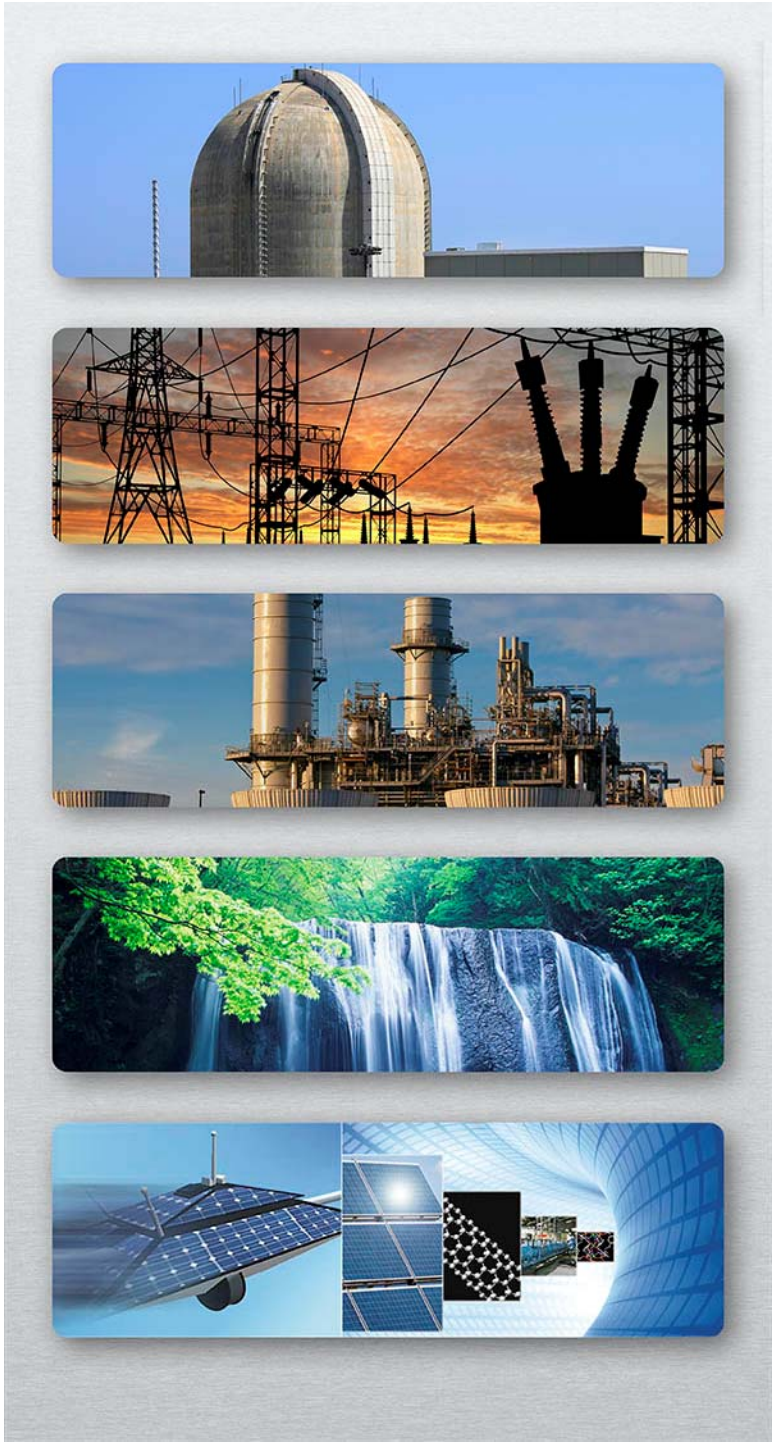

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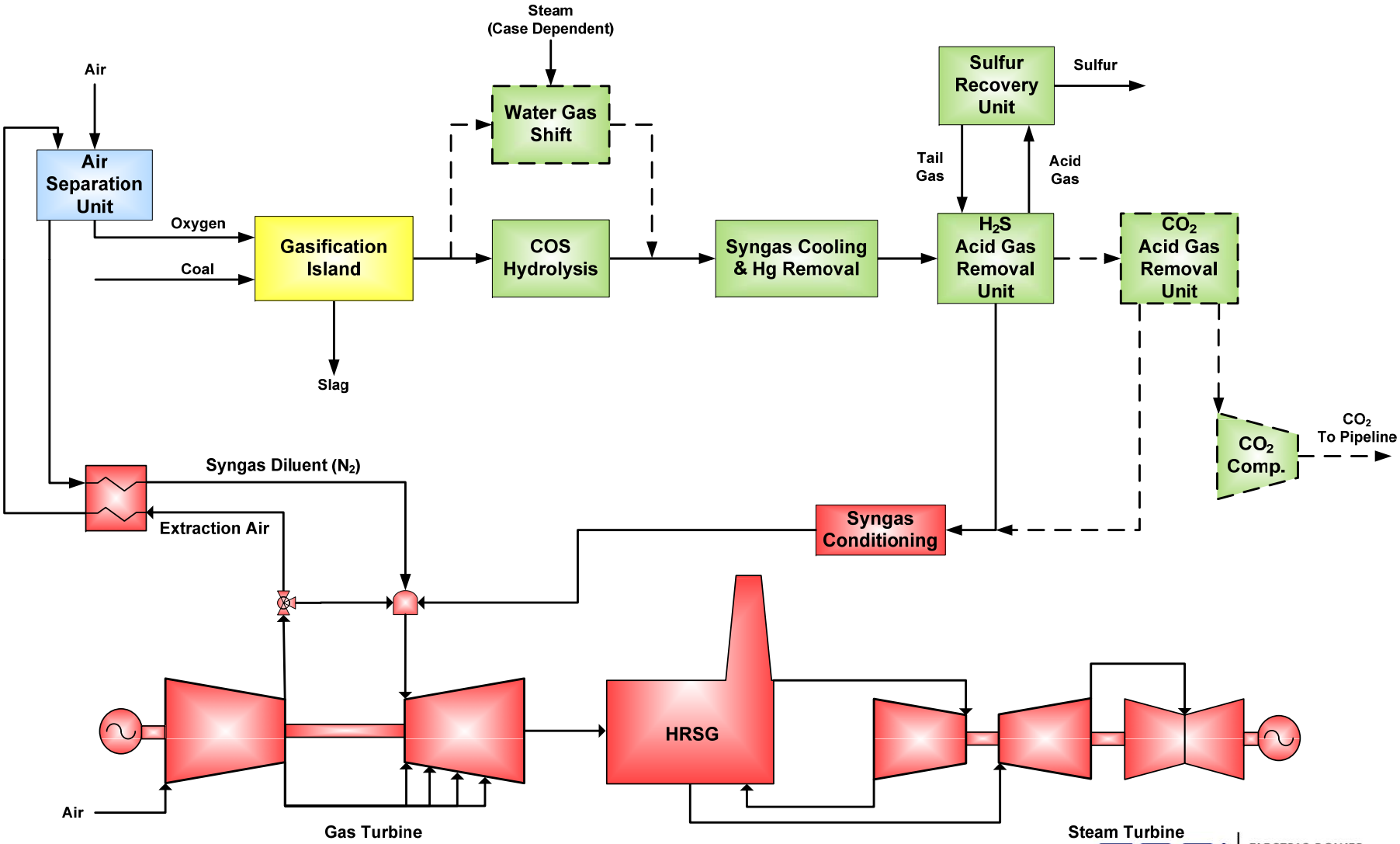
Perspective on R&D Needs in a Carbon Constrained World

2011 University Turbine Systems Research Workshop

Rob Steele
Program Manager – Combustion Turbines and Combined Cycles

IGCC with CO_2 Capture

Process Flow Diagram



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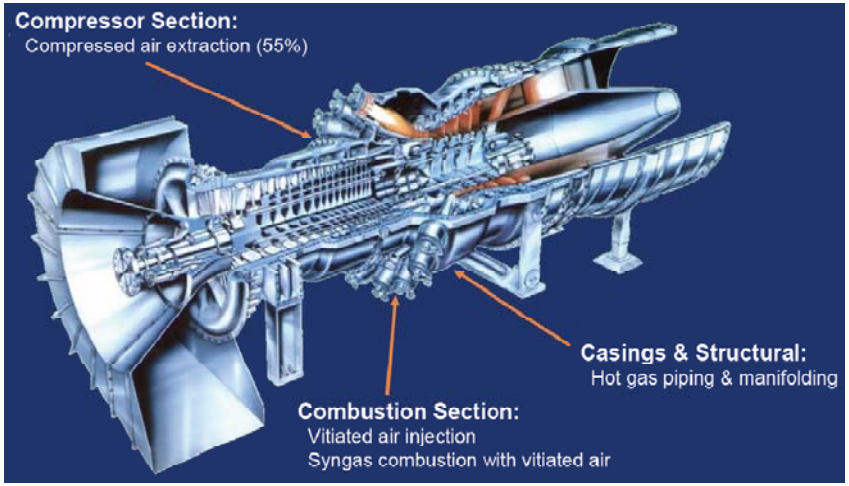
Advanced Gas Turbines for IGCC ?

- Firing Temperature Evolution of Gas Turbines
  - F-Class GT: ~2500°F [1370°C] (GE 7F and Siemens 5000F)
  - H-Class GT: ~2600°F [1430°C] (GE, MHI, Siemens)
  - J-Class GT: ~2700°F [1480°C] (MHI)
  - X-Class GT: ~3100°F [1700°C]
- Increased air extraction
- Higher output
- Higher net plant efficiency



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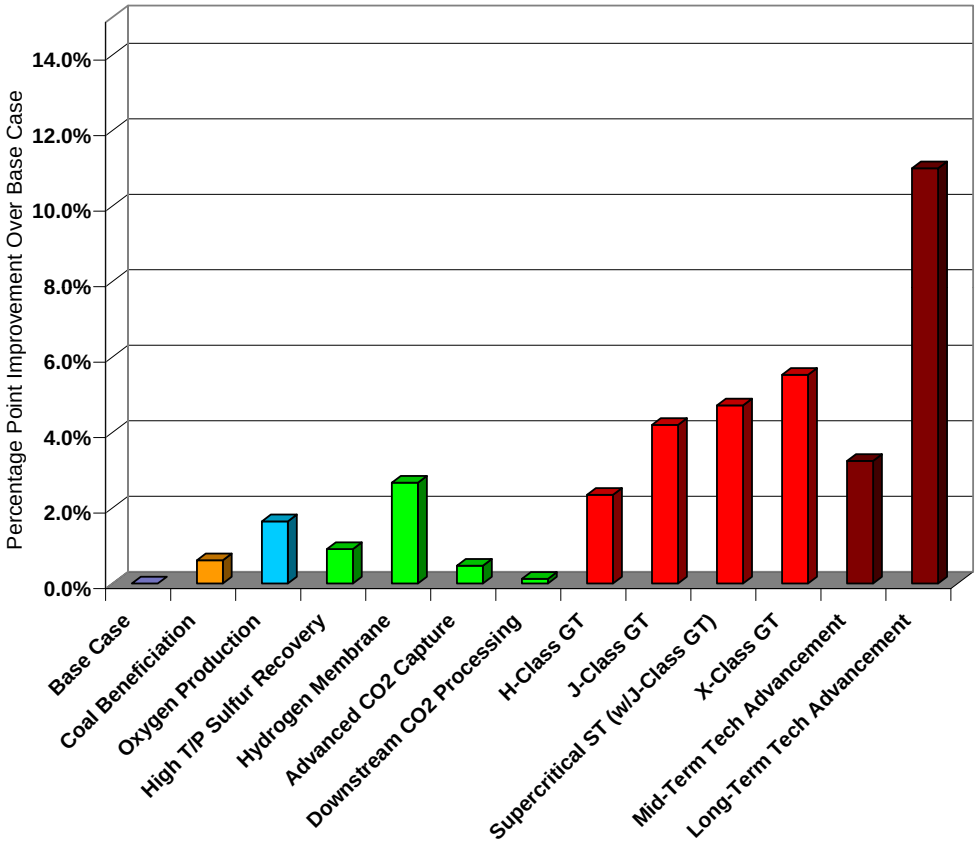
CCPC-EPRI IGCC CCS Technology Evaluation

Listing of Cases Studied

- Base Case Modeling
- Coal Preparation & Feeding
- Oxygen Production
- High Temperature & Pressure Sulfur Recovery (HTPSR)
- Hydrogen Membrane
- Advanced CO_2 Capture
- Downstream CO_2 Processing
- Advanced Gas Turbines
- Supercritical Steam Turbines
- Mid-Term and Long-Term Technology Advancement Cases



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Combined-Cycle Plants Now Exceed 60% Efficiency on Natural Gas

	Siemens SGT5-8000H SGT6-8000H	**Mitsubishi M701J M501J**	**Alstom GT26 Uprate GT24 Uprate**	**General Electric 9FB New (new 7FB ?)**
Status	Commercial Operation	Commercial Installation	Testing Complete	Preparation for Testing
CC Efficiency, %	60.75	>60	>61	>61
Compressor Stages	13	15	22	14
Compression Ratio	19.2:1	23:01	>33.0:1	19.6:1
IGV+VSV Row Count	4	4	4	4
Combustor Type	Can-Annular DLN	Can-Annular DLN	Annular DLN sequential	Can-Annular DLN
Comb. Liner Cooling	Air	Steam	Air	Air
Turbine Stages	4	4	4	4
Airfoil Cooling	Air	Air	Air	Air
Hot Start Time, min.	30	70	30	30
Ramp Rate, %/min.	6.1 max.	-	4.6 avg.	10 max.
CC Turndown Load, %	-	-	20	40
GT Turndown Load, %	40	-	-	30

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Key Technical Evaluation Issues

Efficiency

Flexibility

Durability

Reliability

Compatibility

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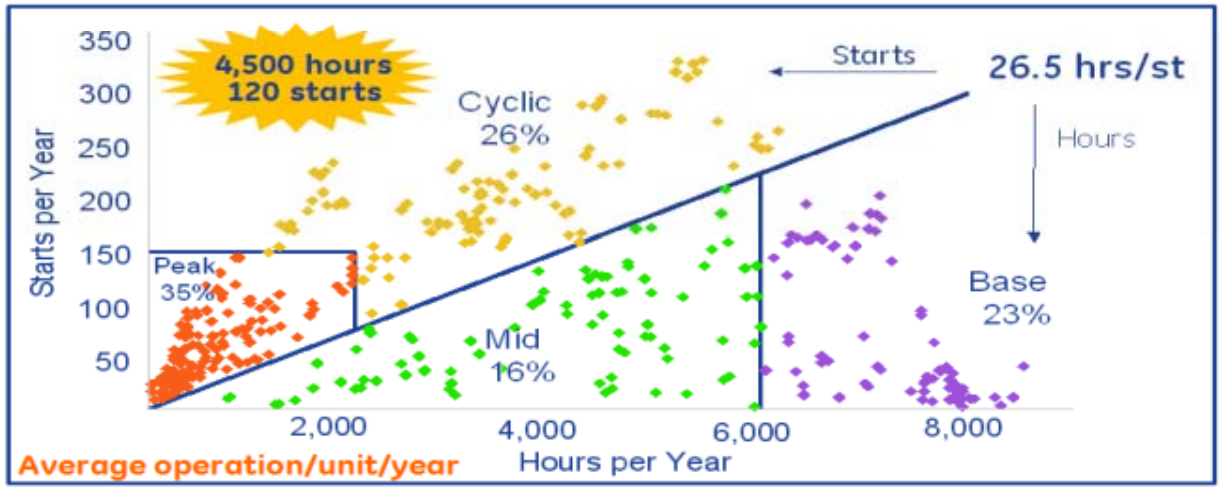
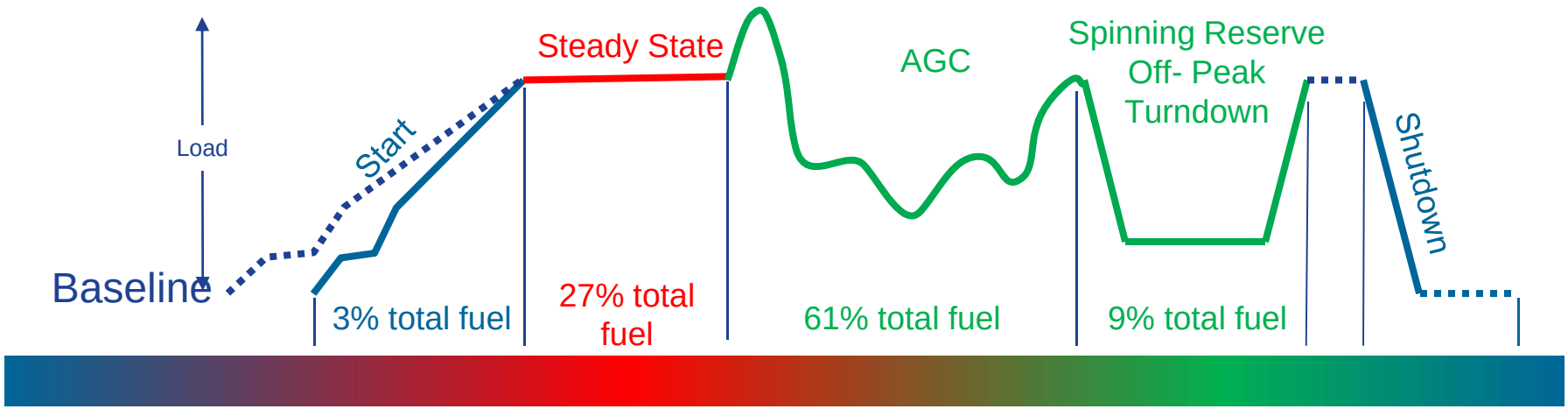
How are GTs being used?



Plants spend relatively little time in base load steady state



Start Reliability	Ramp Rate	Part Load Efficiency	Turndown
98%+ (28 minutes)	50 MW/min	>60% to 87% plant load	to 40% plant load

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What the future holds …

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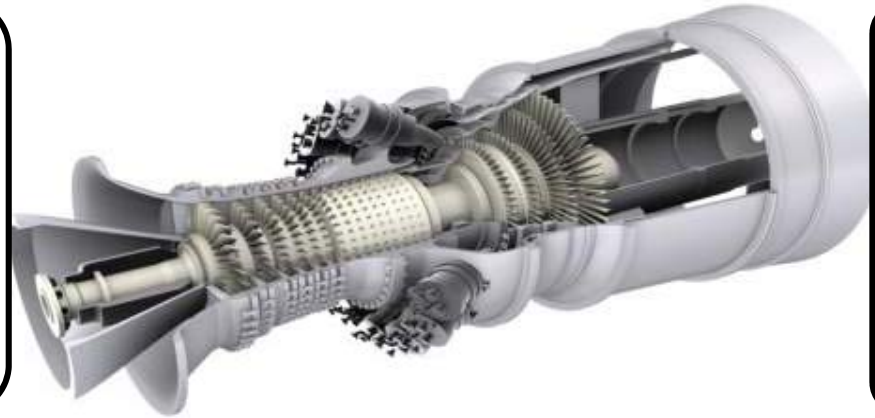
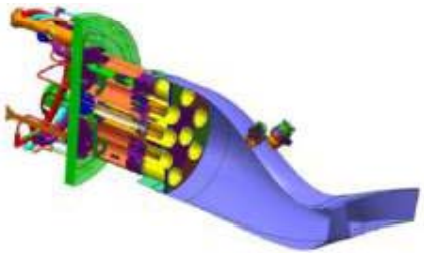
Redefining turbine efficiency

3-D Compressor Aero

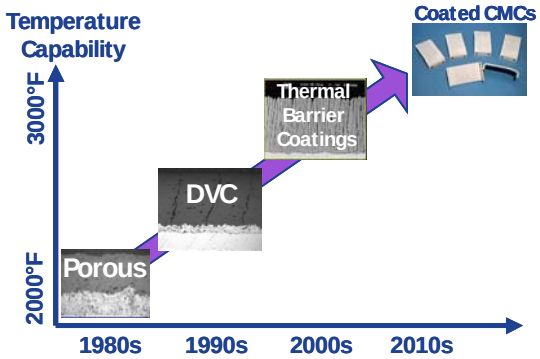


Advanced Combustion

Advanced premixing, axial fuel staging



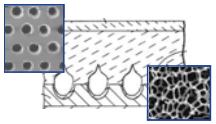
Advanced Thermal Coatings



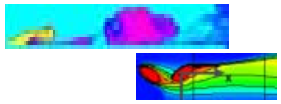
Ceramic Matrix Composites

+300°F temperature capability vs. superalloys

Advanced Cooling & Sealing

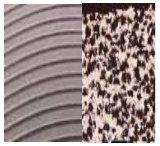


Micro-pore



Pulse & Fluidic Film

Conforming



Abradable

Path toward 65% combined cycle efficiency

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Recommended R&D Topics

Increase efficiency of IGCC + CCS systems:

- Improve GT integration with Air Separation Unit
- Modify GT for lower pressure requirement for N_2 diluent
- Design for high H_2 syngas without derating firing temperature
- Improve combustor design for low NOx control for high H_2 syngas
- Offer larger MW GT for economy-of-scale advantage (G, H, J, ?)
  - MHI 320 MWe J-series (1700°C, 3100°F)

Look to NG-fired GT development for topic areas:

- Ramp and cycle faster and more often
- Spend more time at part load
- Increase reliability and durability

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Together…Shaping the Future of Electricity

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