GE
Energy

R&D Needs for Gas Turbine Power Generation in a Carbon Constrained World

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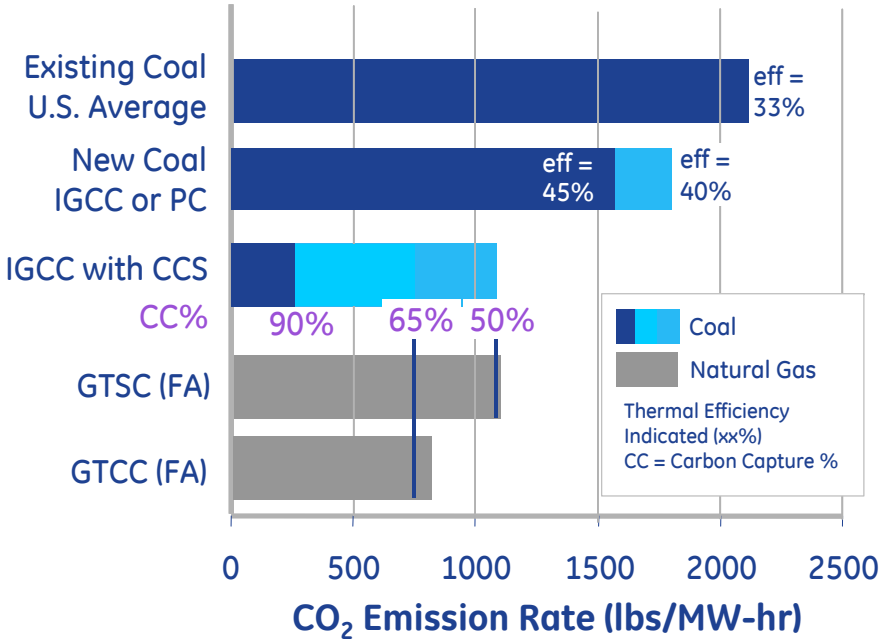
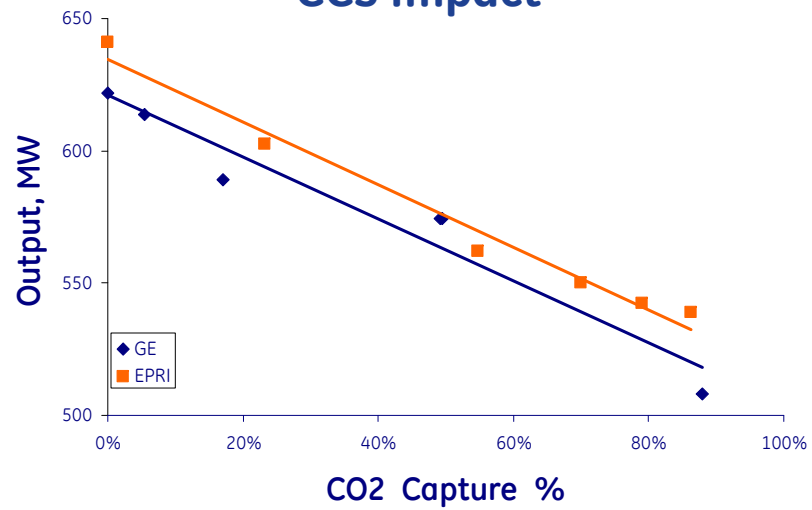
Impact of Carbon Capture

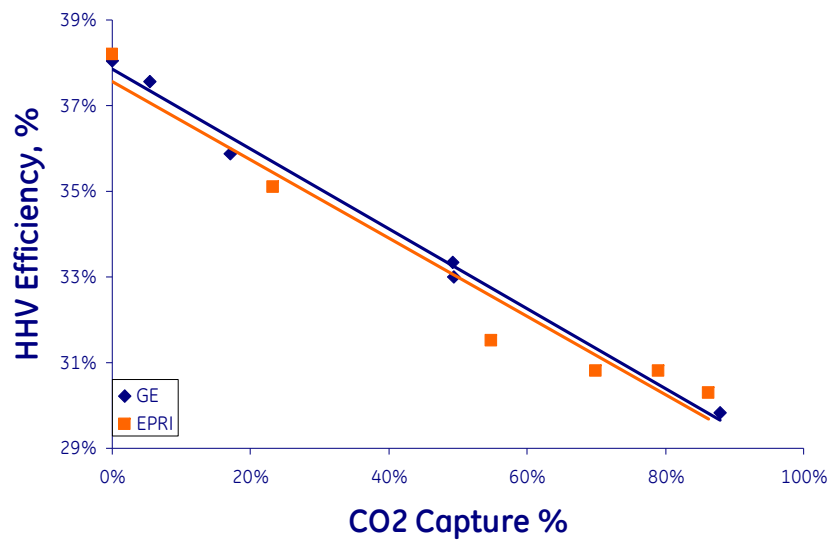
Carbon Footprints



References: DOE NETL; EIA; IEA and GE Energy Internal Data

CCS Impact





Sources: GE Internal Study, 2007 and EPRI IGCC Design Considerations for CO2 Capture: Engineering and Economic Assessment of IGCC Coal Power Plants for near-term Deployment, 2008

- IGCC w/ CCS is a solution for the carbon constrained world
- Technology is available today
- Currently key barriers to implementation are cost and CO2 policy/legislation
- Further technology development can improve cost competitiveness

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GT Technology Can Offset Much Of CCS Penalty

Combustion

- Higher temperature, lower emissions operation with highly reactive fuels

Turbine Aero/Heat Transfer

- Higher component efficiency with higher flow rates

Materials

- Higher temperature materials and coatings in an IGCC/H2 environment

Systems

- Improved gas turbine Integration with balance of plant

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Aero and Heat Transfer Challenges

- Limitations of existing design tools, manufacturing techniques, etc.
- Achieving higher film effectiveness – e.g. less cooling & leakage flows
- Design combination of cooling, material capability, thermal insulation

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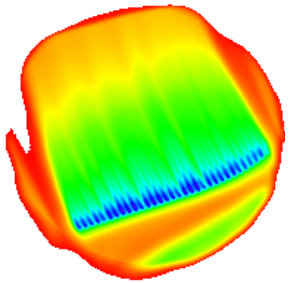
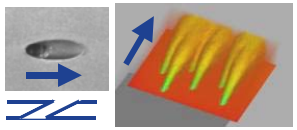
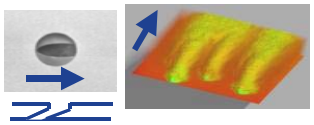
University Research Topics – Heat Transfer

- **Improved Cooling**
  - airfoil surface cooling with film cooling or other approaches
  - internal surface cooling
  - Address hole plugging/clogging from particulate deposition in and around the cooling passages



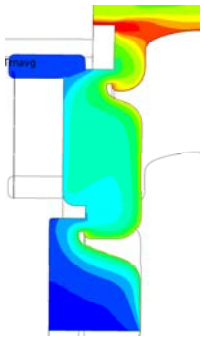


Round Holes



Crater Holes

- **Improved Sealing/Reduced Purge Flow**
  - Advanced concepts for rotor/stator sealing
    - Develop concepts so performance will not degrade with time, such as compliant, non-contacting seals.
    - Model and control stability and general seal behavior.
  - Rotor rim geometry concepts to maintain/improve aero efficiency and minimizing ingestion



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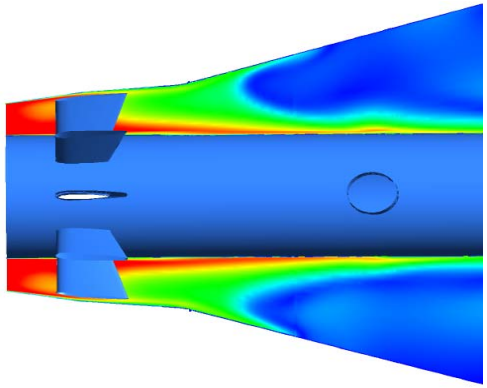
University Research Topics – Aero

Higher IGCC mass flow produces greater exit Mach Numbers

- Better airfoil shapes at high mach numbers
- Exit conditions more suitable for diffusers
- Increase diffuser performance when high inlet Mach Number

IGCC sometimes produces greater temperature variation

- Determine impact of radial & circumferential temp variation vs. turbine performance
- Determine how to counter effects



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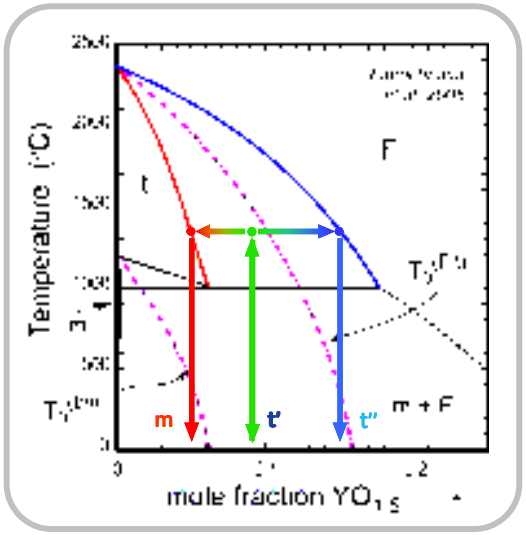
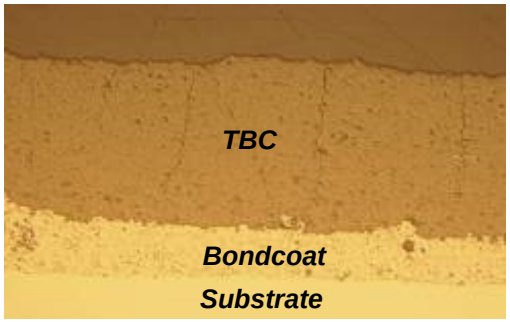
Materials Challenges

- Validation of the environment – targeting conditions beyond current experience
- Formation of deposits under IGCC and high hydrogen conditions
- Phase stability and sintering
- Spallation
- Progressive TBC Thinning
  - Erosion
  - Microspalling





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University Research Topics – Materials

- Approaches for TBC lifing models
- High Temperature Toughness Test for TBC's
- Higher temperature TBC bond coat with reduced rate of Thermally Grown Oxides (TGO)
- Improved corrosion resistance - to higher moisture content and deposits such as Na_2SO_4 and $CaSO_4$.
- Better Non Destructive Evaluation (NDE) Techniques

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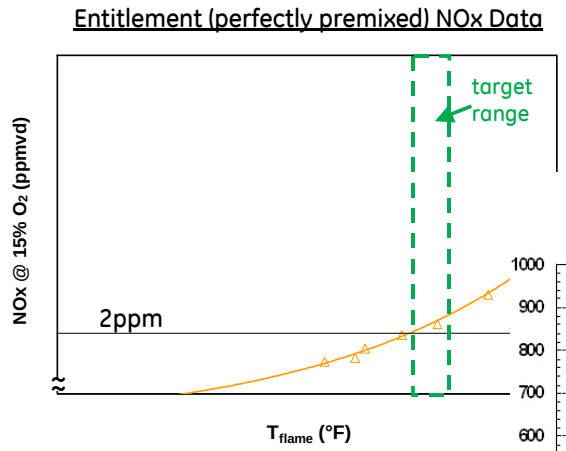
Combustion Challenges

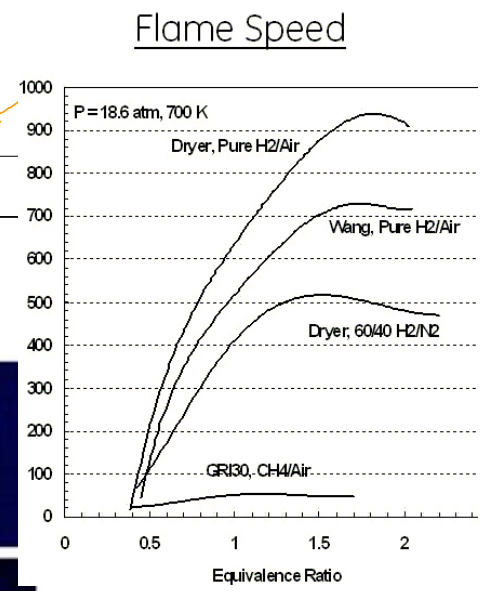
NOx

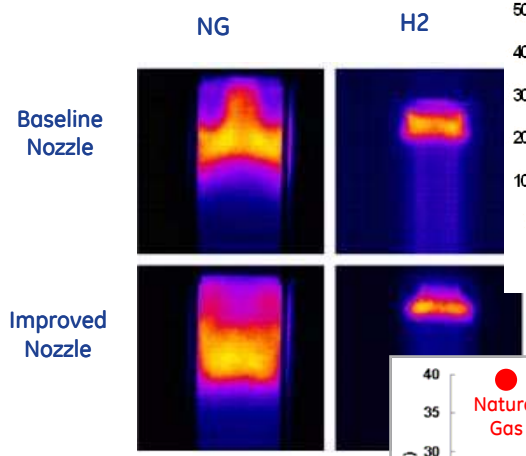
Flashback

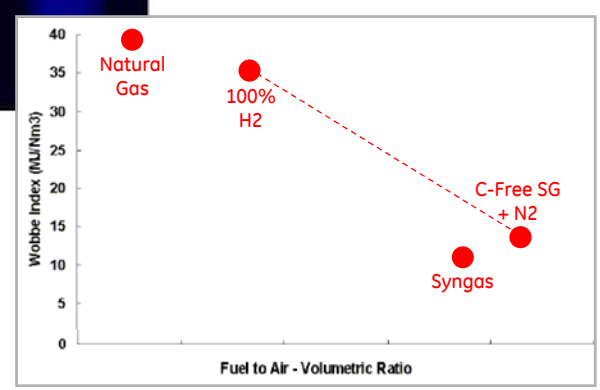
Dynamics

Fuel Flexibility









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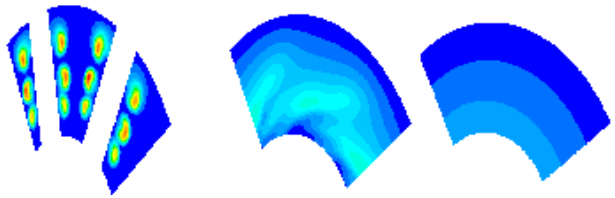
University Research Topics – Combustion

- Measure turbulent burning velocities - of fuels at high pressure (with and without diluent)
- Develop and validate a kinetics mechanism - including NOx chemistry
- Develop analytical and/or computational predictive models - to study jet-in-crossflow flame stabilization
- Evaluate combustion dynamics



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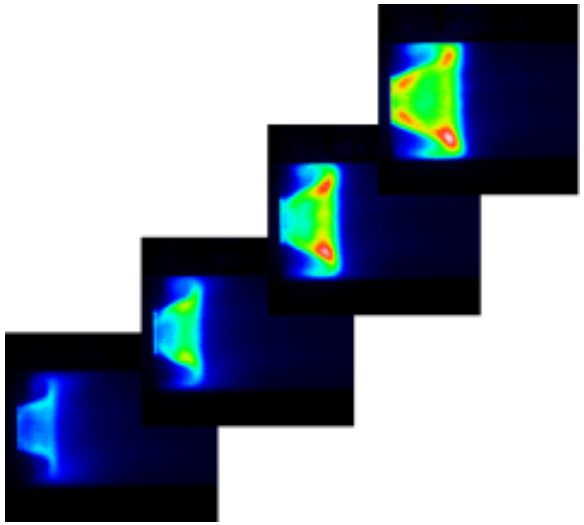
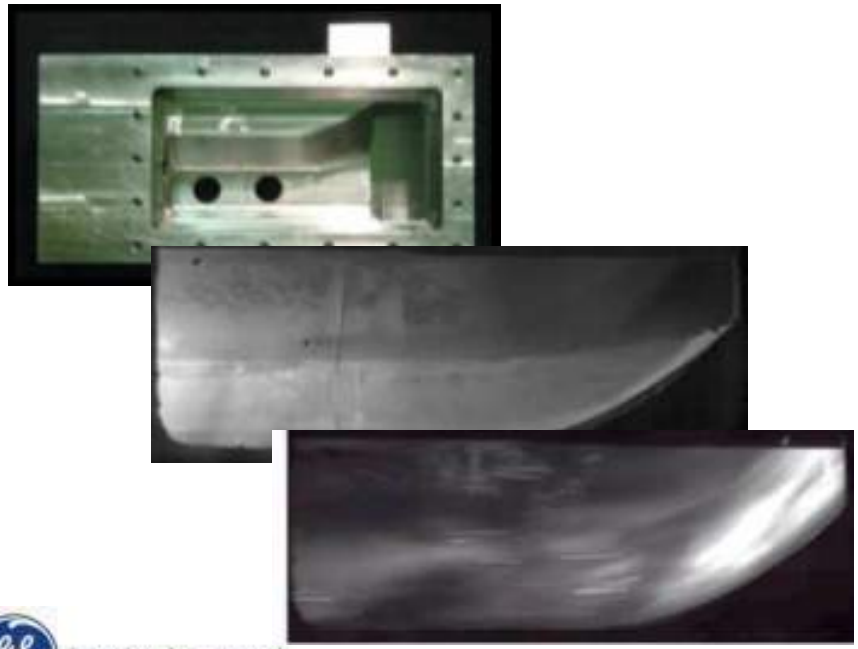
Details on Combustion Research Topics

- Flame Transfer Function
  - High Speed Imaging
  - Fundamental Physical Phenomena
  - Requirement for dynamics predictions with carbon free fuels





- Flashback Visualization
  - High Speed Imaging
  - Fundamental Physical Phenomena
  - Requirement for evaluating design robustness with carbon free fuels

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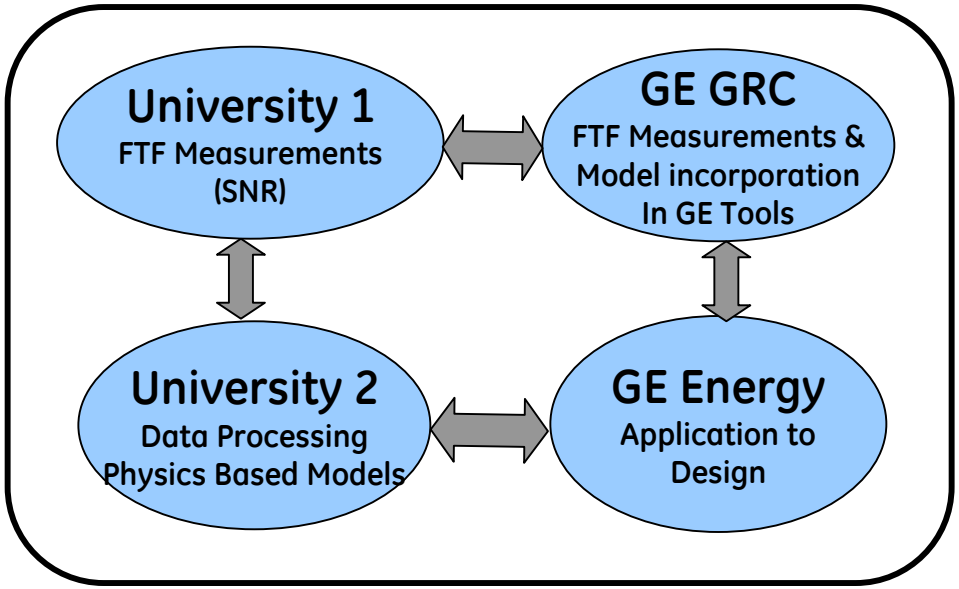
GE/University Synergy – Combustion Example

Flame Transfer Function Measurement & Modeling To Enable Improved Dynamics Prediction Capability



University Role

- Transfer of fundamental understanding and findings to Industry
- Leverage data from tests and incorporate into physics based models
- Transfer of knowledge in new measurement techniques & new rig designs

GE Role

- Identify key areas of research relevant to industry
- Communicate with the University team on product related issues & Current industry approach to resolving these issues.
- Leverage University partnership to complete long term industry needs.

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Summary

- GE working on gas turbine technology advances needed for future IGCC products with Carbon Capture and Sequestration.
    - Higher efficiency, lower cost, lower emissions
- Universities play a critical role in the gas turbine technology R&D process
    - Track record of success
    - Keep up the good work!!!

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