Noxon Rapids Interpole Connection Failures
Iris Rotating Machine Conference

June 14, 2022

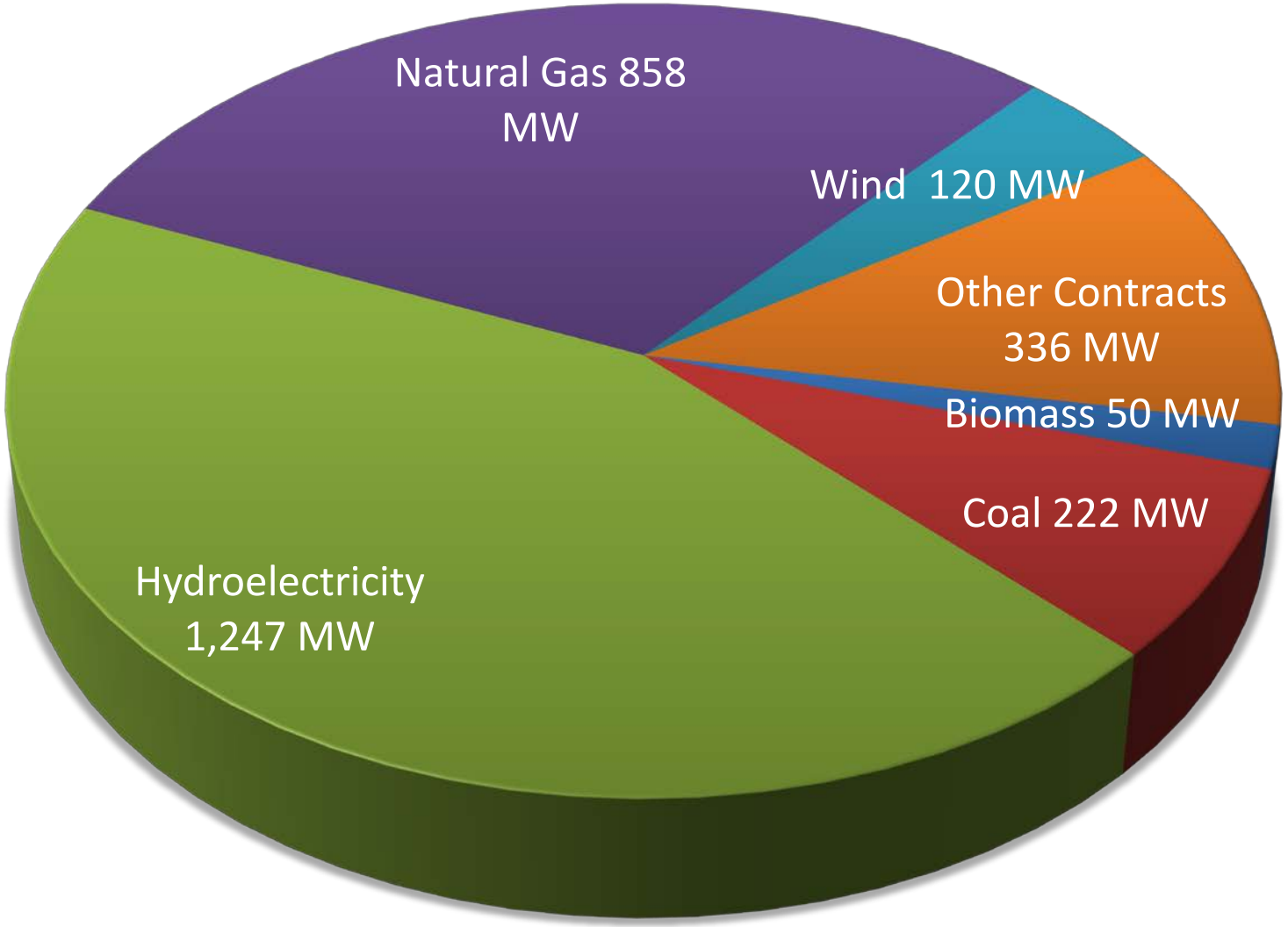
Generation Capability and Service Territory

HYDROELECTRIC	GENERATION CAPABILITY (MW)
1 Noxon Rapids (Noxon, MT)	562.4
2 Cabinet Gorge (Clark Fork, ID)	254.6
3 Long Lake (Spokane, WA)	81.8
4 Little Falls (Spokane, WA)	34.8
5 Post Falls (Post Falls, ID)	18.8
6 Nine Mile (Spokane, WA)	17.8
7 Monroe Street (Spokane, WA)	15.0
8 Upper Falls (Spokane, WA)	10.2
Total Hydroelectric Capability	**955.4**

THERMAL	GENERATION CAPABILITY (MW)
9 Coyote Springs 2 (Boardman, OR)	276.3
10 Colstrip (Units 3 & 4) (Colstrip, MT)	223.0
11 Rathdrum Combustion Turbines (Rathdrum, ID)	149.0
12 Northeast Combustion Turbines (Spokane, WA)	81.2
13 Kettle Falls Biomass Plant (Kettle Falls, WA)	50.0
14 Boulder Park (Spokane, WA)	24.0
15 Kettle Falls Combustion Turbine (Kettle Falls, WA)	6.9
Total Thermal Capability	**751.4**

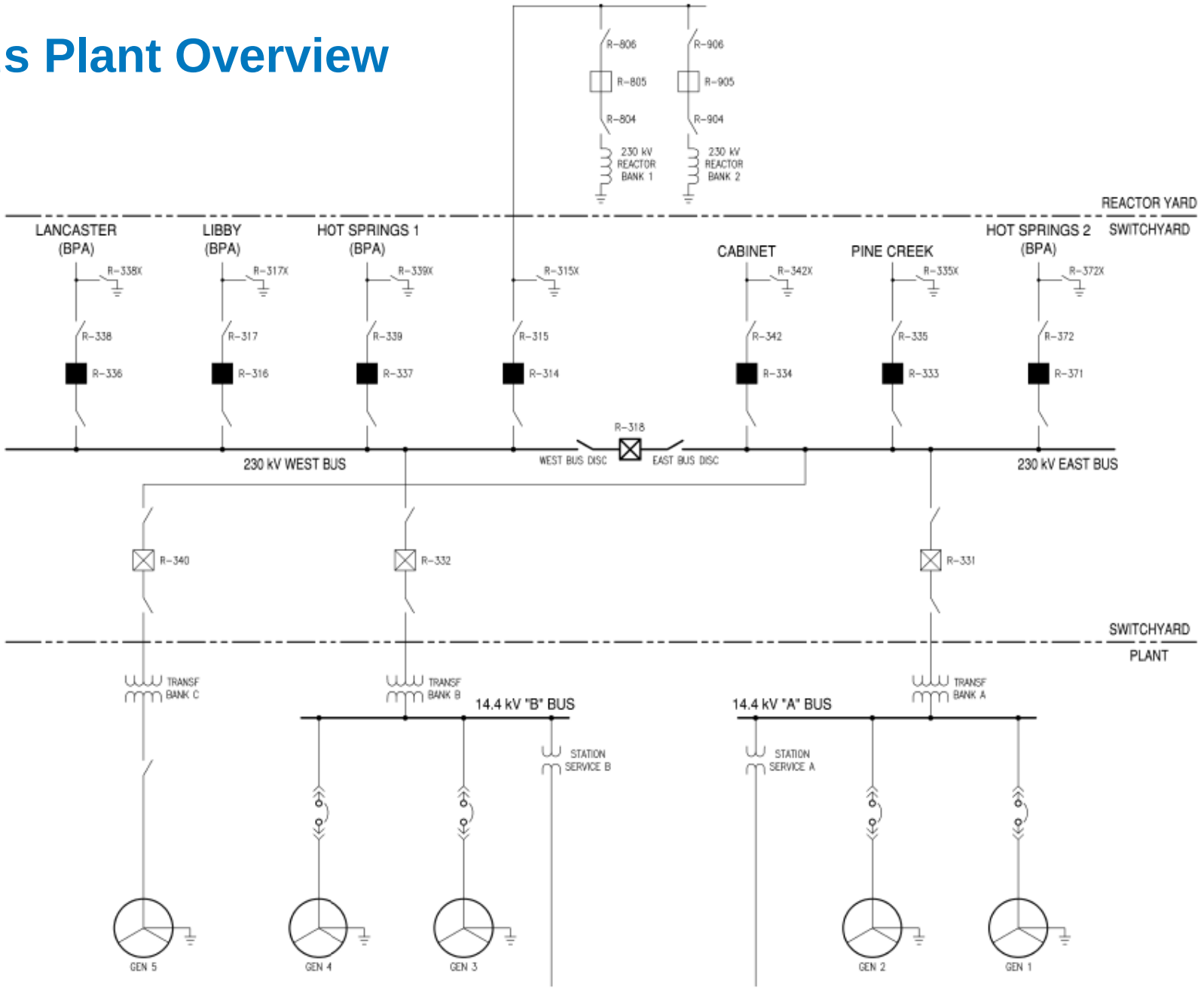
PURCHASED	GENERATION CAPABILITY (MW)
16 Lancaster (Rathdrum, ID) – Contract	275.0
Mid-Columbia Projects	**100.0**
17 Wells (Douglas PUD)	
18 Rocky Reach (Chelan PUD)	
19 Wanapum (Grant County PUD)	
20 Priest Rapids (Grant County PUD)	
21 Stateline Wind Farm (Touchet, WA)	35.0
Total Purchased Generation Capability	**410.0**

Avista Generation Resources



Noxon Rapids Plant Overview

Noxon Rapids Plant Overview

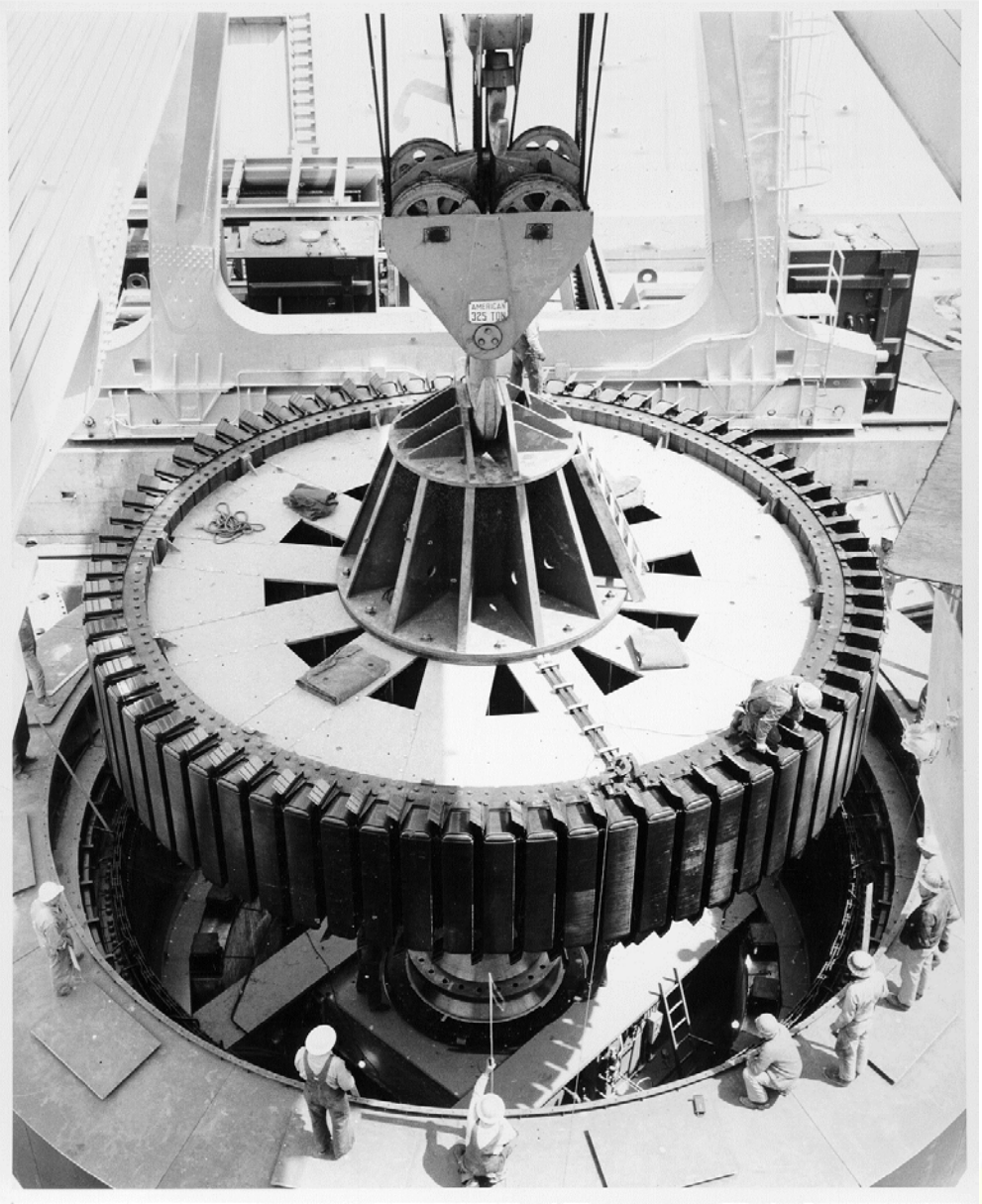


Noxon Rapids Powerhouse

- 1959 – 1960 4 Units Placed In-Service
- 1977 – Unit 5 Placed In-Service
- Turbine
  - Allis Chalmers
  - Vertical Francis
  - 100 RPM
  - Rated Horsepower 138,000
  - Gross Operating Head 154’
  - Design (Net) Head 152’
  - Diameter 18’

Noxon Rapids Powerhouse

- Typical Generator
  - General Electric
  - 96MVA
  - 14.4 kV
  - 0.8 Power Factor
  - 100 RPM



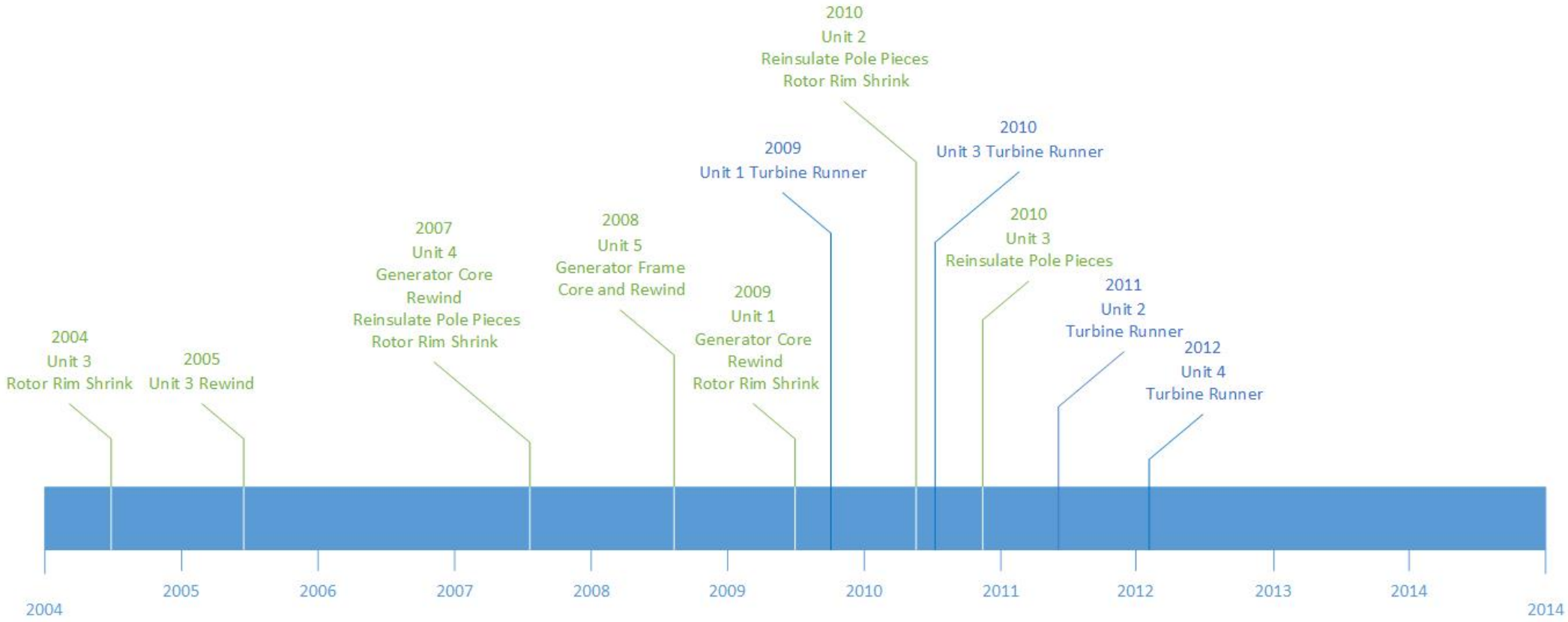
Noxon Rapids Powerhouse

- 2004 – 2012 Turbine Generator Rehab Program

Noxon Rapids Powerhouse

- 2009- 2012 - Turbine Upgrades
- Units 1 - 4
- Efficiency upgrade to help meet Renewable Energy Requirements

Noxon Rapids Powerhouse



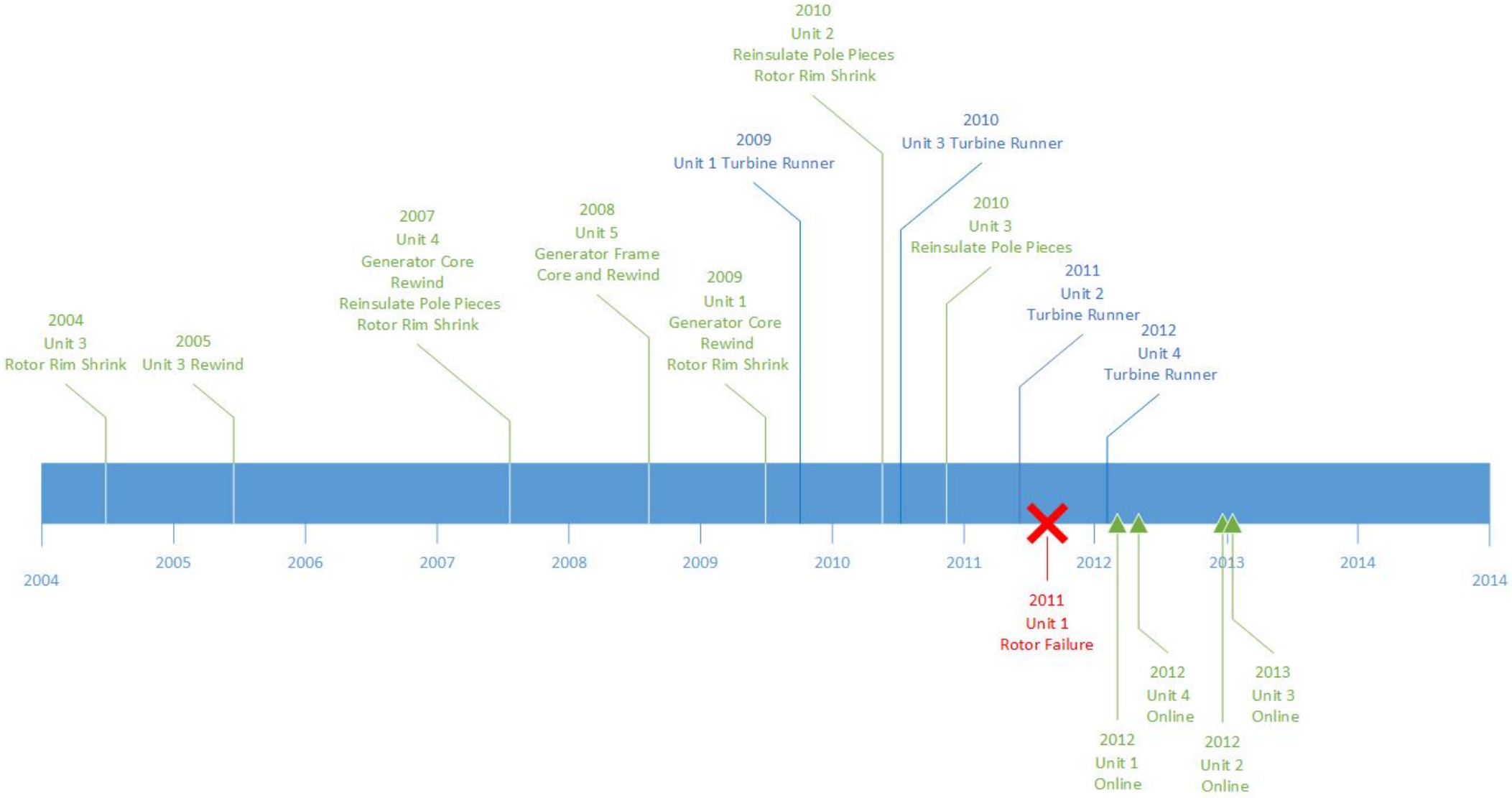
Noxon Rapids Powerhouse

- Unit 1 Pole Connection Failure

Noxon Rapids Powerhouse

- Root Cause – Fatigue Failure

Noxon Rapids Powerhouse



Noxon Rapids Powerhouse

- Now What?
- Same design for Unit 1 was used on Unit 4
- Should we re-evaluate connections for Unit 1, 2 and 3?
- Shutdown and Inspect

Noxon Rapids Powerhouse

- Analyze Failure Mechanism
  - Heat of the soldering iron annealed the copper to make the copper leaves brittle
  - Safety margin was too low for overspeed event

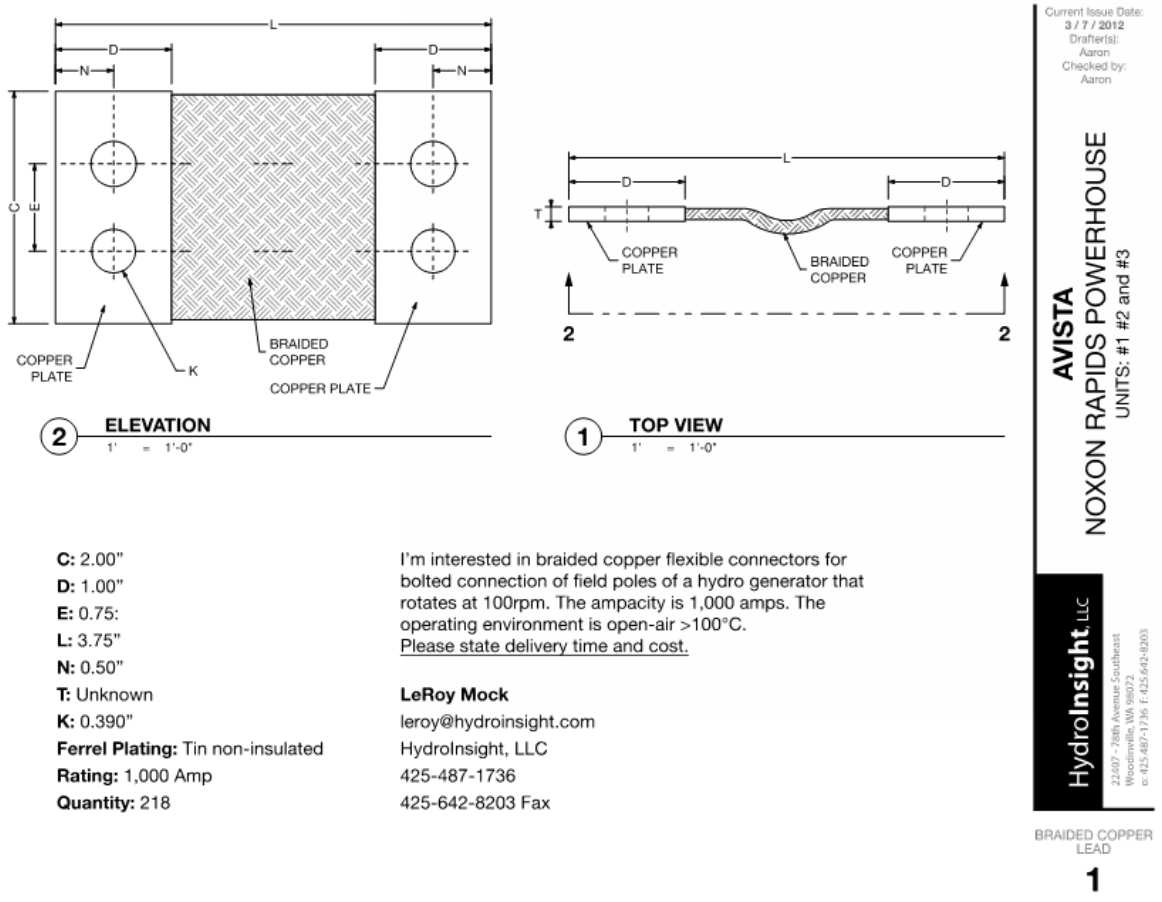
Noxon Rapids Powerhouse

- Evaluate Options

- Option 1: Keep existing leads. Not recommended due to failures
- Option 2: Reduce the mass of leads.
- Option 3: Shorten annealed leads and install flexible connection.

Noxon Rapids Powerhouse

- Recommended Redesign of Interpole Connections



C: 2.00"
D: 1.00"
E: 0.75:
L: 3.75"
N: 0.50"
T: Unknown
K: 0.390"
Ferrel Plating: Tin non-insulated
Rating: 1,000 Amp
Quantity: 218

I'm interested in braided copper flexible connectors for bolted connection of field poles of a hydro generator that rotates at 100rpm. The ampacity is 1,000 amps. The operating environment is open-air >100°C.
Please state delivery time and cost.

LeRoy Mock
leroy@hydroinsight.com
HydroInsight, LLC
425-487-1736
425-642-8203 Fax

Noxon Rapids Powerhouse

- Fabrication Tools and Jigs

Noxon Rapids Powerhouse

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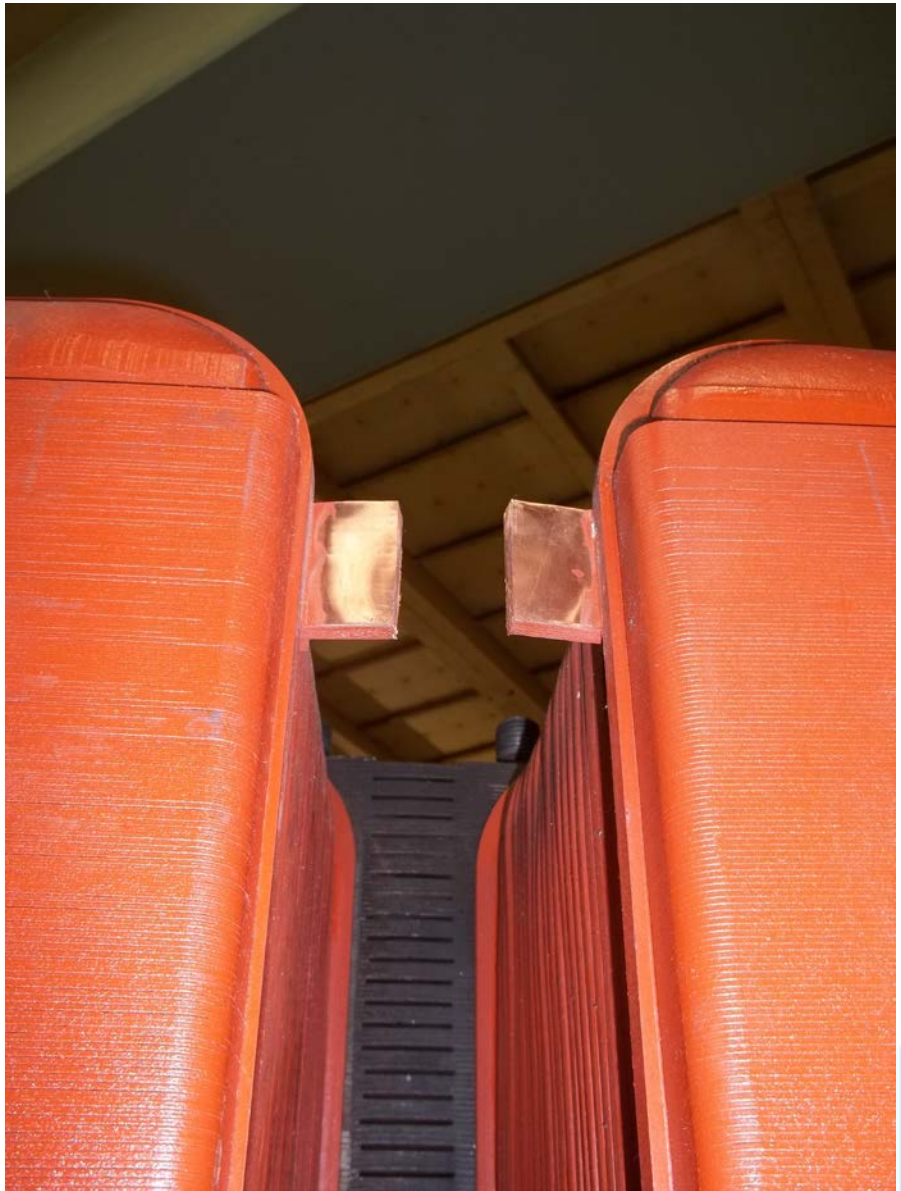
Noxon Rapids Powerhouse

- Fabrication Tools and Jigs



Noxon Rapids Powerhouse

- Fabrication Tools and Jigs

Noxon Rapids Powerhouse

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Noxon Rapids Powerhouse

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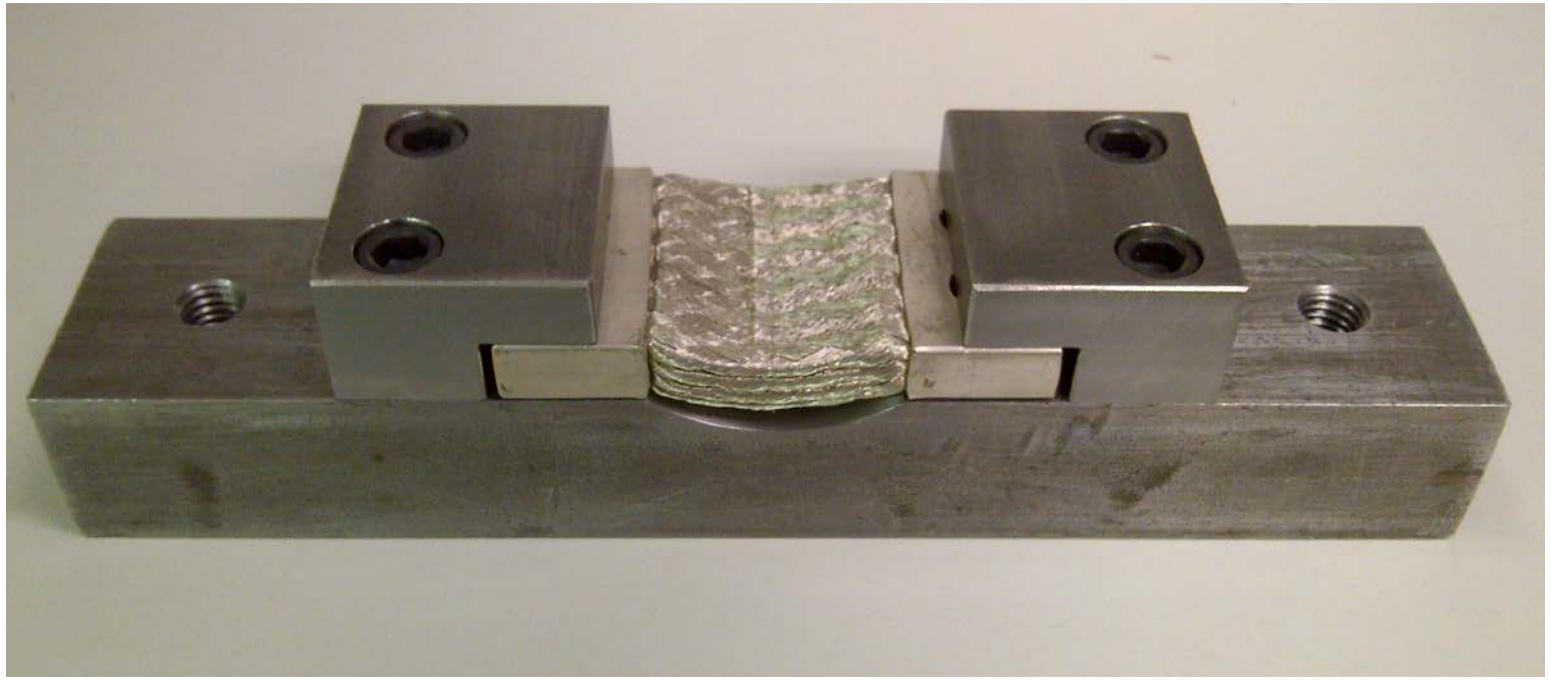
Noxon Rapids Powerhouse

- Fabrication Tools and Jigs
- First Redesign
- Prebend Braided Connection

Noxon Rapids Powerhouse

- Fabrication Tools and Jigs



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- First Design Implemented

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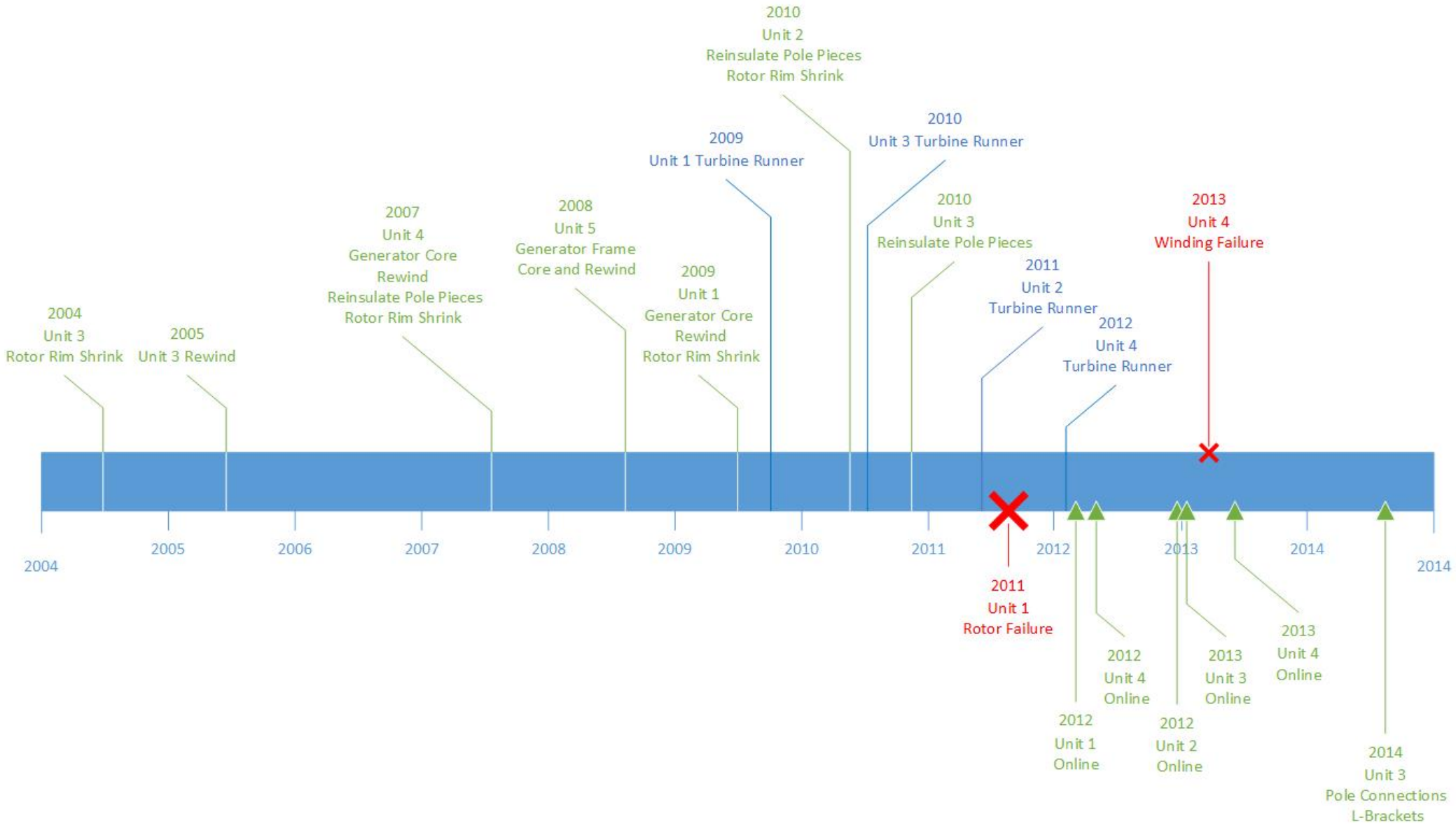

Noxon Rapids Powerhouse

- Refined Design to include L-Brackets on the Outside

Noxon Rapids Powerhouse

- Lessons Learned
  - Hire an independent consultant to review design of interpole connections
  - Perform structural and dynamic stress analysis

Noxon Rapids Powerhouse

Questions?