

# Generator Design Optimization – Nuclear Power Plant Applications

August, 2008  
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imagination at work



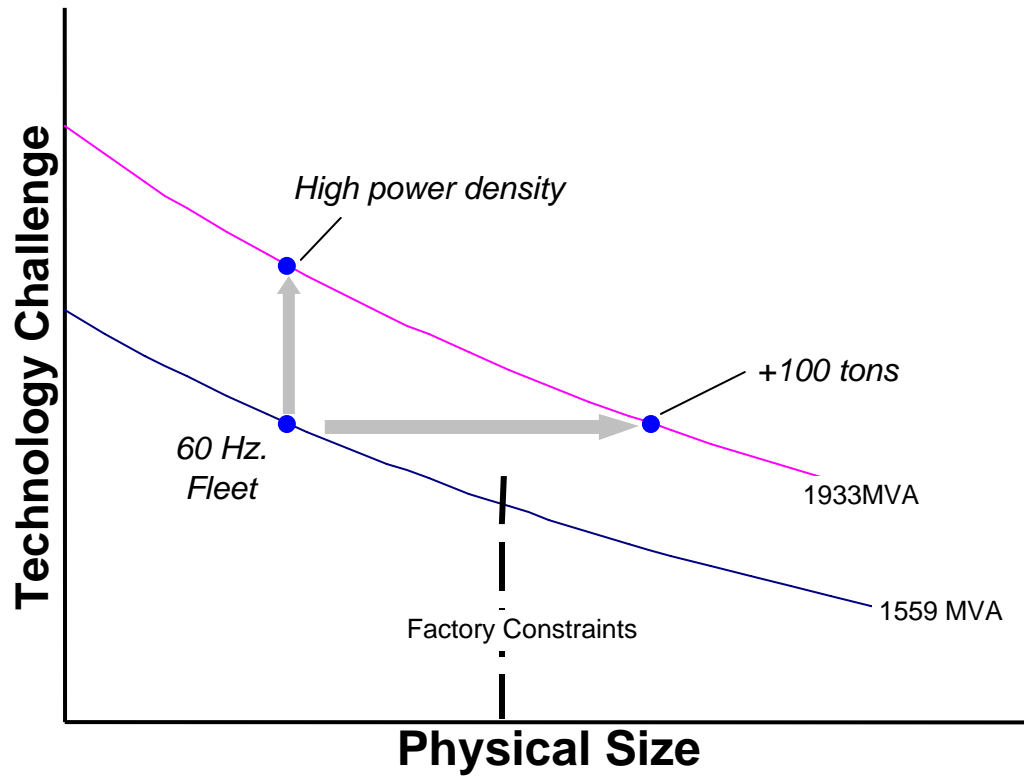
# The Challenge

Design & manufacture a 4 Pole generator:

- At ~ 25% higher rating than current experience
- With 60 year expected life

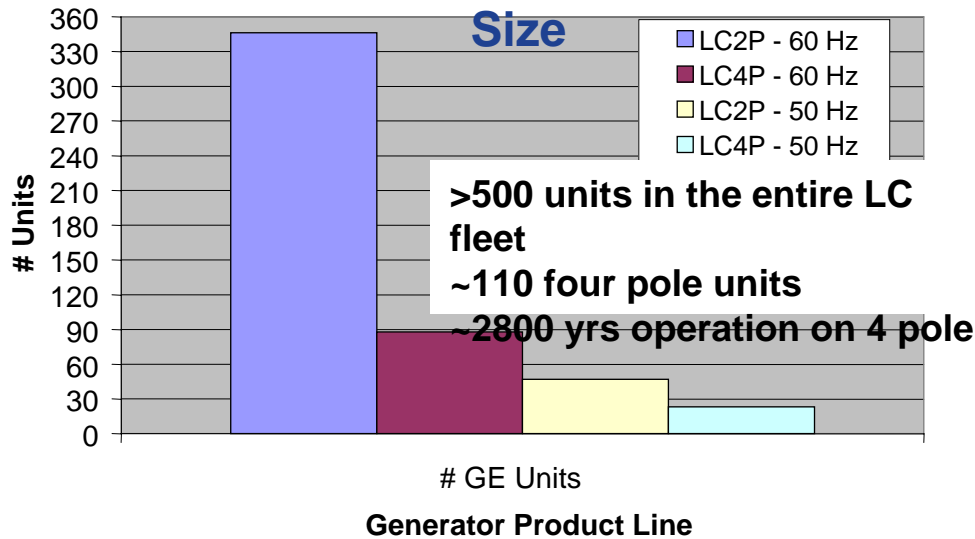
# The Choices

- Higher Power Density ?
- Larger Physical Size ?

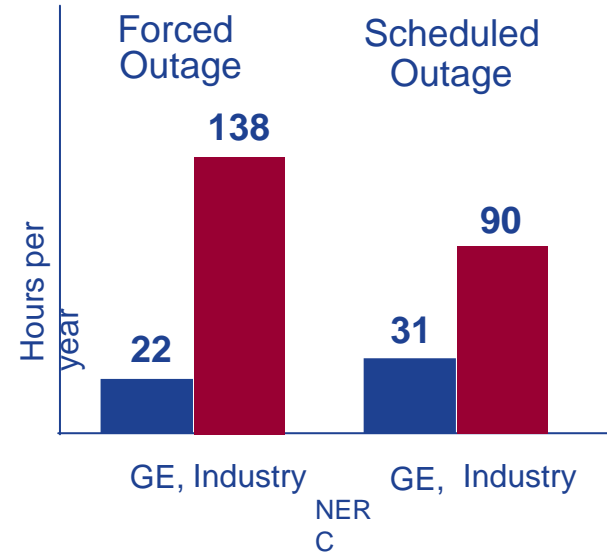


# Build on Proven Generator Technology

## GE Liquid Cooled Fleet



## World class reliability & availability

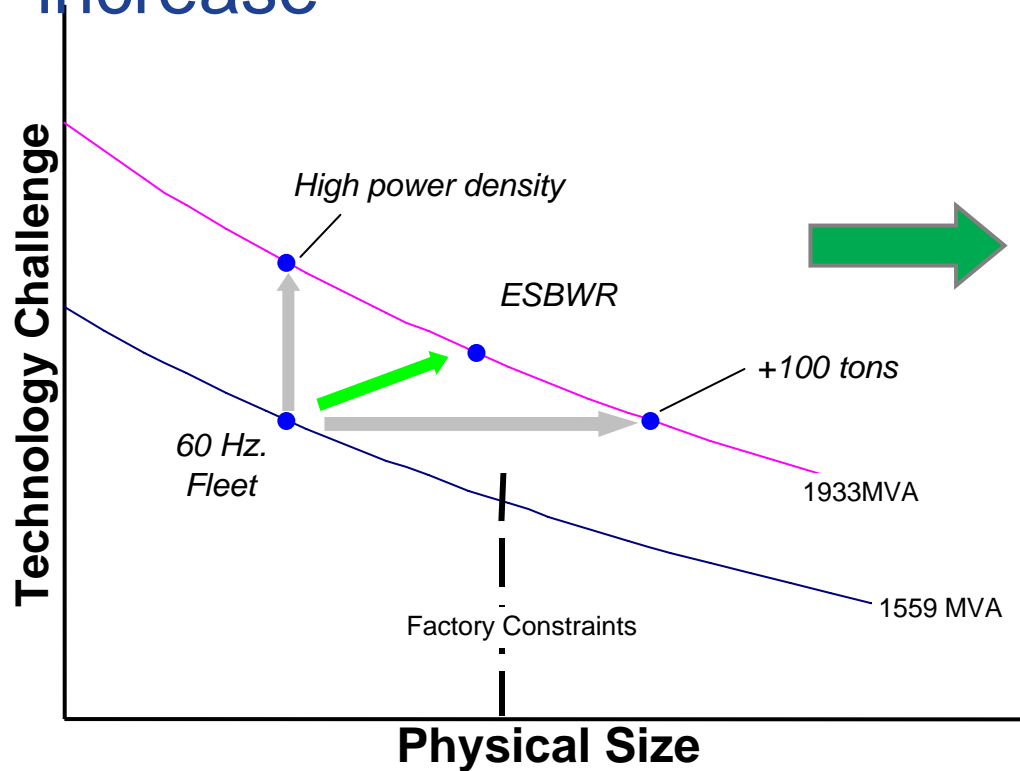


## Top 10 MVA Rated 4-pole Running Experience

Country	Project Qty	Ship -1st Unit	MVA Rating	RPM	Frequency (Hz)
United States	3	1-Jan-78	1559	<u>1800</u>	60
Japan	2	30-Jun-94	1540	<u>1500</u>	50
United States	2	1-Dec-79	1450	<u>1800</u>	60
United States	1	1-Jan-77	1447	<u>1800</u>	60
United States	1	1-Mar-87	1439	<u>1800</u>	60

# The Solution

## ESBWR Generator ~+25% Output 10% size increase



### ESBWR Generator Challenges

- +10 % Higher Terminal Currents
- +17% Torque Loads
- Factory Infrastructure limitations

# The Result

## Stator Design

- Optimized core-end profile
- End shield mounted bearing
- Robust core suspension
- Single ended output terminals

## Armature Windings

- Micapal® Insulation System
- Advanced TetraLoc® End-winding support system
- Non phosphorous series loop brazes

## Rotor Design

- Single piece forging
- Radial Flow Cooling

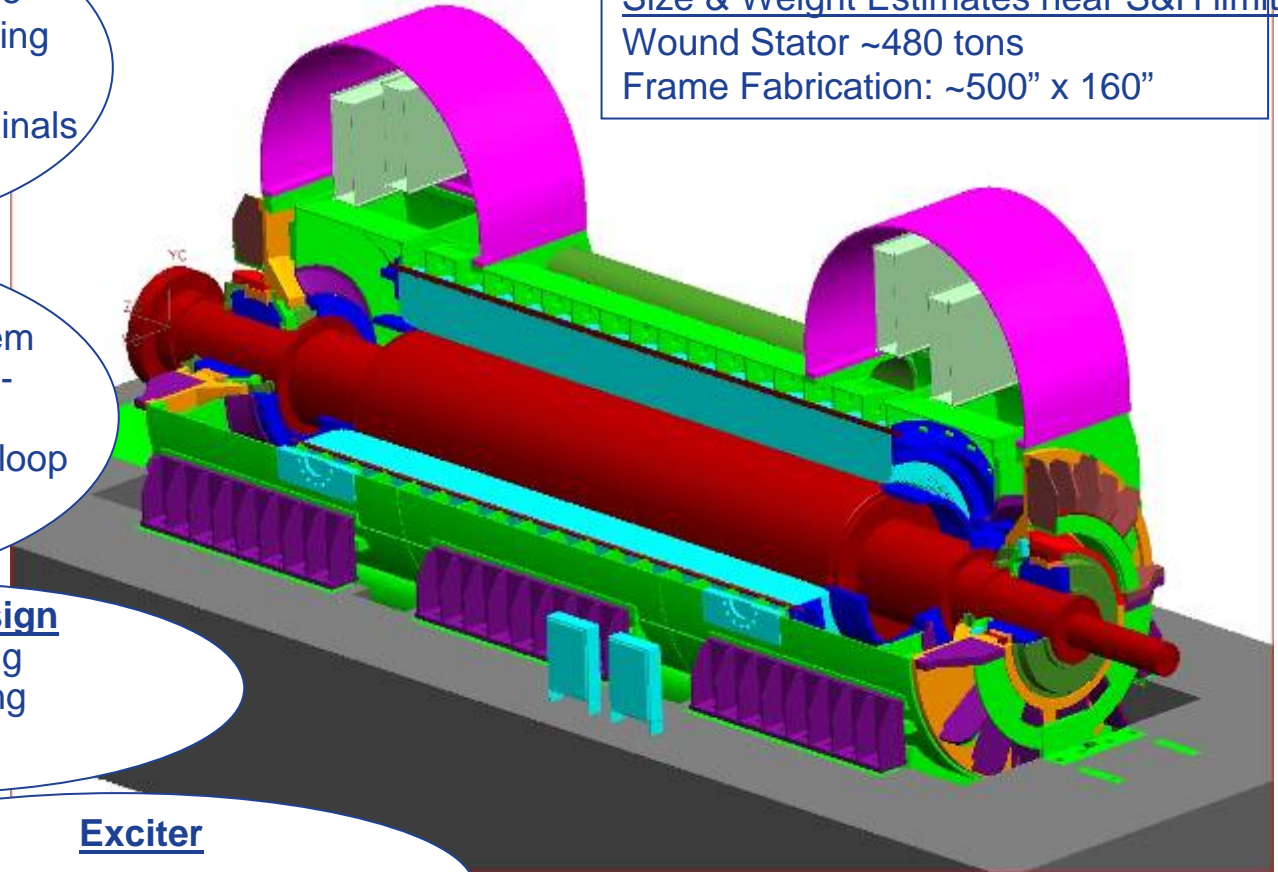
## Exciter

- Static 4-Bridge Bus Fed EX2100
- Triple Redundant Controls

Size & Weight Estimates near S&H limits

Wound Stator ~480 tons

Frame Fabrication: ~500" x 160"



# Risk Retirement

## Proactive Risk Identification

- Identifying 60 year life issues now
- FMEA at all stages

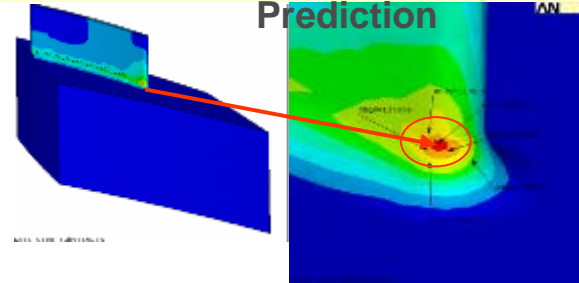
## Mitigate known risks

- Electromagnetic, thermal, static, and Vibration analysis
- Component and factory test
- Manufacturing facility upgrade

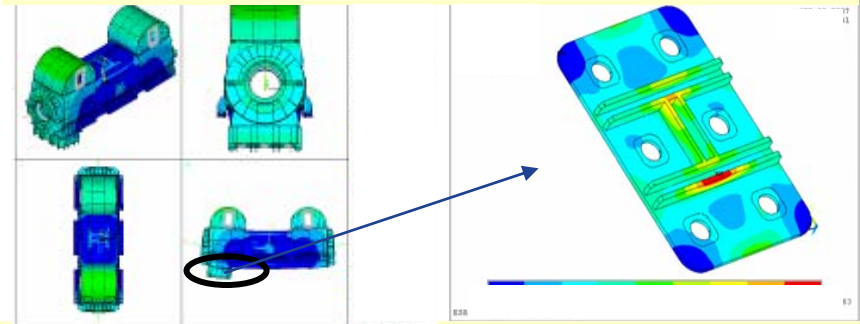
## Understand critical design areas

- Core End Optimization
- Key bar voltages

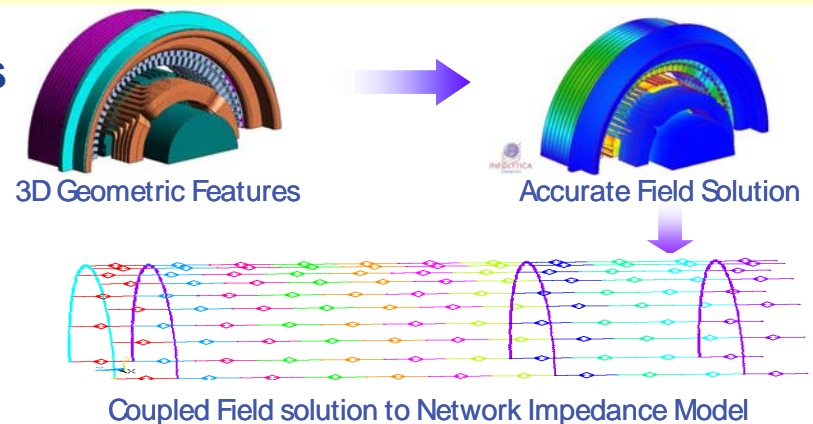
## Model Refinement for accurate Life Prediction



## FEM Tools to assess Top Risks



## Methods to assess electromagnetic effects

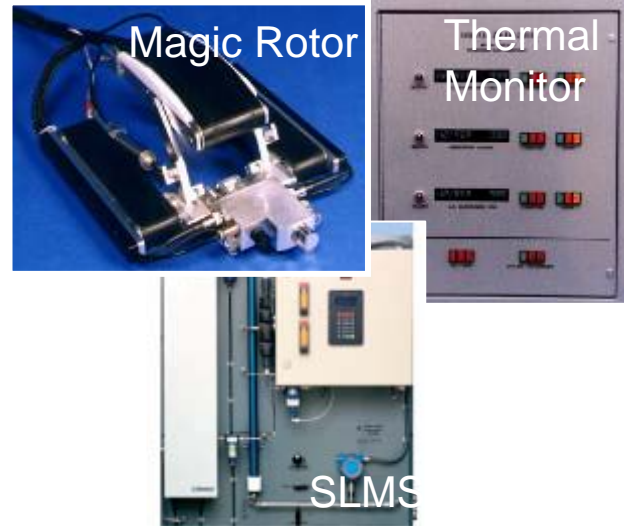




# Leverage Service Technology for Life Extension

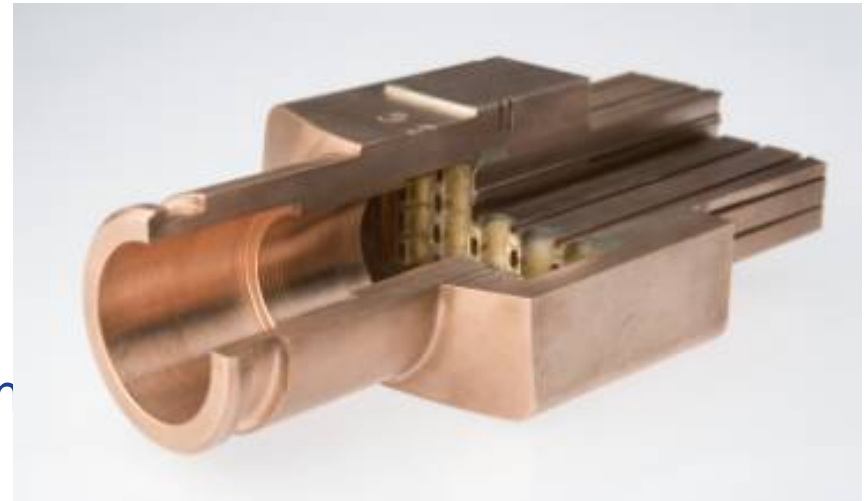
Enable outage interval extension

- SLMS-HP
- Advanced monitoring
- Robotic inspections



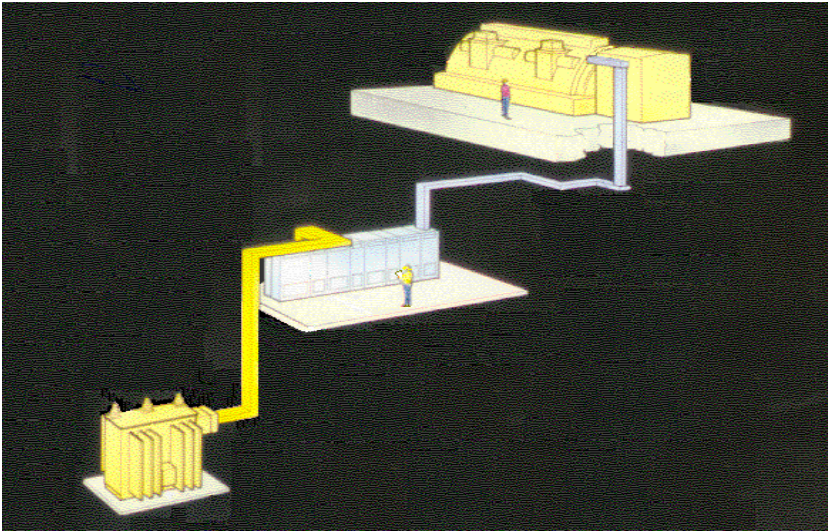
Minimize planned maintenance

- Leak-Free Stator bar braze
- Top Ripple Spring Wedge System
- TetraLoc<sup>®</sup> End-winding Support
- Robust Radial Cooled Field Windings





# Static Bus-Fed Excitation System



## Potential Power Transformer (PPT)

- Cast Coil
- Free Convection Cooled

## Static Exciter (GE EX2100)

- Integrated Control System
- Fault Tolerant Design
  - TMR Control
  - N+1 Bridges (4)
- 6 pulse Rectifier Bridge
- Forced Air Cooled rated @ 40C (<80 dB)
- On-Line Maintenance (Bridge & Control)
- High Initial Response (160% ceiling, 2.0 RR)
- Power System Stabilizer (Integral of Acc. Power)

## Benefit

- Improved Reliability and Availability
- Improved System Efficiency
- Lower Maintenance and Operating Cost
- Grid Performance

# Summary

- **ESBWR Generator design established**
  - **Extending proven Technology to deliver ~+25% higher power for 10% increase in size**
  - **Leveraging advancements in services technology and analytical capability to add value and retire risks**
  - **No insurmountable technical challenges**
  - **Design driving lower life cycle costs**
- **Excitation System**
  - **Static Bus Excitation System enhanced reliability**
  - **High response for grid stability**

