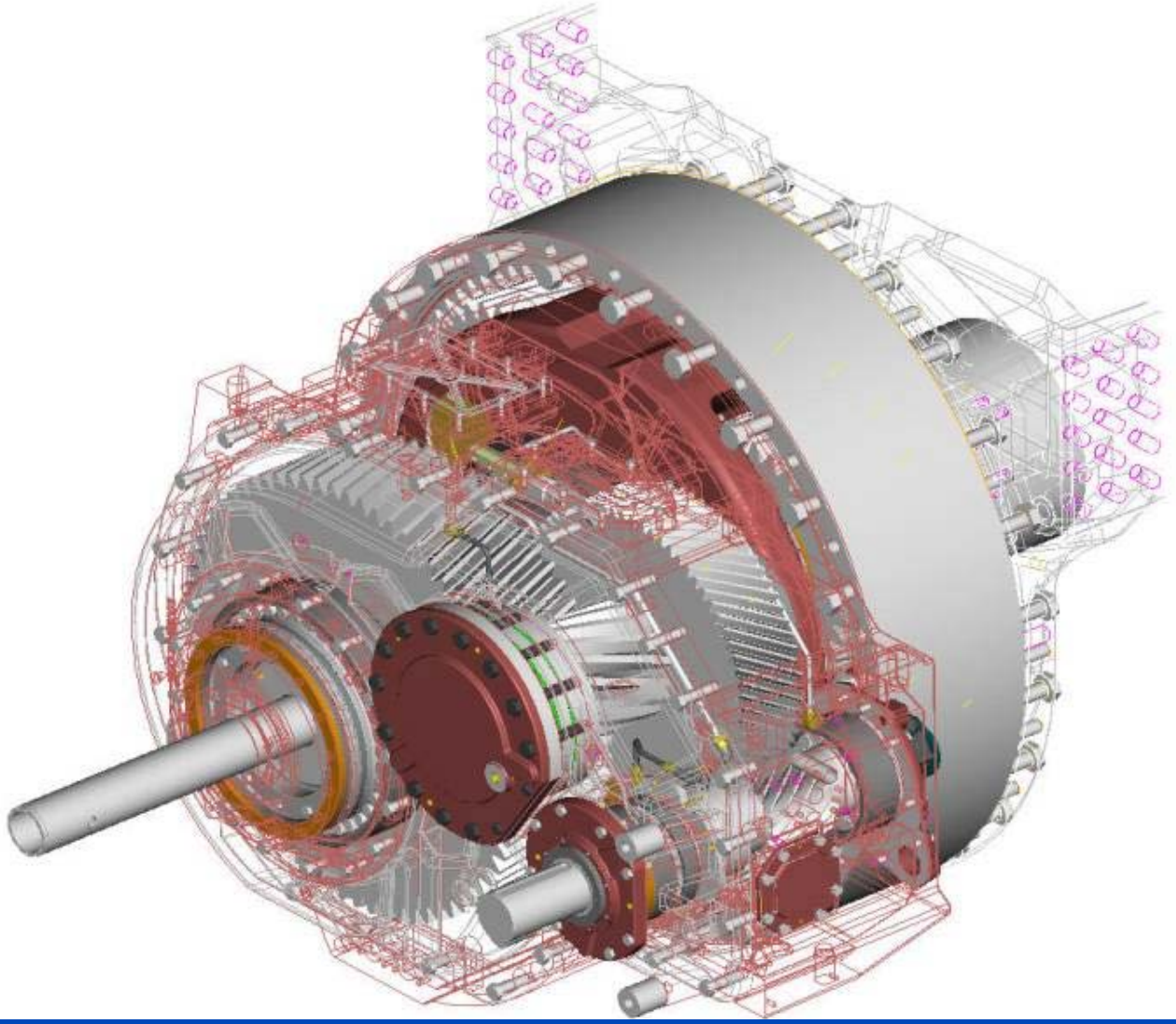
- **Fleet Gearbox Repairs**
  - 254 gearboxes repaired, 150 annually by 2015
  - 33 technologies - proprietary procedures and techniques developed in-house
  - Regenerative Test Stand
  - Repair cycle reduce from 118 to 34 days
  - Up-tower Repair Center of Excellence
- **Fleet Part & Services**
  -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



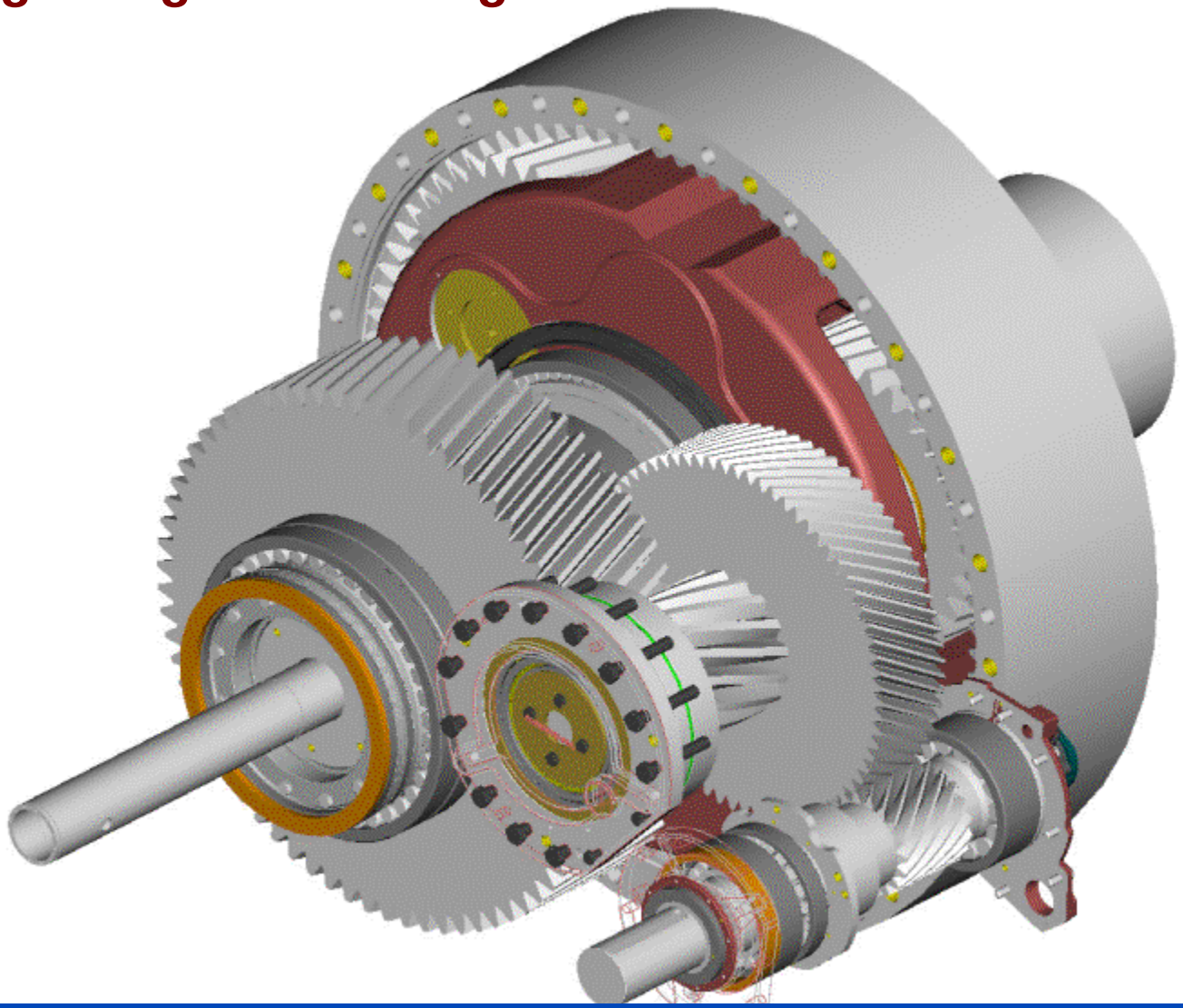
Exterior casing and auxiliary equipment (brakes, oil pumps, instrumentation and case deflection)

Look at bolting, cover and inspection plates



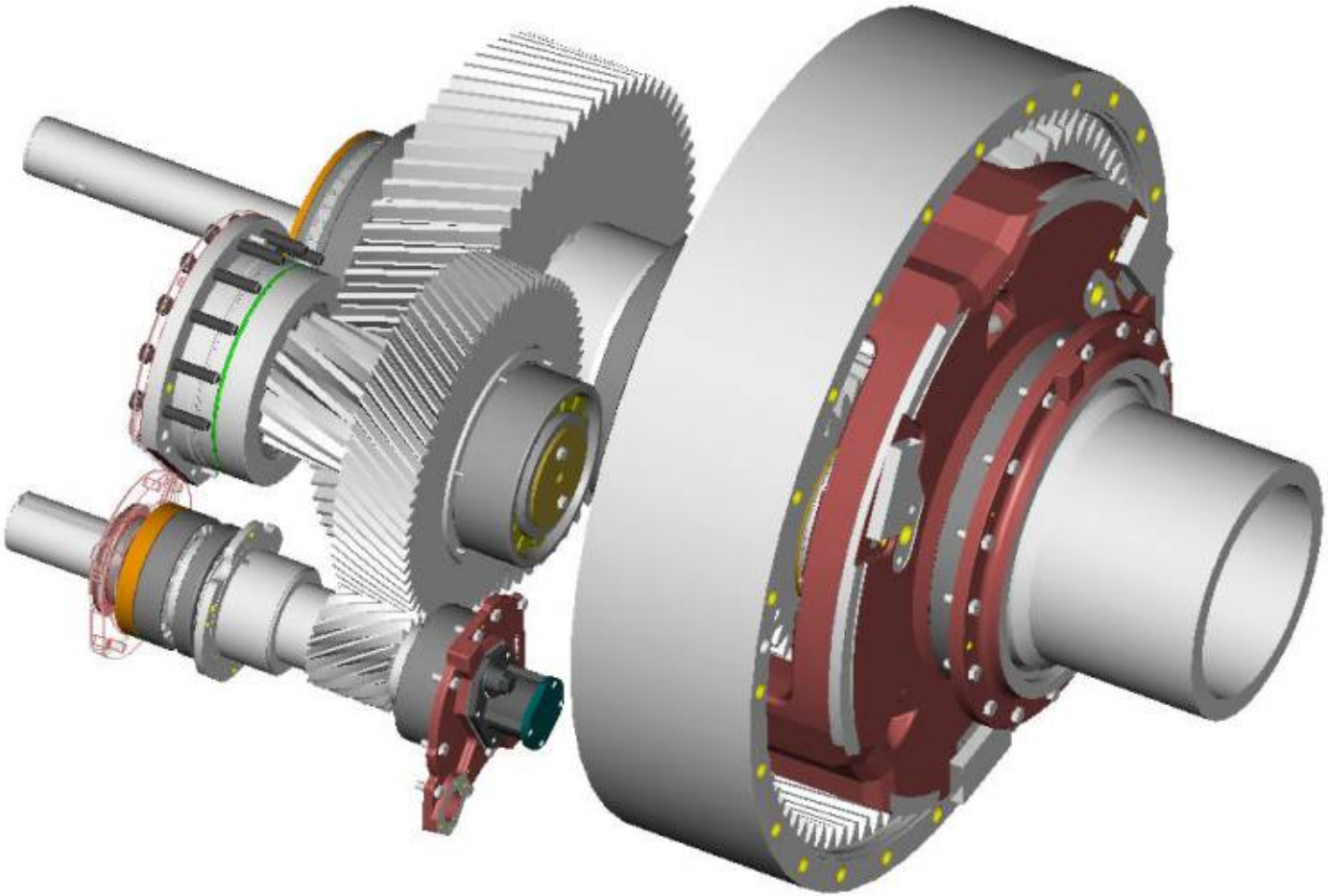
Borescoping is critical to seeing inside a gearbox prior to failures

Look at gearing and bearings



Inspect loading patterns, wear patterns and lubrication performance

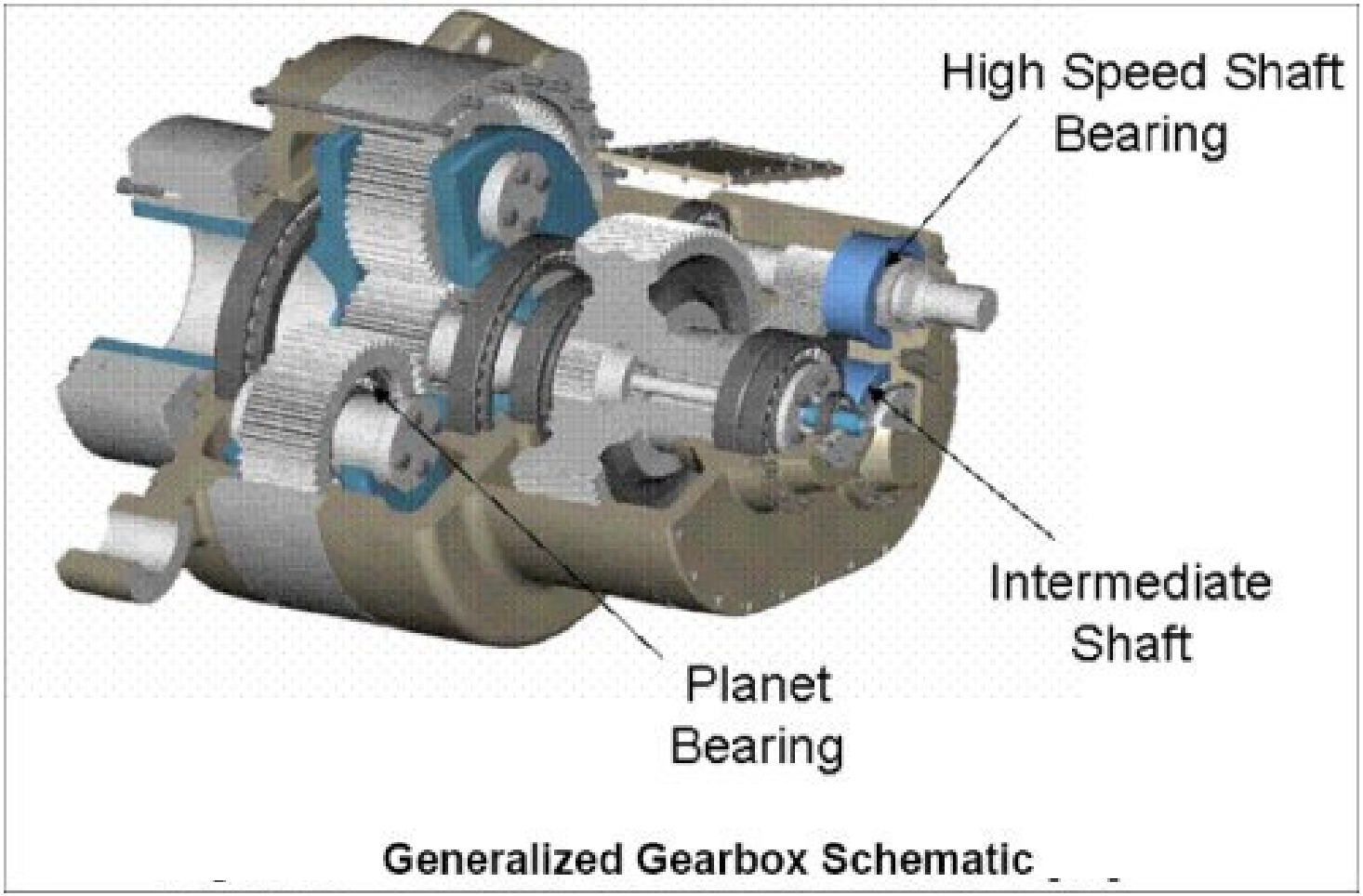
Look at disassembly and reassembly processes



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

NEXTera® ENERGY RESOURCES

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

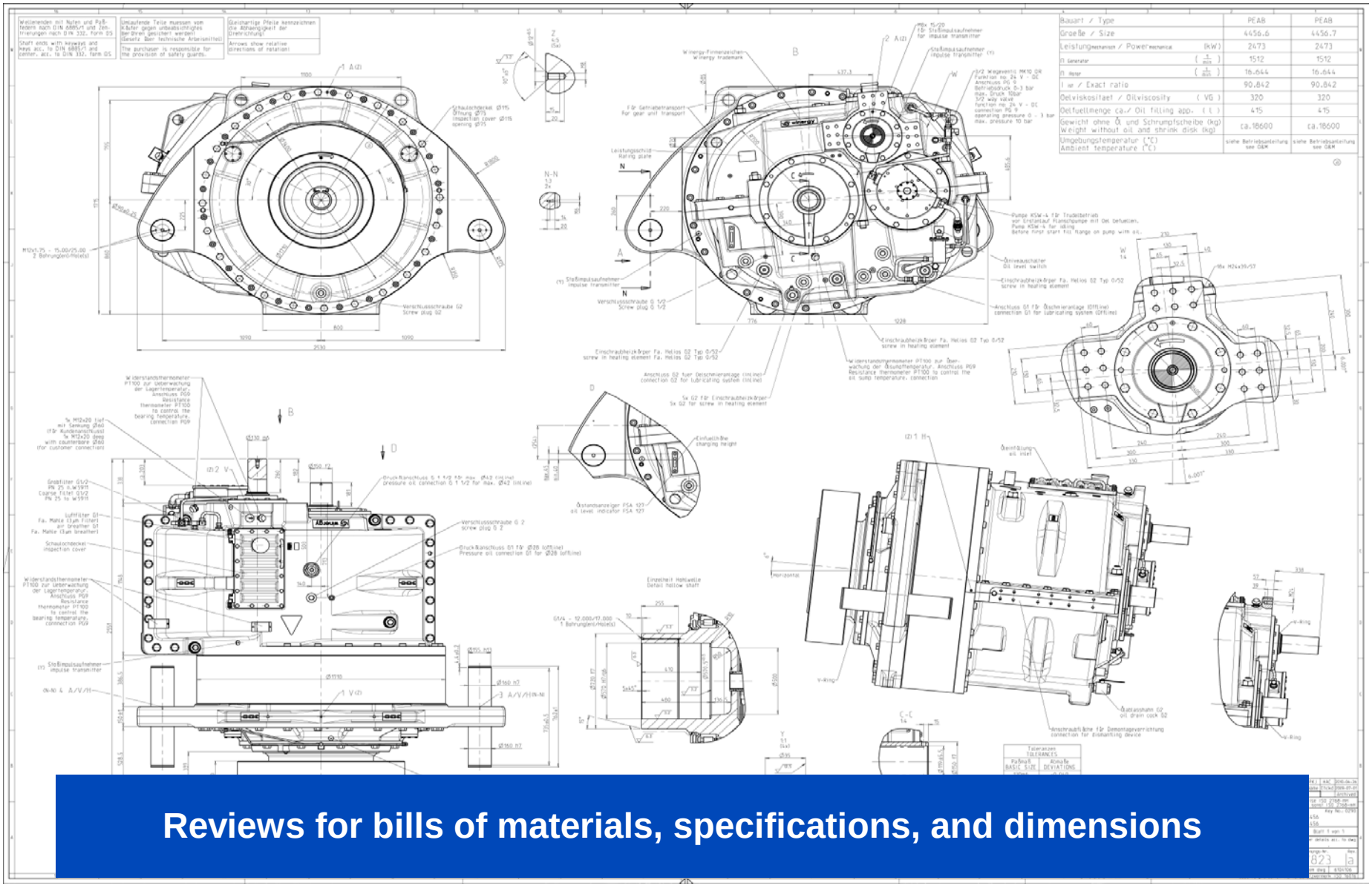


Generalized Gearbox Schematic

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

NEXTera® ENERGY RESOURCES

GRS reviews many engineering drawings



Reviews for bills of materials, specifications, and dimensions

NEXTera® ENERGY RESOURCES

AGMA (American Gear Manufactures Association) standards are used

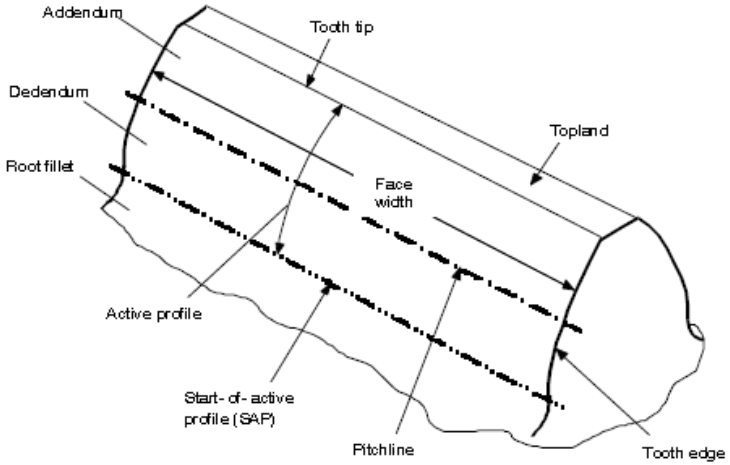


Figure G1 – Gear nomenclature

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

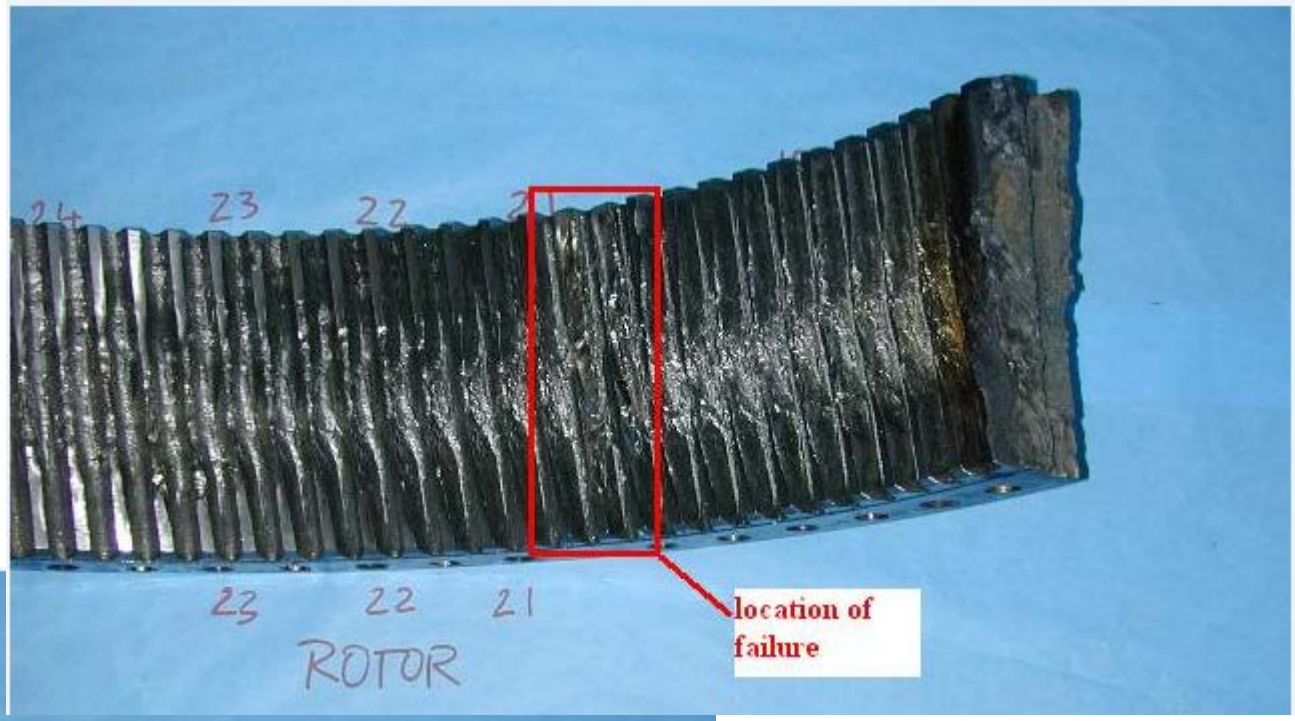
Old 90's vintage wind gearboxes were class 8. New gearboxes are at least class 12.

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

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

NEXTera® ENERGY RESOURCES

Ring gear pinion secondary damage from previous slide

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

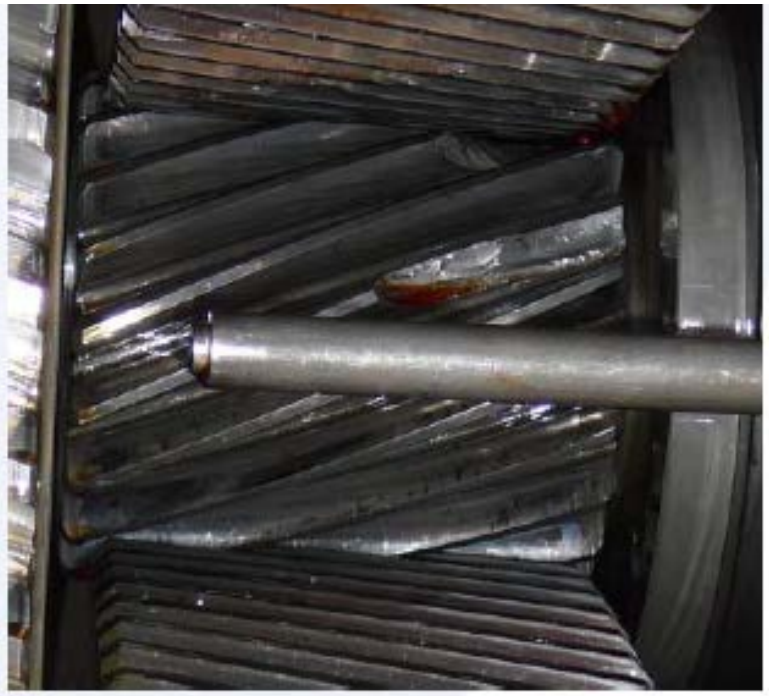
Macro pitting of a spherical roller planet gear bearing race

Spalling of inboard races

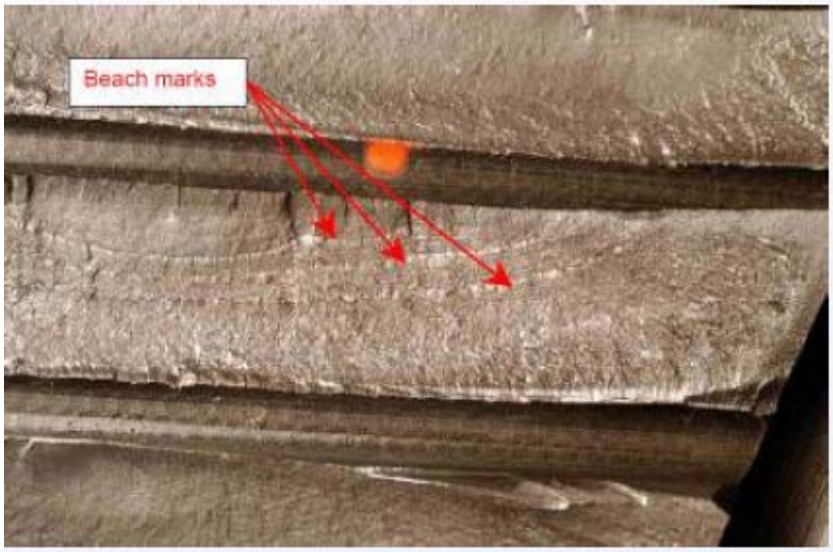
Typical bearing analysis, indications of overloaded bearing due to higher loads than expected. Bearing selections that work in other industry do not work in wind.

NEXTera® ENERGY RESOURCES

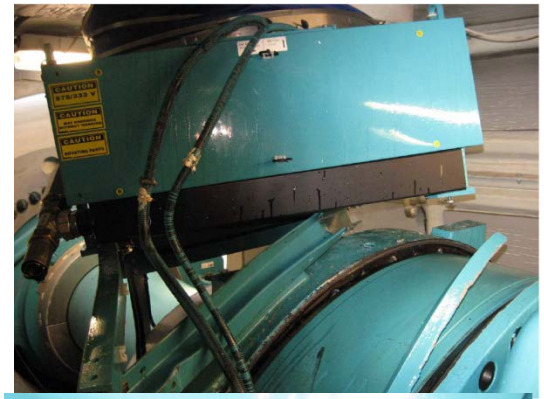
Gear tooth overloading associated with a tolerance problem

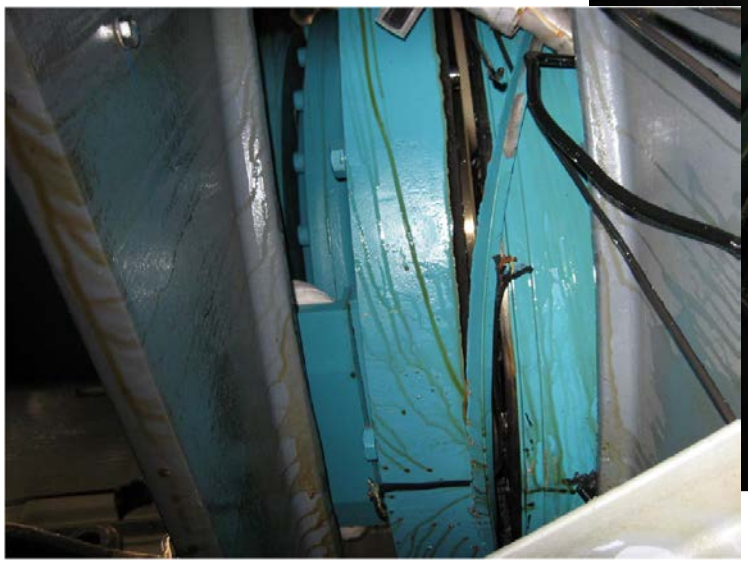


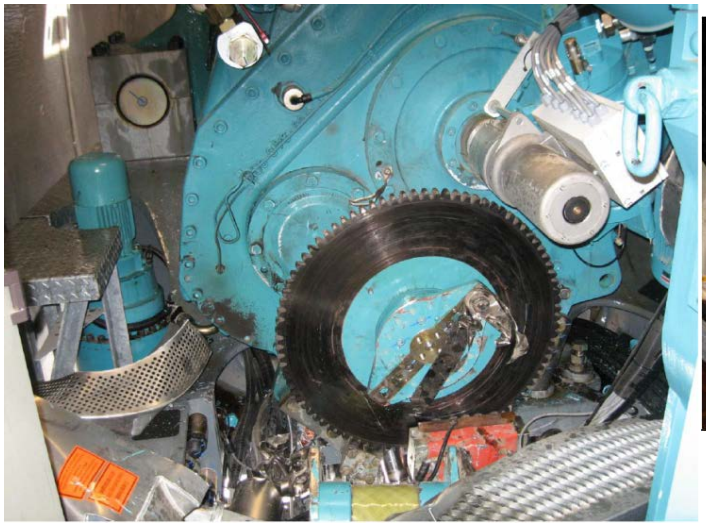
High cycle fatigue – wear over life of the component



Catastrophic Failure







Salvage some gearing and send gearbox to scrap vendor

NEXTera® ENERGY RESOURCES

Plastic deformation of a pair of tapered roller bearings

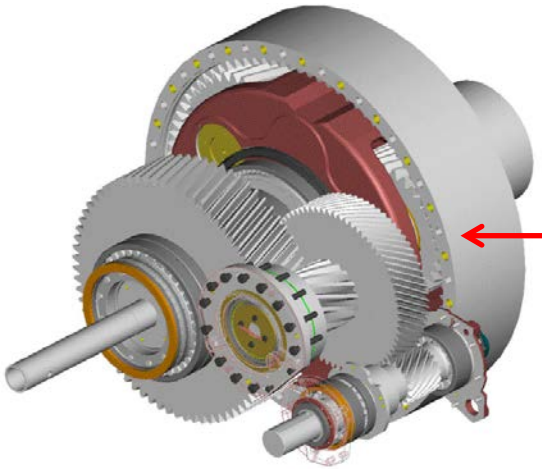
Bearing race white etching prior to spalling of race

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

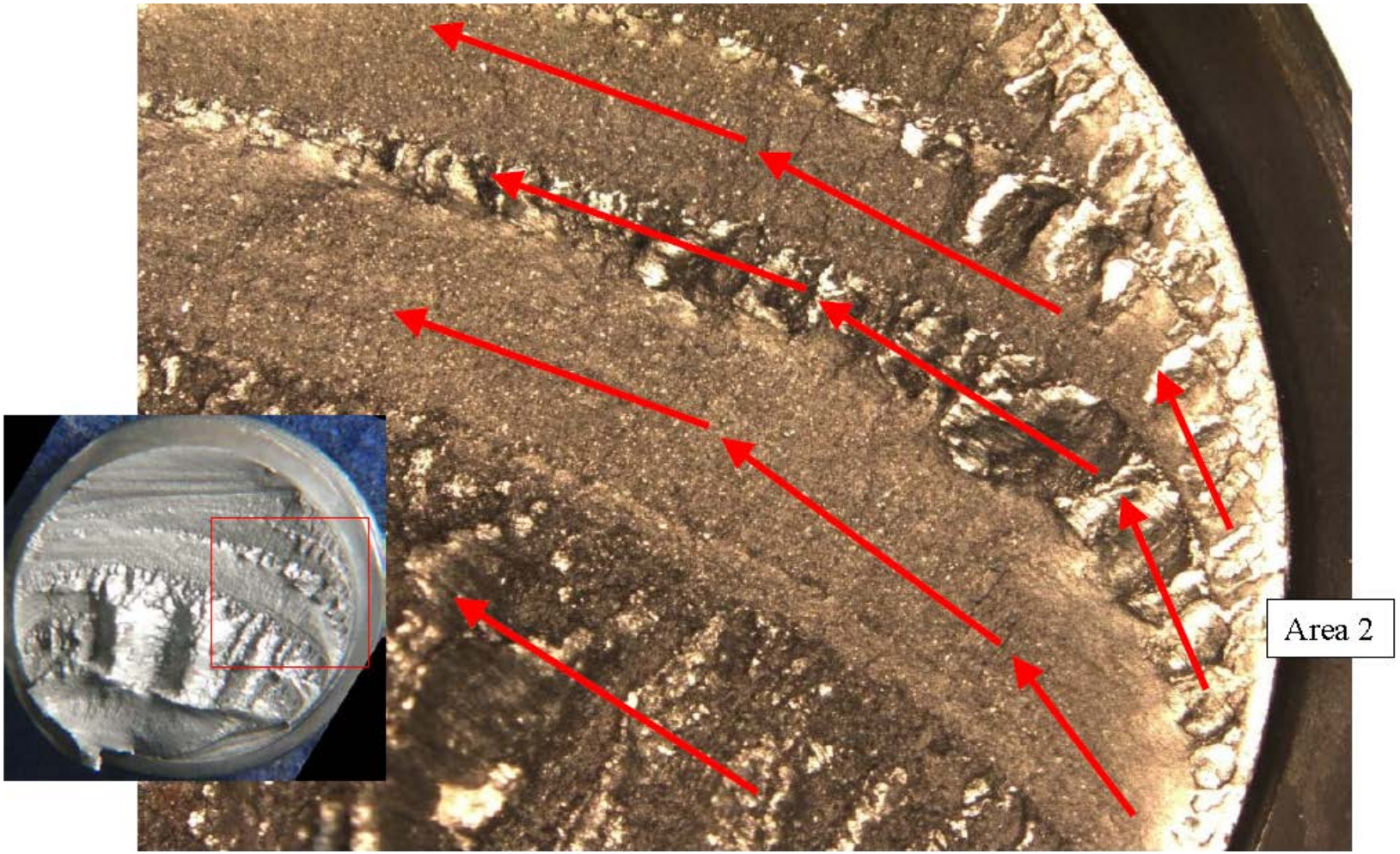
NEXTera® ENERGY RESOURCES

Failure pictures



Failure area

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

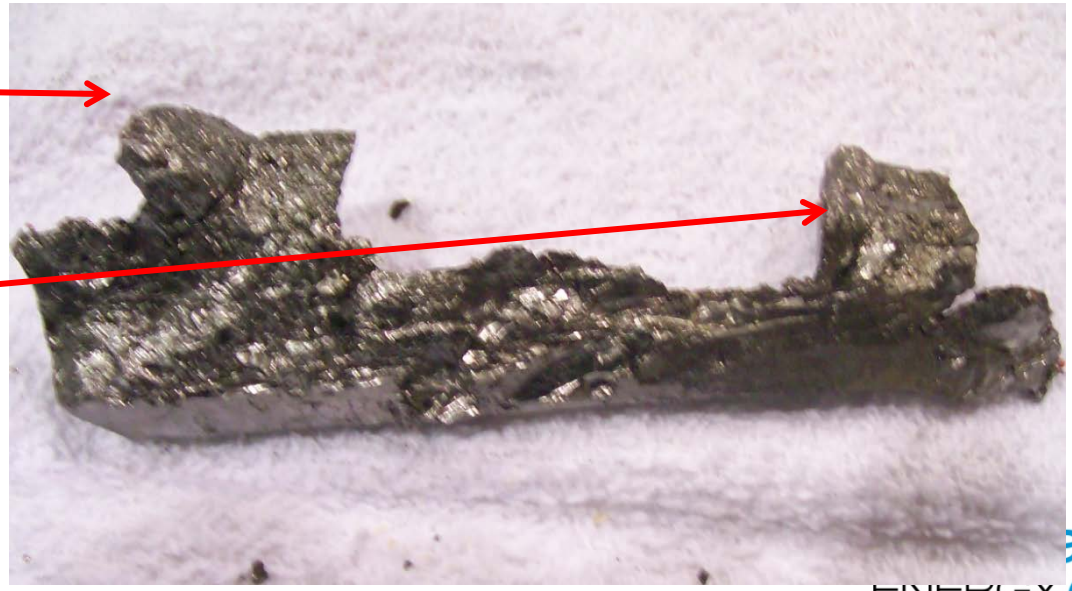


Broken Gear and Ring Gear – cracked in two pieces

Failure debris pictures

Planet gear tooth

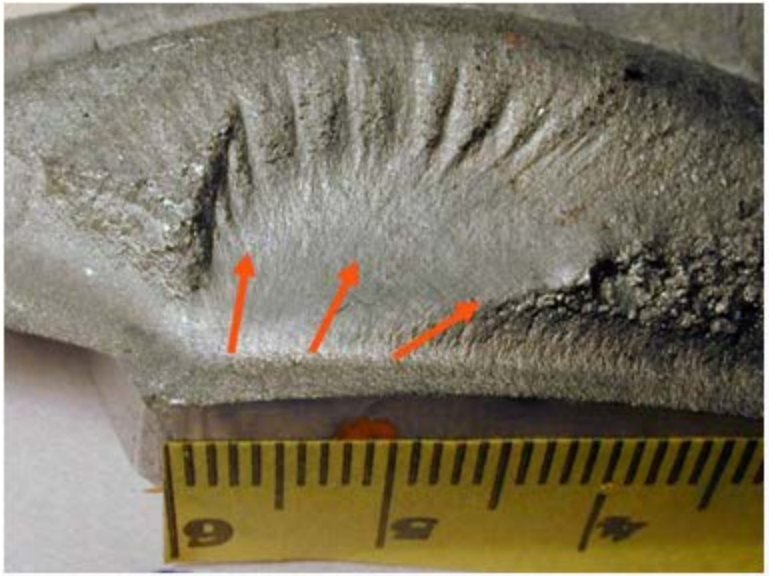
2 ring gear teeth cold welded together due to the energy of the failure

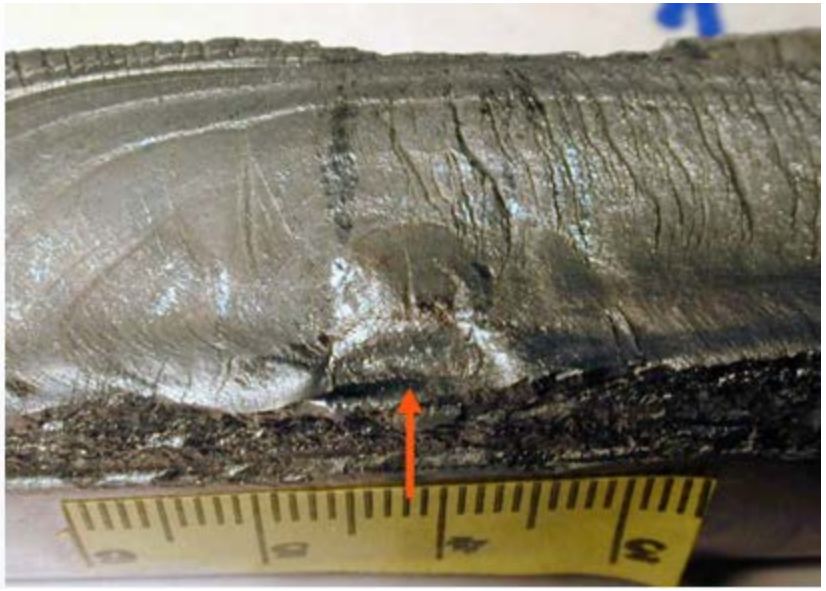


Intermediate pinion – Double helix or herringbone design

Overloading failure

Inclusion failure





Non metallic inclusion usually aluminum or silica

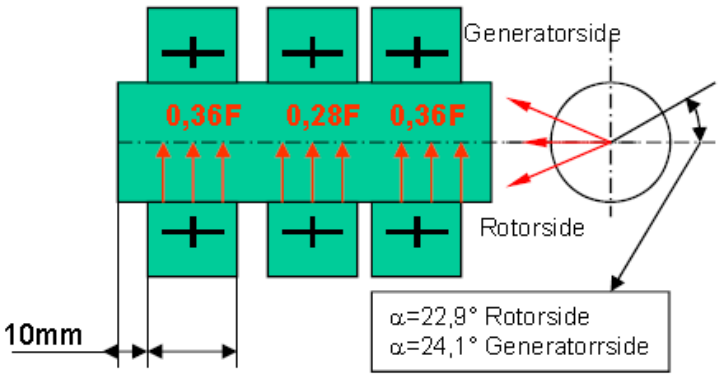
Macro spalling

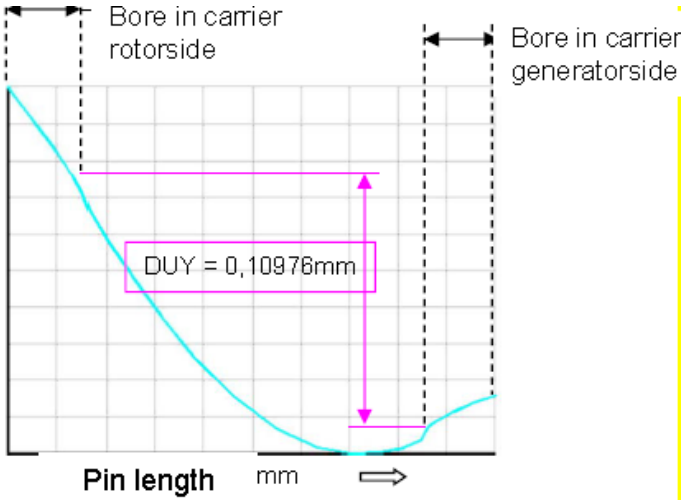
One sided spalling can suggest an alignment issue

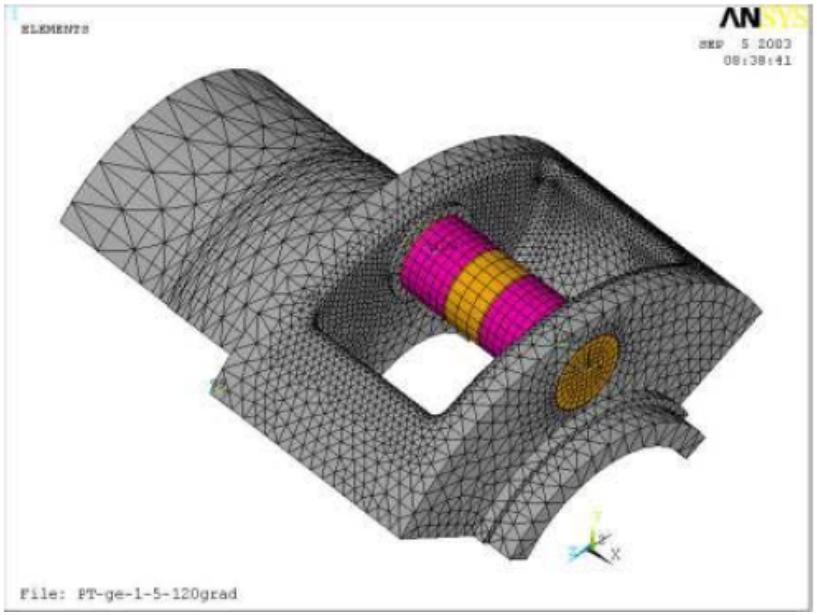
Planet carrier with 5 planet gears
Wind turbines commonly have 3 planets

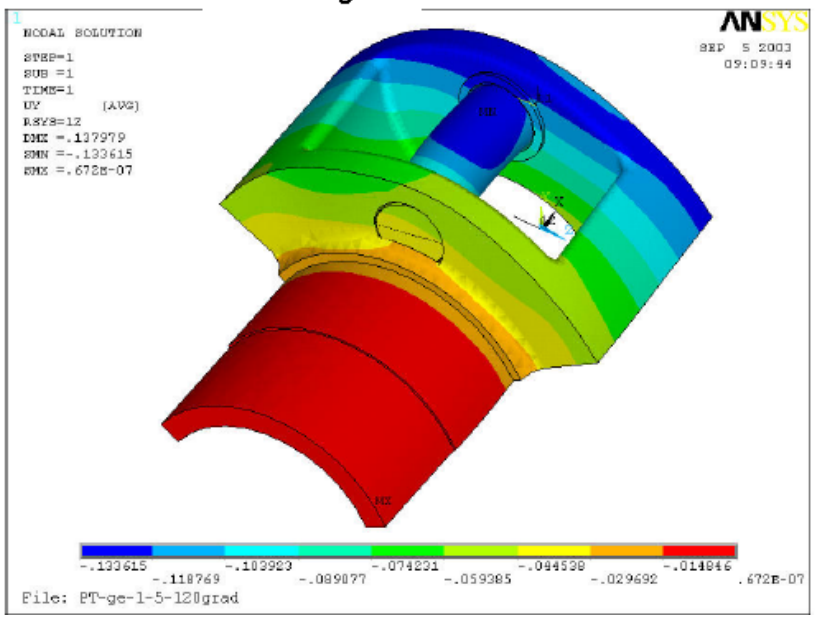
NEXTera® ENERGY RESOURCES

Load modeling for analysis









Design Calculations

	gear ratio	center distance	No. of teeth	phase dispacement	Normal module	profile shift coeff	face width	helix angle	tip diameter	contact ratio transv.	contact ratio overlap	spec. sliding itp	spec. sliding root	b/sun diameter or b/pinion diameter	b/annulus diam. or b/center distance	load distri-bution flank	load distri-bution root	safety factor ISO flank	safety factor ISO root	safety factor scuffing DIN integral	safety factor scuffing DIN contact	safety factor scuffing FVA 166 TZM
	i	a	z	Delpe	m	x	b	β	da	εα	εβ	ξ	ξ -	b/dw	b/dwa	KHß	KFß	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		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		0,229			1,43	1,63			
annulus			-94	0,333		-1,3644			1291,5	1,598	1,055	0,16	-0,19			1,15	1,13	1,86	2,04	(FVA45 I/II)		
																RMS = 0 (AGMA rec.)						
																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						

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

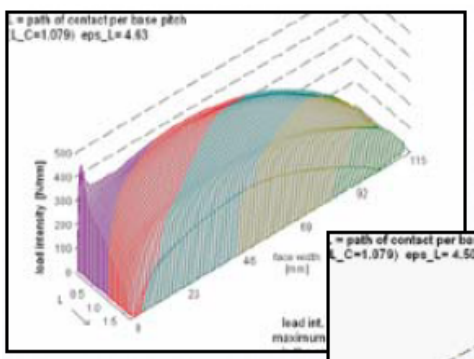
Gearwheel material: 18CrNiMo7-6 (1.6587) | SigHlim = 1510 N/mm² | Sig Flim = 520 N/mm²

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

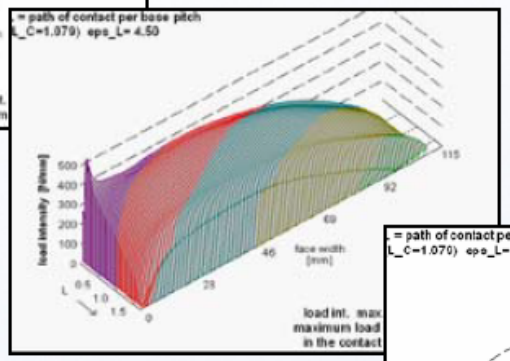
K.5.42004

NEXTera ENERGY RESOURCES

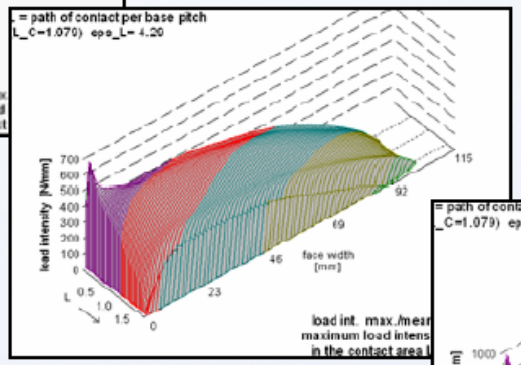
Design calculations associated with load sharing of multiple gears



0.005” Timing Error



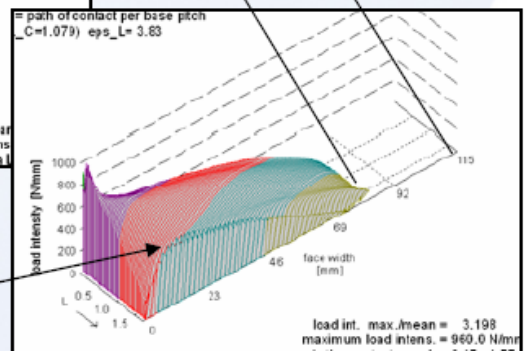
0.010” Timing Error



0.020” Timing Error

Region of elevated tooth bending stress

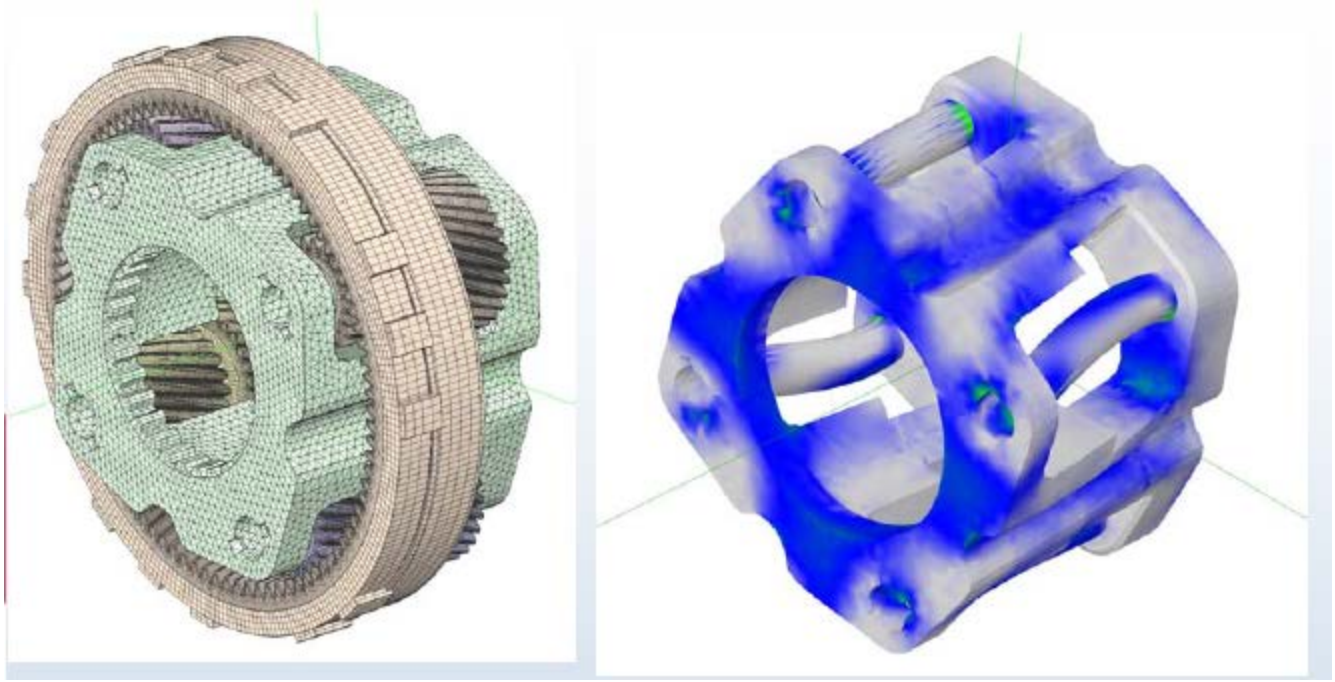
Region of no contact



Region of elevated tooth bending stress

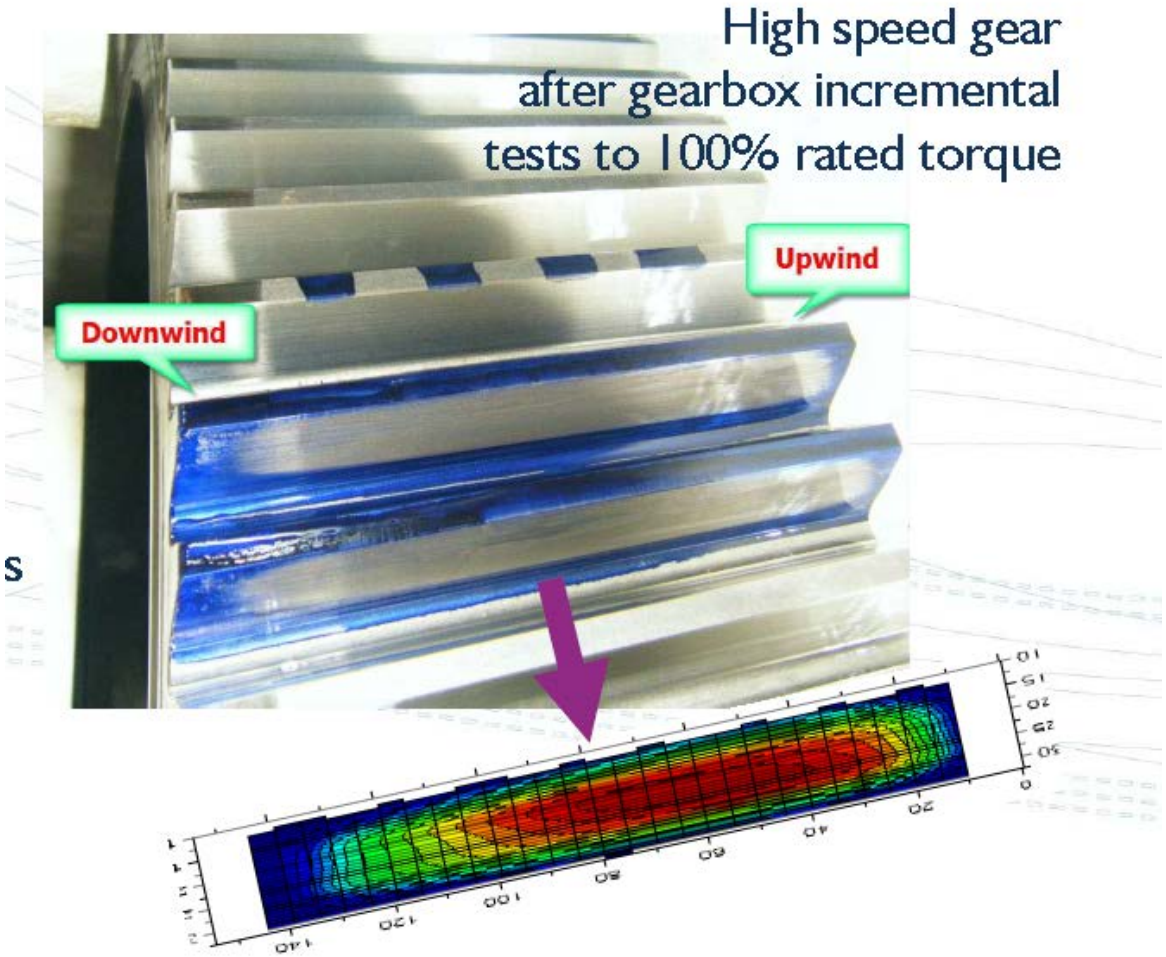
Timing of gears is critical to some gear train designs

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

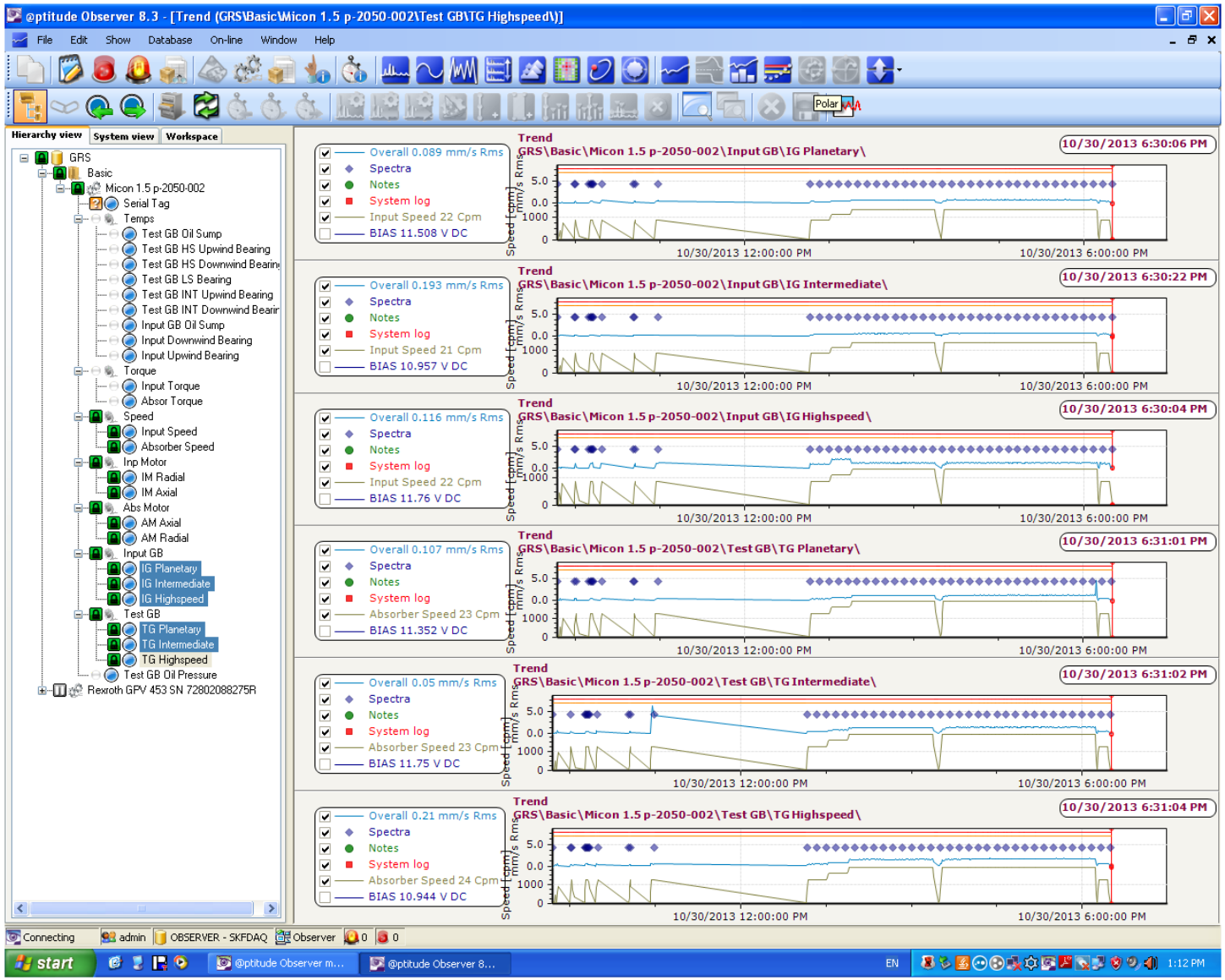
Heating

ENERGY RESOURCES

All > 1MW gearboxes get load tested at the shop

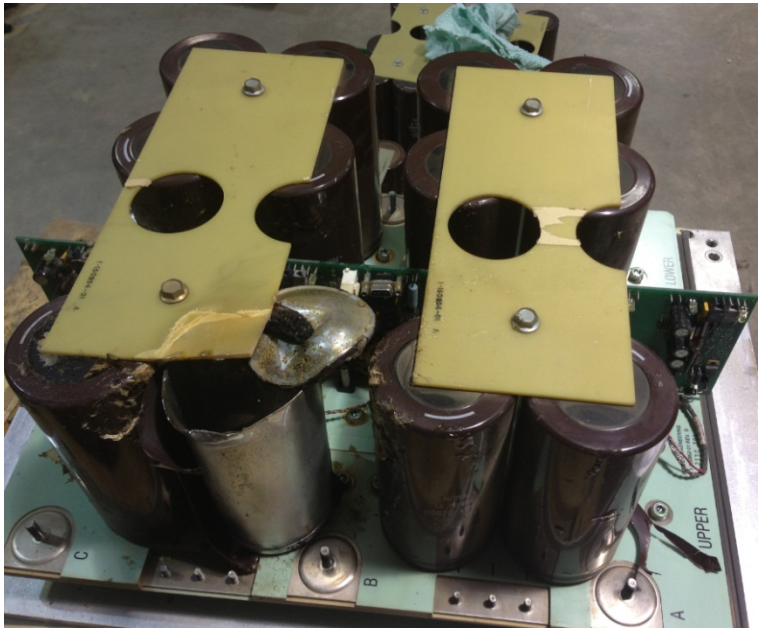
Torque Feedback Test Stand

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



All bearing vibrations and oil flows are monitored

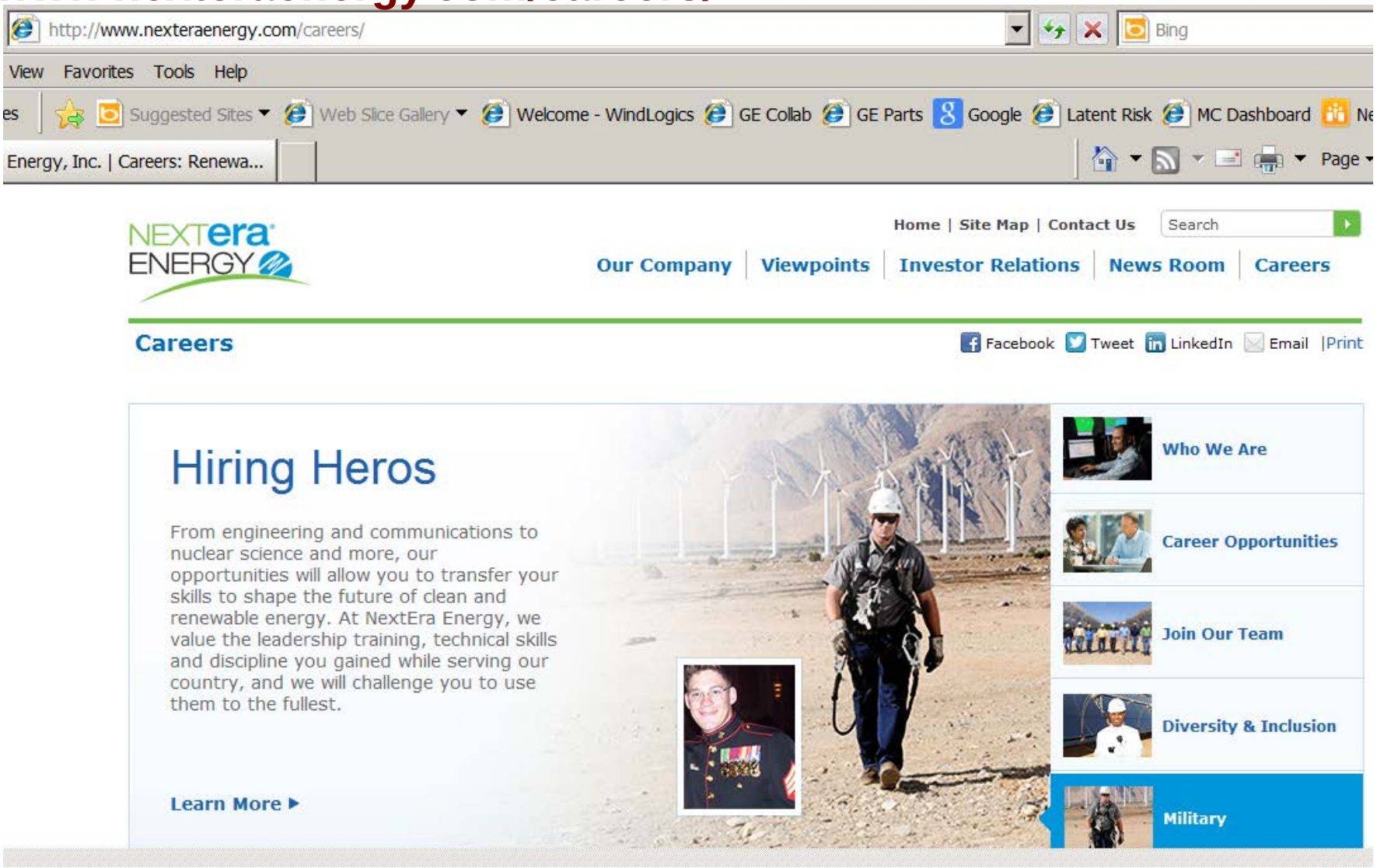
Electronic repairs will start at the facility next year



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

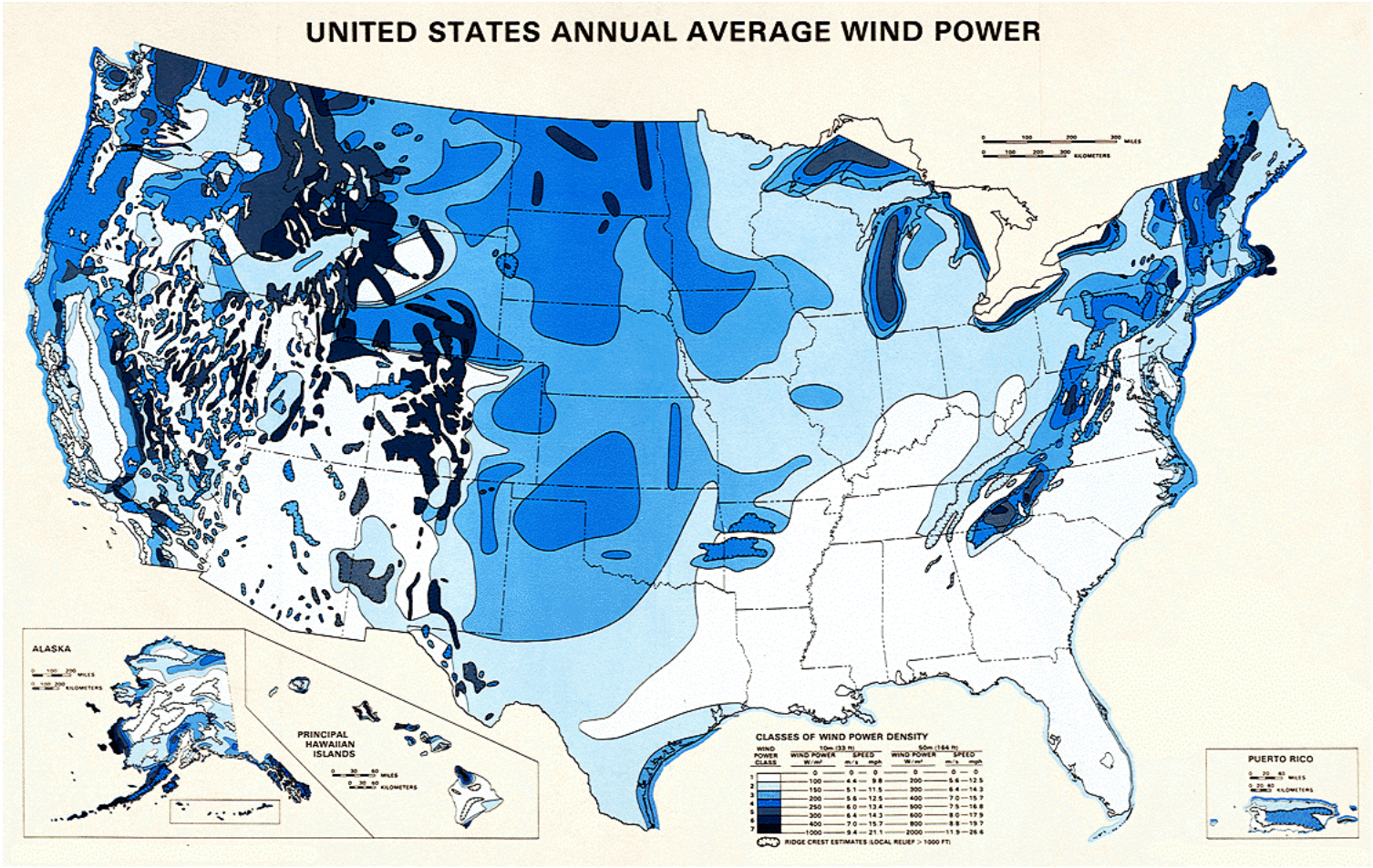
Job opportunities with NextEra can be found at

www.nexteraenergy.com/careers/

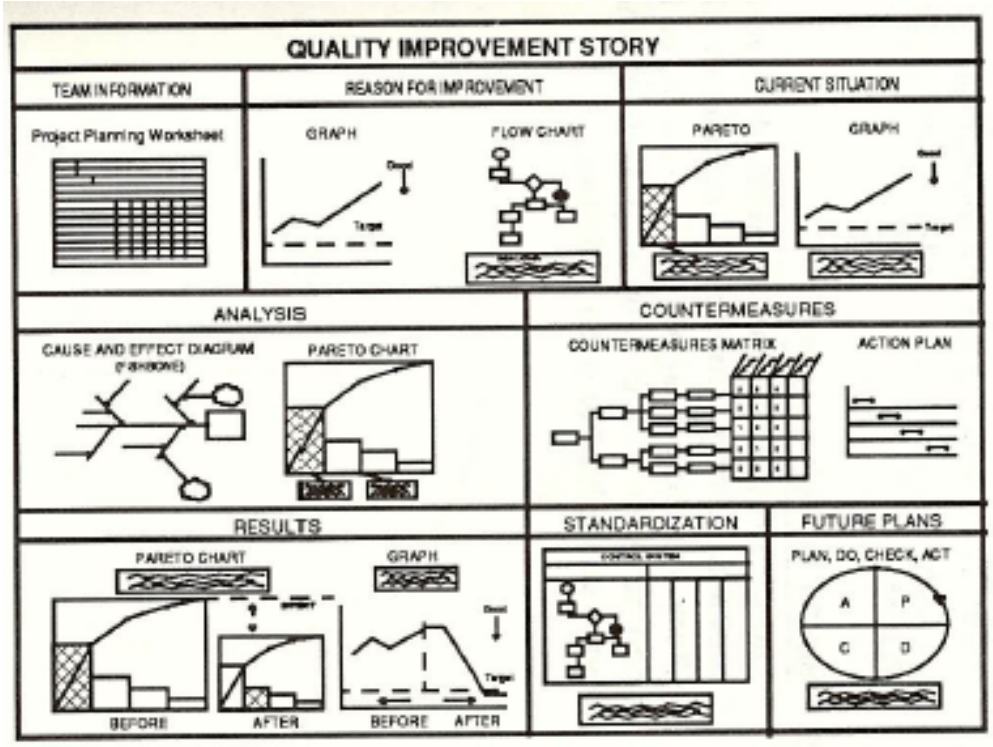


NEXTera ENERGY RESOURCES

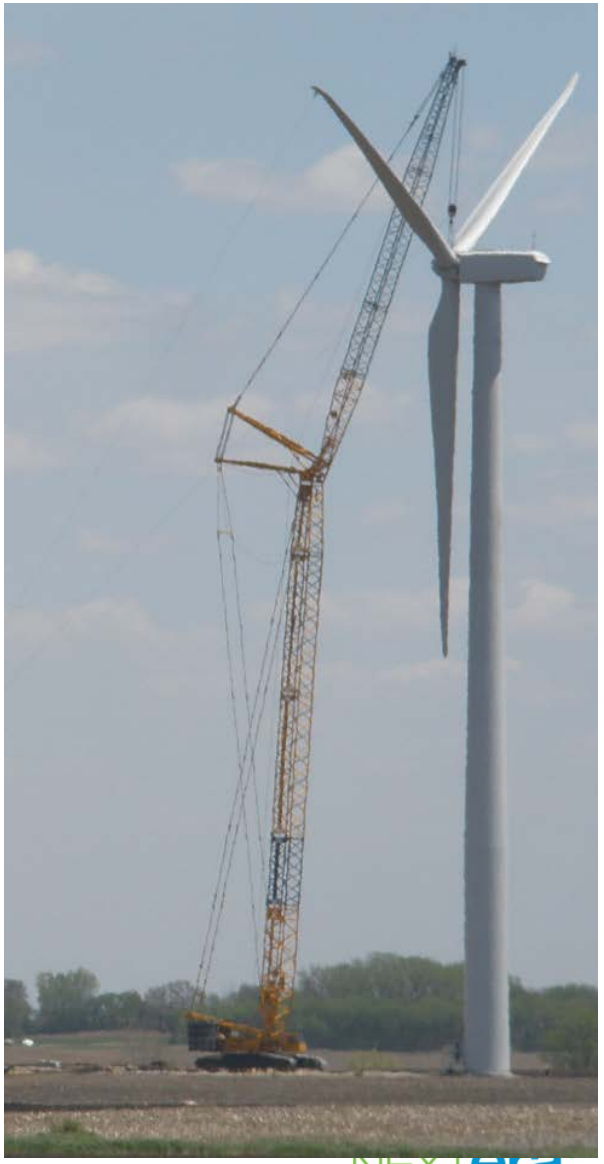
Questions?



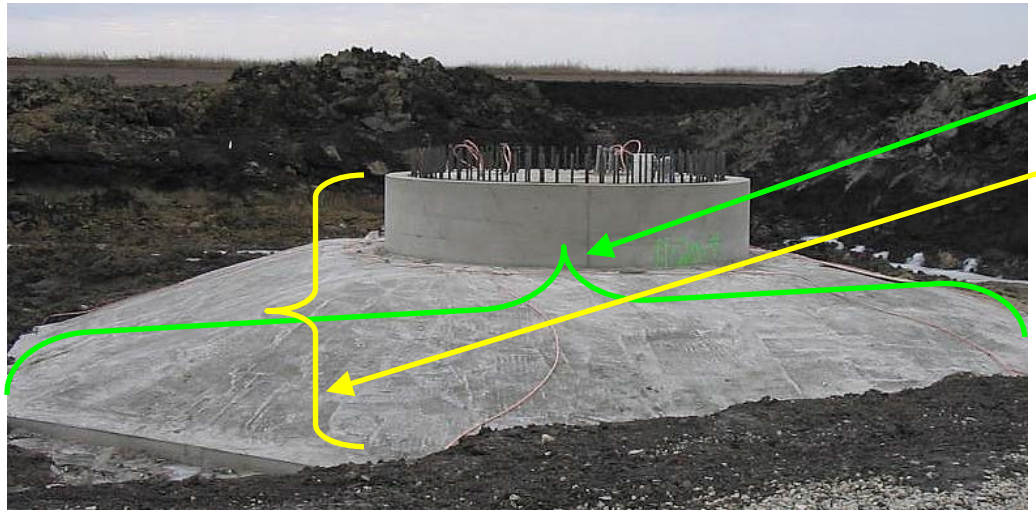
NEXTera® ENERGY RESOURCES


QUALITY IMPROVEMENT STORY
TEAM INFORMATION
Project Planning Worksheet
REASON FOR IMPROVEMENT
GRAPH
FLOW CHART
CURRENT SITUATION
PARETO
GRAPH
ANALYSIS
CAUSE AND EFFECT DIAGRAM
PARETO CHART
COUNTERMEASURES
COUNTERMEASURES MATRIX
ACTION PLAN
RESULTS
PARETO CHART
GRAPH
BEFORE
AFTER
BEFORE
AFTER
STANDARDIZATION
FUTURE PLANS
PLAN, DO, CHECK, ACT
A
P
C
D

Some Assembly Required



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