Advanced Multi-Tube Mixer Combustion
For 65% Efficiency
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WHY is reaching 65% important?

- Less emissions produced
  - Tons per year less CO$_2$ than 60% GTCC

- Lower $/kW & heat rate
  - Faster adoption
Technology Pipeline for 65% Efficiency

- **Unsteady Physics**: Supercomputers unlock improved aero designs
- **Advanced Combustion**: Technology driving efficiency
- **Additive Manufacturing**: Ceramic Matrix Composite
- **Future**: Durability 500°F hotter than metals, uncooled

Efficiency %

Now: 61%

+4 yrs

+8 yrs

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Picking up the Pace

150°F+ Growth. Accelerated by DOE Technologies, University Research

Time in Years

Combustor Exit Temperature

150°F+ Growth

Today

DLN2.6
Phase 1 Program

Advanced Cooling Technologies

• Survey GE Aviation and GE Power for advanced cooling techniques.
• Couple available techniques with recent/future materials and coatings to select a cooling approach that minimizes $W_{nch}$ and $dP/P$.

Limited Test Campaign

• Select the system parameters required to reach the target temperature
• Implement the system parameters in GTTL hardware.
• Verify the ‘recipe’ at full scale conditions.

Configuration Proposal for Phase 2 Development

• Understand key trades and select key parameters.
Materials and Cooling Technologies

Challenge: Increase heat load while holding durability and dP/P

1. Research cooling technologies best suited to handle higher heat loads. Review both internal and external material
2. Pair with materials and coatings technology and combustor configuration to optimize cooling dP required for 65%

Multi-Tube Mixer

The Multi-Tube Mixer is a distributed, premixed approach to combustion of high-hydrogen fuels.

- Utilizes jet-in-cross flow mixing of fuel and air
- Design air velocity above flame speed with reasonable pressure drop.
- Mixing length ($L_{mix}/D$) may vary based on fuel and conditions.

Multi-Tube mixer is easily scalable without changing fundamental geometry and adaptable to range of fuels.
Multi-Tube Mixer Full Can Rig Results

Fuel: 63/4/33 % H2/CH4/N2

- Single digit NOx (corrected to 15% O2) over target temperature range with hydrogen-nitrogen fuel
- Below 3 ppm NOx (corrected) with 20% of inlet air replaced with pure nitrogen.
Advantages
- Lower turndown
- Improved cooling
- Faster installation

Advanced premixing
- Low NOx at high $T_{\text{fire}}$
- Fuel Flex – Inerts and MWI

Axial fuel staging (AFS)
- Low NOx at high $T_{\text{fire}}$
- Improved turndown

Unibody extended transition piece
- Reduced residence time
- Tailored TP cooling

Going to hotter temperatures with constant emissions
Final Summary

• 65% is an aggressive but necessary goal.
• Will require advancements in every aspect of combustion design.
• Multi-Tube Mixer and Axial Fuel Staging are excellent building blocks.
• DOE and University projects have already accelerated the pace of technology development, and will continue to be critical to the success of the project.

Questions?

Imagination at work

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