

20th SYMPOSIUM ON INDUSTRIAL APPLICATIONS OF GAS TURBINES



SGT-800 CONTINUOUS RAMS DEVELOPMENT IN CHANGING MARKET CONDITIONS

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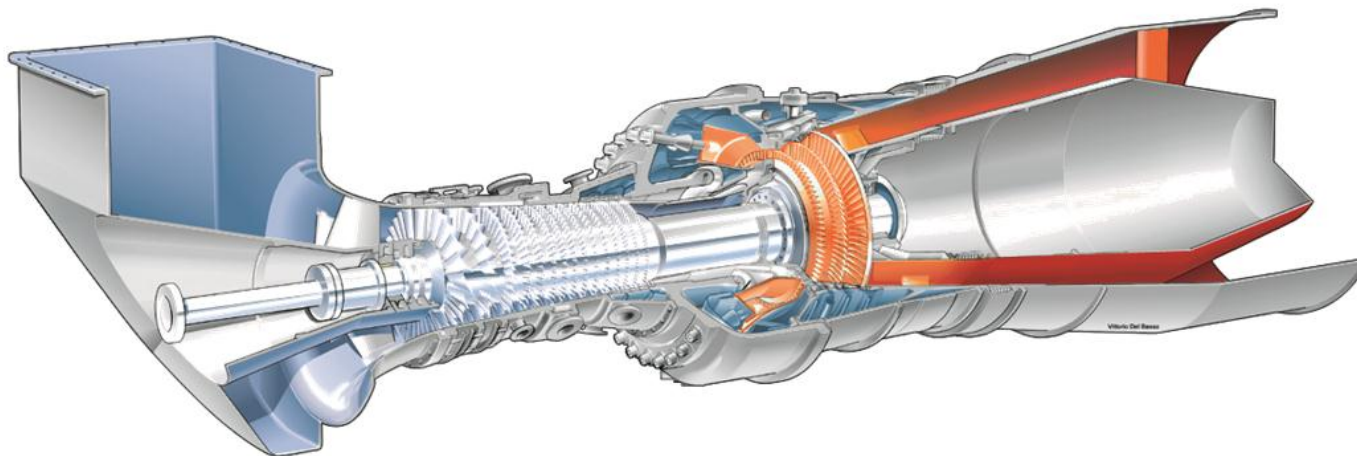
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Outline

- The SGT-800 gas turbine, applications, market
- Product development strategy
- Case study – combustion system
- Summary & conclusions

SGT-800 overview

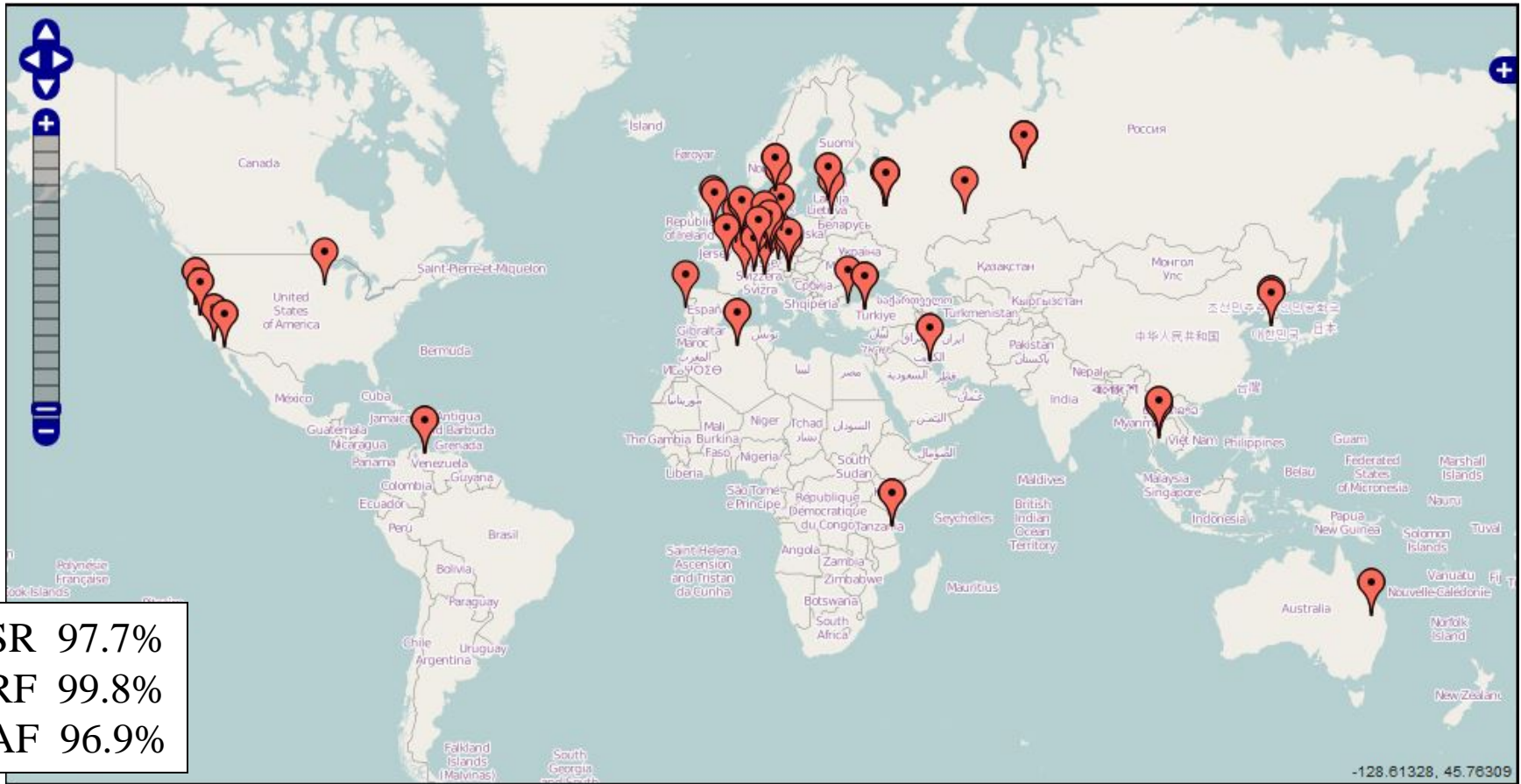
- Single-shaft, 15-stage compr., 3-stage turbine
- Annular dry low emissions combustor
- Optimized for combined cycle performance
 - High TIT, medium PR, high exhaust temperature
- Competitive maintenance intervals



Successful development

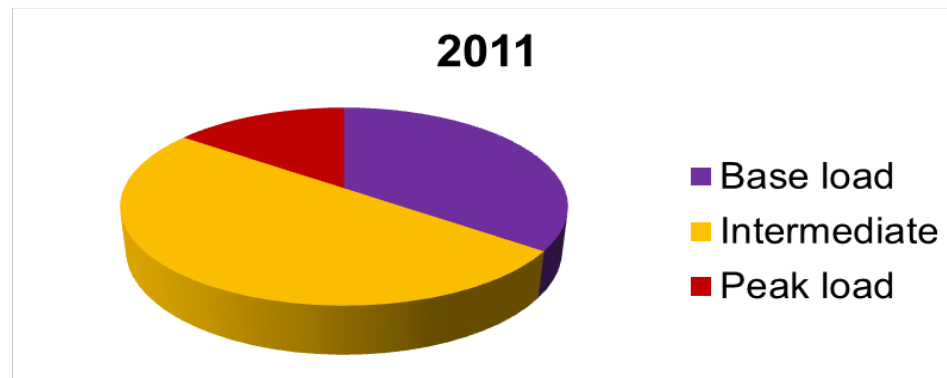
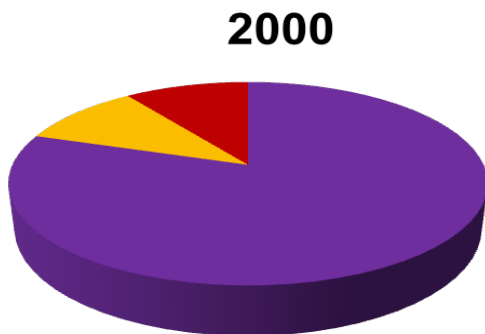
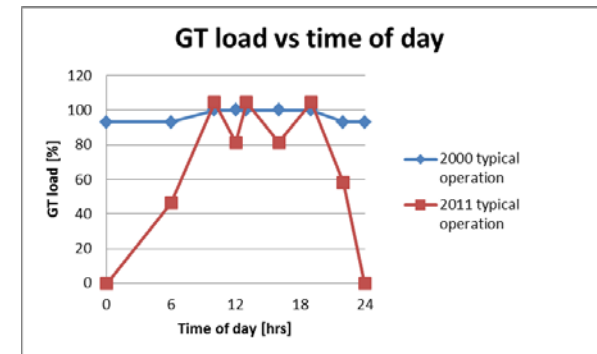
- Power 43 -> 45 -> 47.5 -> 50.5 MW
- Lower turndown emissions limit 70% -> 50%
- Fuel flexibility increase
 - N₂ content, liquid, natural gas composition
- Efficiency increase
 - SC 37 -> 38.3%, CC 53 -> 55.1%, CHP >94%
- Availability/Reliability increase
 - RF 99.2 -> 99.8%, AF 93.9 -> 96.9%,
SR 72.5 -> 97.7%

Operating SGT-800 plants



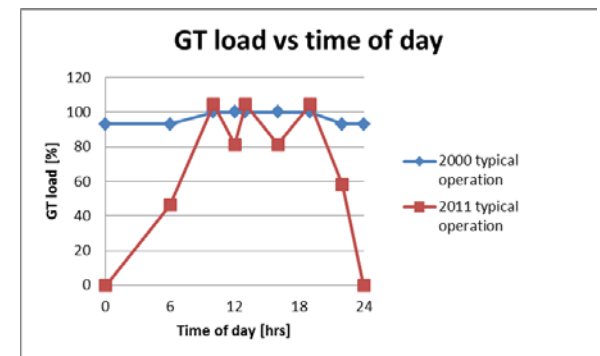
Gas turbine market change

- More complex power production mix, fuel price changes
 - Transition to "load following"
 - Shorter operation seasons
 - Non-standard fuels
- Base load market <40%



Market change consequences

- More focus on operation below full load
 - Combustion stability, load change tolerance
- Starts and load changes more important
 - *Plant* cycling capability
- Fuel flexibility and dual fuel capability
 - Fuel changeovers
 - Manage composition variations and higher contaminant levels
 - No combustor staging

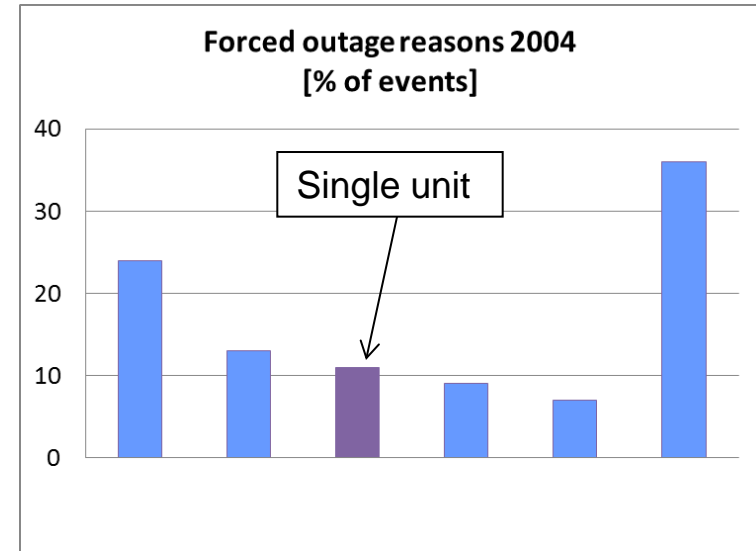


Customer feedback & product performance monitoring

- Operating statistics
- Reported issues
- User conferences
- Customer surveys
- Other customer interaction
- Product KPI monitoring

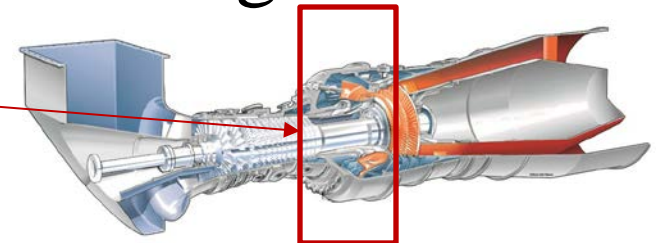
⇒ As-is versus as-desired

⇒ Single customers and entire fleet



Areas of development 2000 - 2011

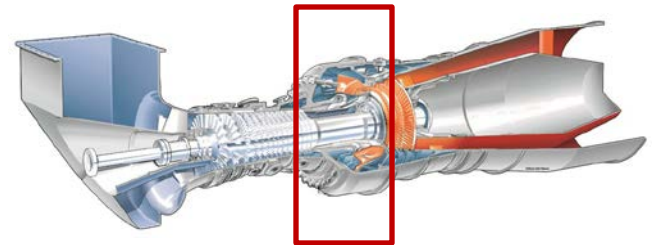
- Controls and measurement system
- Core engine components
- Maintenance tools & instruments
- Engine package
- Maintenance concept
- Remote monitoring & troubleshooting
- Combustion system



Case study - combustion system

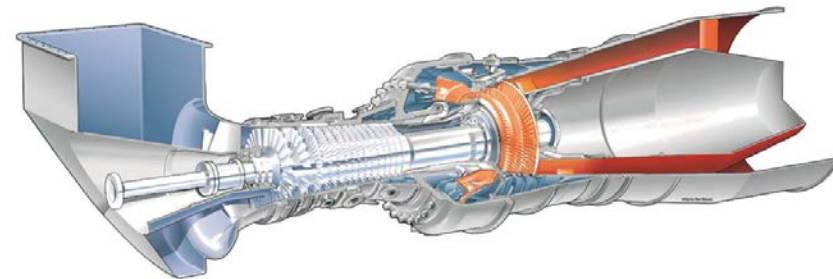
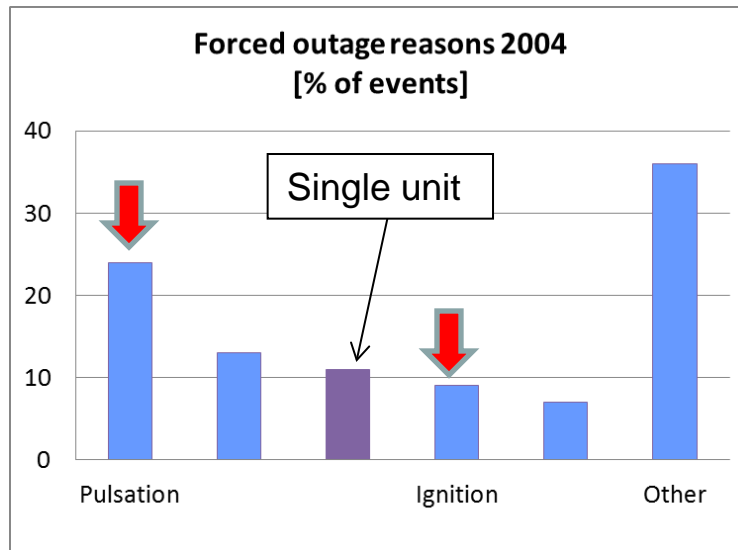
Original:

- Annular combustor, advanced burner design
 - Repairs expensive and challenging especially in cyclic operation
- 15ppm NO_x requirement met
 - In near-full-load regime
 - Narrow natural gas selection
 - Sensitive to changes in operation parameters: Fuel composition, ambient conditions, ...



Starting point

- Standard root cause system analysis of emergency shutdowns
 - Combustion system most frequent reason for forced outage (~31% of all outages)

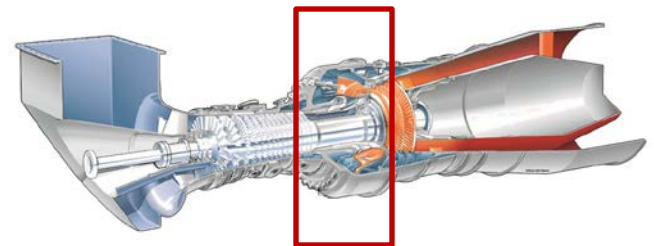


↓ = Combustion related

Long term goals

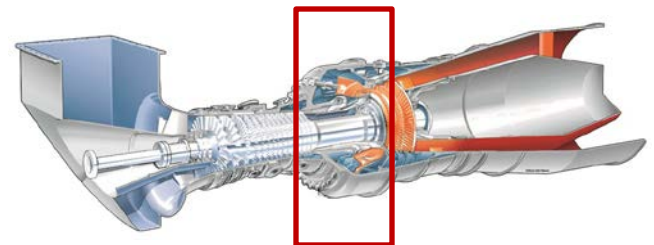
- Stable operation with maintained emissions and wider fuel spec in extended load range
- Cost effective repairs for current and foreseeable new operation conditions
- Reduced need for inspections
- Higher power output

Mission impossible?



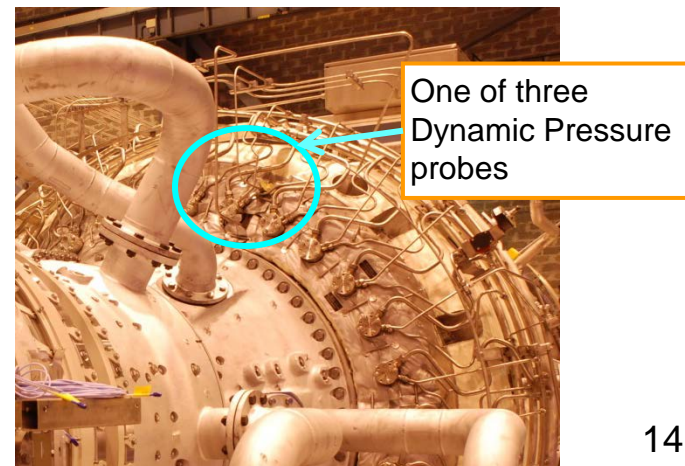
Combustor improvement plan

- **Step 1:** Increase margins of operation, easier combustor repairs
- **Step 2:** Improved turndown, burner repair development
- **Step 3:** Increase tolerance to anomalies, further repair optimization



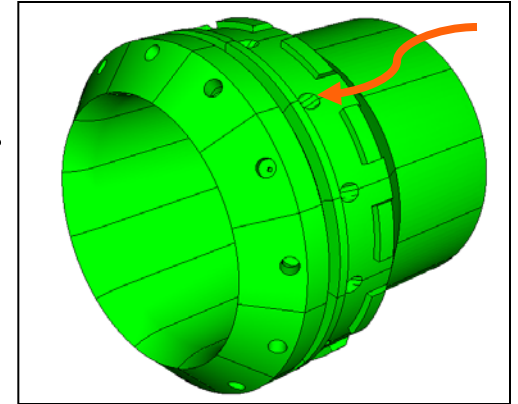
Solutions: margins of operation

- Combustion flame stabilization
 - Central gas => combustion “anchor point”
- Built-in combustion pulsation damping
 - Acoustically soft combustor panel does not reflect vibrations
- Modified pulsation monitoring hardware
 - Mechanical redesign
 - Electrical wiring rerouted

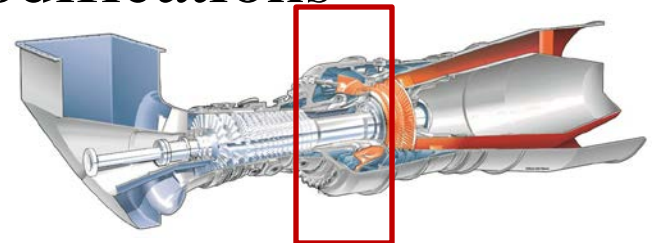


Solutions: turndown, burner repairs

- Pilot burner premix
 - Controlled leakage outside burner wall led into premix cavity
 - Premix cavity also heat barrier reducing mixing tube heat load

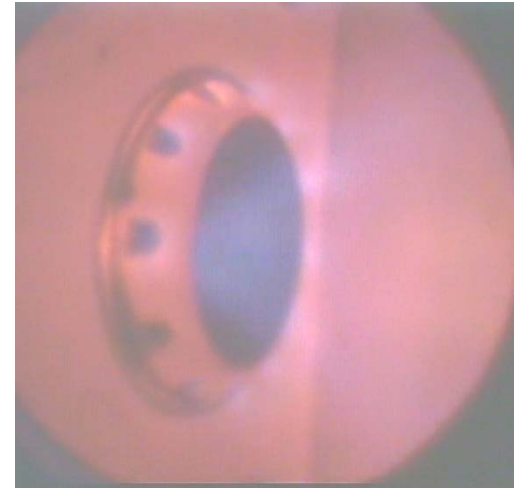


- Redesign for improved cyclic life
 - Materials, geometry, coating modifications
 - Transient heat load tuning for improved durability
 - Tip replacement repair standardization



Solutions: controls improvement

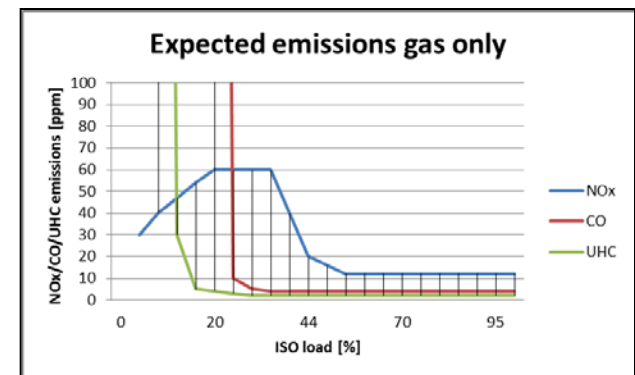
- Active controls
 - High-frequency pulsations minimized through pilot fuel flow adjustment
 - Refined turbine governing to maintain flame during sudden operation disturbances
- Pulsation monitoring self-diagnostics
- Remove obsolete, now-redundant protection features



Summary: Combustor achievement

2011:

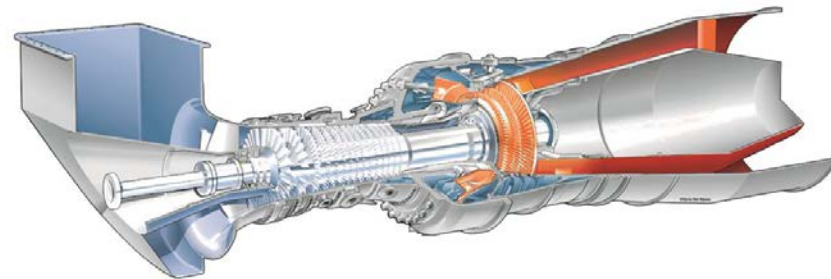
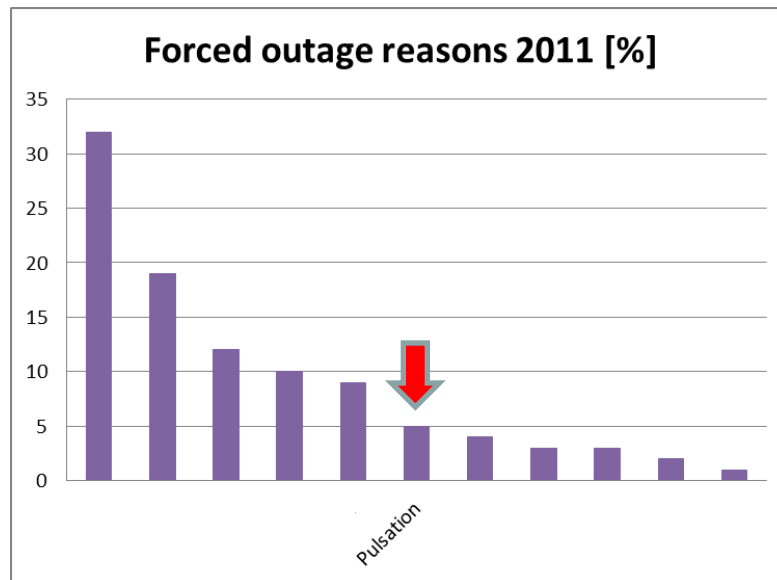
- Improved combustor & burners
 - Multiple affordable repairs possible in base load and cyclic operation
- 15 ppm NO_x requirement met
 - In 50 – 100% load range
 - Natural gas, low-energy gas, “standard” liquid*
 - Highly robust combustion controls



* = Liquid fuel emissions levels maintained in same load range

Current performance

- Combustion now down to 5% of FOH
- Disturbance frequency 3 times improvement
- Power 43 -> 45 -> 47.5 -> 50.5MW



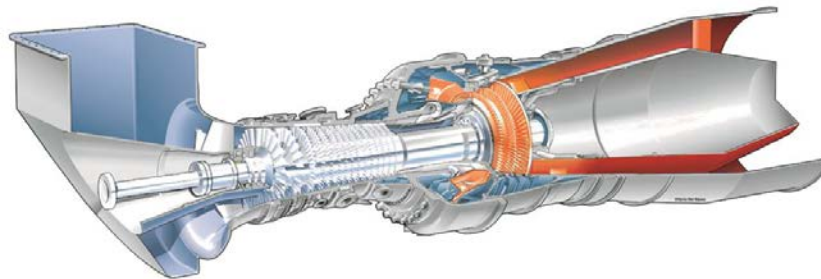
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Conclusions

- Simultaneous performance increase, availability and reliability improvement
- Requires continuous systematic development
- Key: Honest, regular fleet feedback

| | |
|----|-------|
| SR | 97.7% |
| RF | 99.8% |
| AF | 96.9% |

50.5 MW



| | |
|-----|-------|
| SC | 38.3% |
| SC | 55.1% |
| CHP | >94% |

Thank you

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