Advanced Hydrogen Turbine Development

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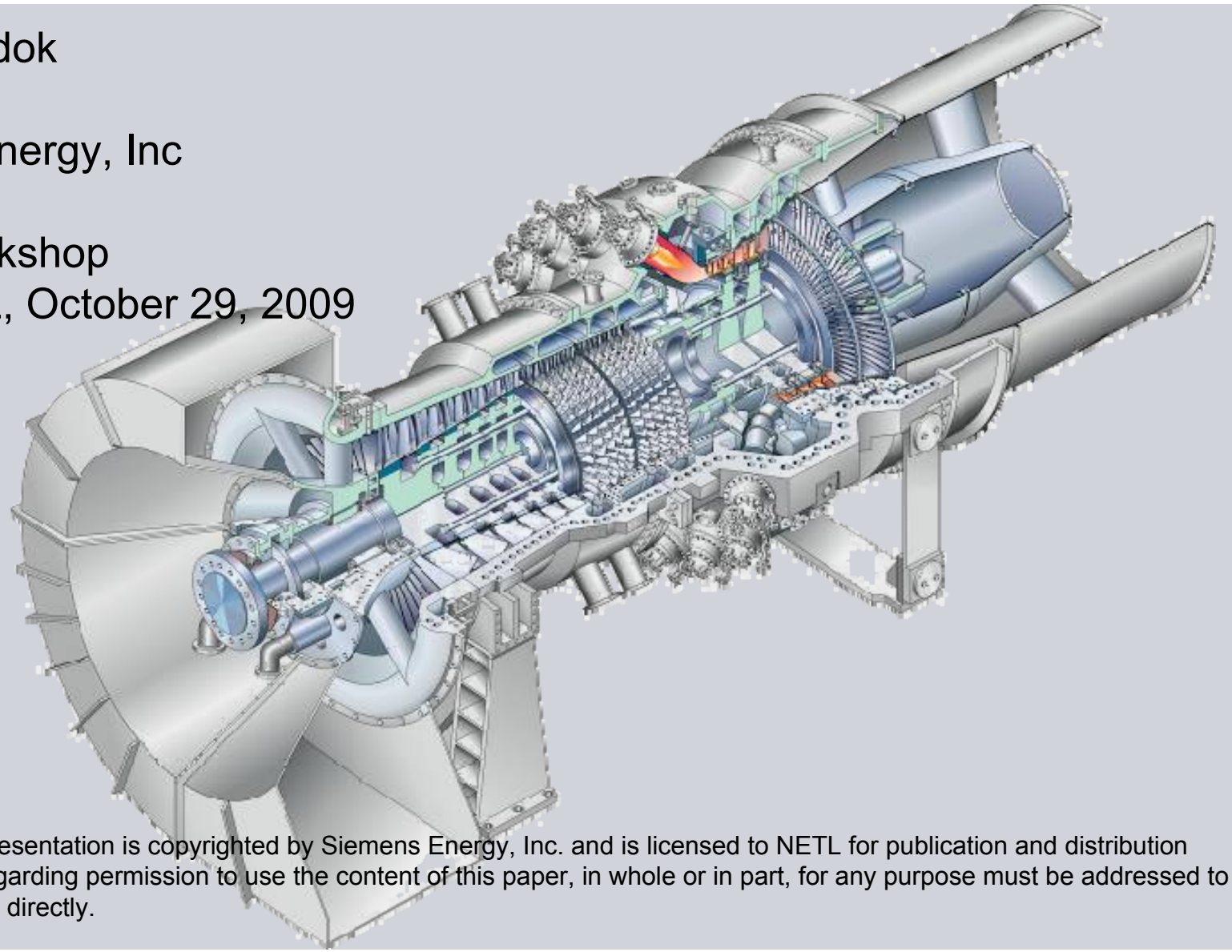
Joseph Fadok

Siemens Energy, Inc

UTSR Workshop
Orlando FL, October 29, 2009



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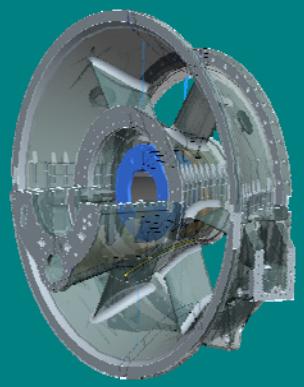
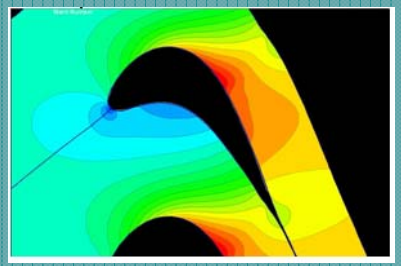
Advanced Hydrogen Turbine Program Phases

Phase 1 Studies
Conceptual Design



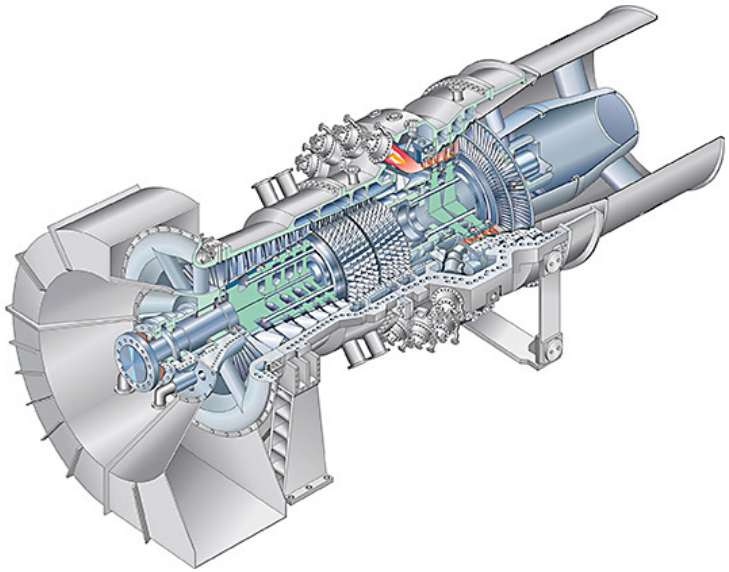
Complete

Phase 2
Technology Development and Validation



In Progress

Phase 3 Manufacturing, Construction, and Operation



Phase 3 not included in current award

2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

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Program Development and Major Activities

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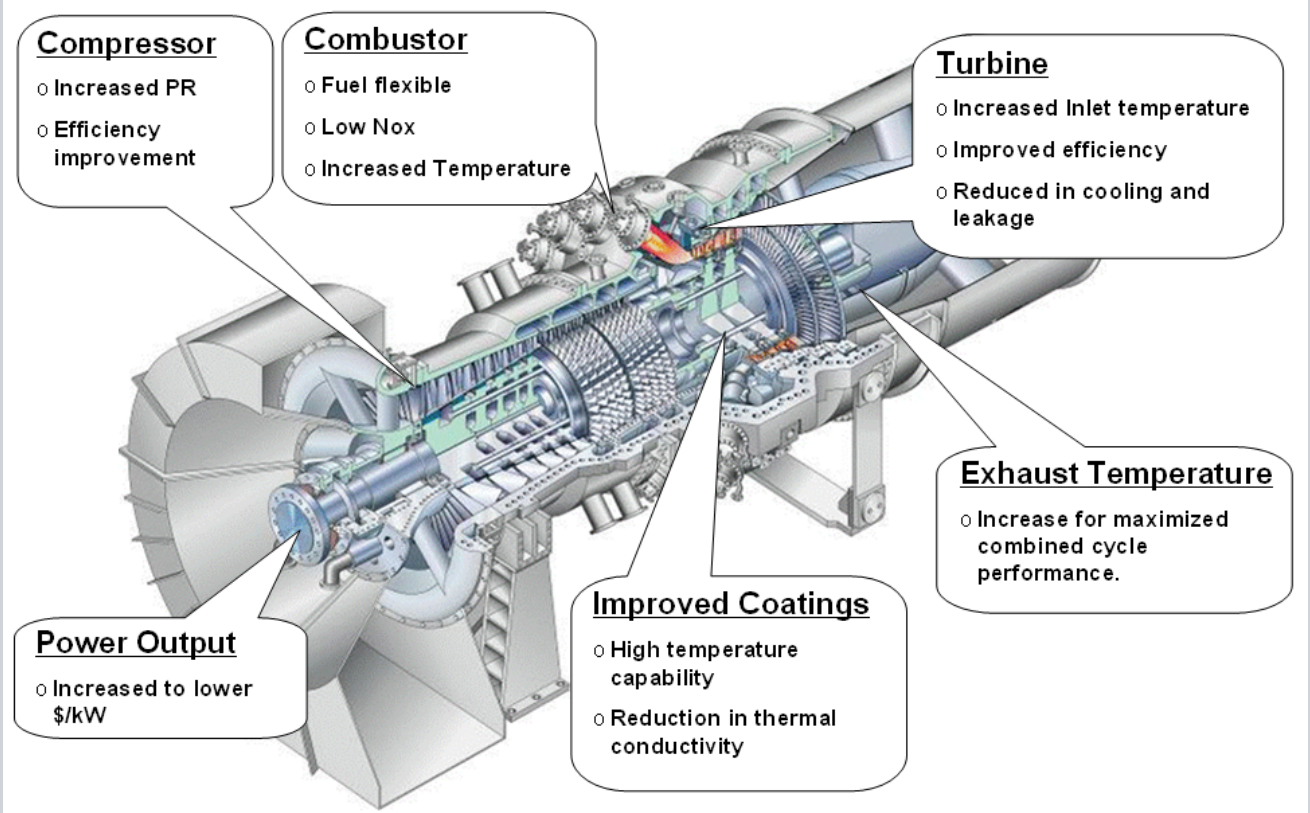
IGCC Plant

- Improved Efficiency
- Fuel Flexibility NG,Syngas,H_2
- Low Emissions
- Reduction in Plant Cost $/KW
- CO_2 Sequestration Ready

Targeted Areas of Improvement



Program Development and Major Activities are Driven by Plant Level Goals

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A Steep Growth In IGCC Turbine Inlet Temperature is the Target

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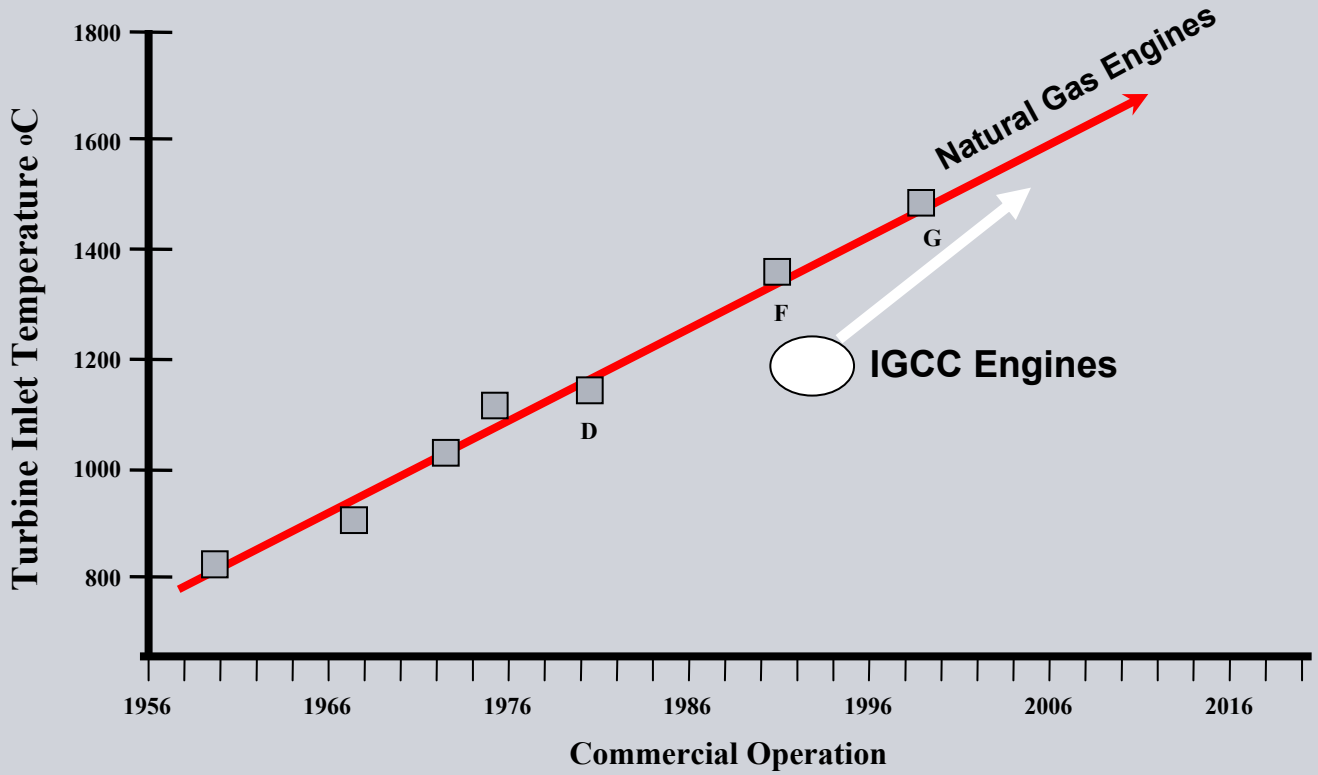

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Combustion System Options for IGCC applications

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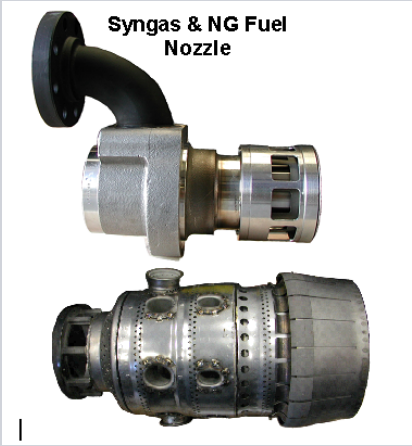

Premix Combustion System

- Demonstrated rig testing above F class temperature without dilution.
- Susceptible to flashback and dynamics.
- Proven single digit NG NOx emissions.

Diffusion Flame Combustion

- Currently Offering
- <15 ppm NOx achievable beyond G-class firing temperature
- Requires dilution for NOx
- 25 ppm NG NOx emissions with dilution.

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Combustion Systems Development Challenges High Hydrogen Content Fuels

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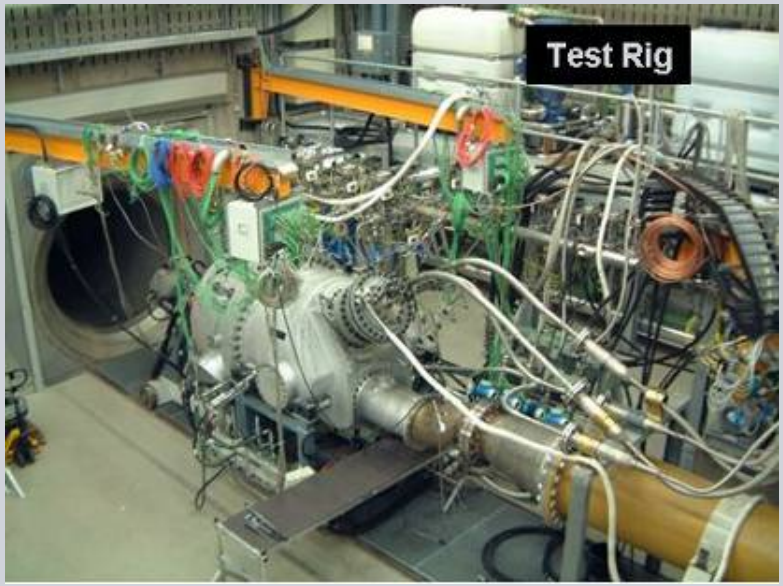
Challenges:

- Flame Speed
- Flashback
- Combustion Dynamics / Acoustics
- Fuel Flexibility (Always need back-up fuel)
- Low Emissions at Increased Temperature
- Large variation in fuel properties depending on feedstock.



High Pressure Combustion Test Rig

High pressure full scale testing is expensive. Better predictive tools are needed and requires fundamental research and development.

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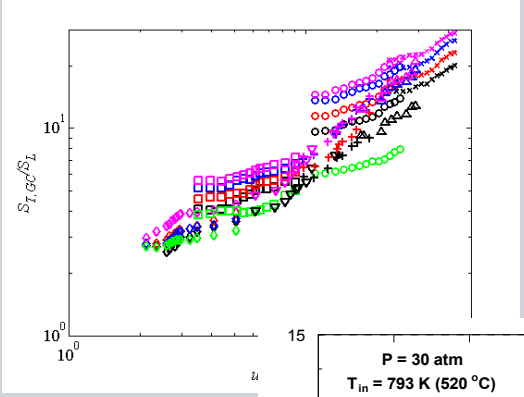
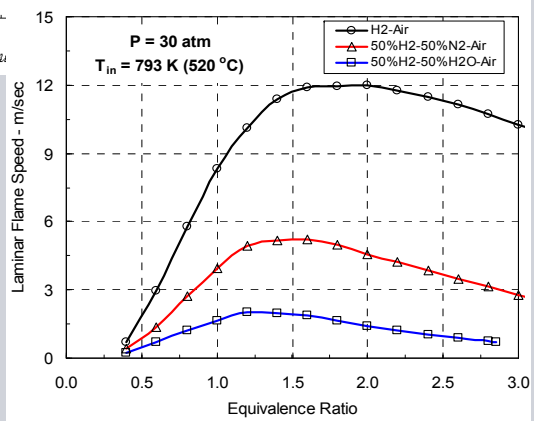
Fundamental Data Needed

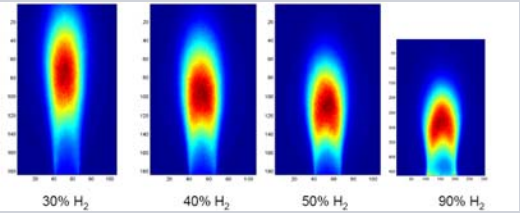
Turbulent Flame Speed Data

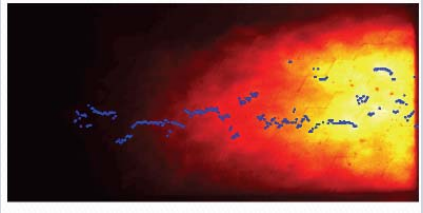
Kinetics Modeling

Improved CFD









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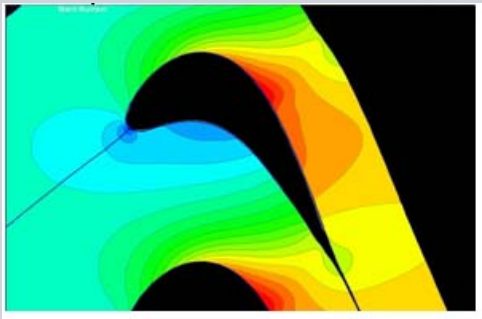
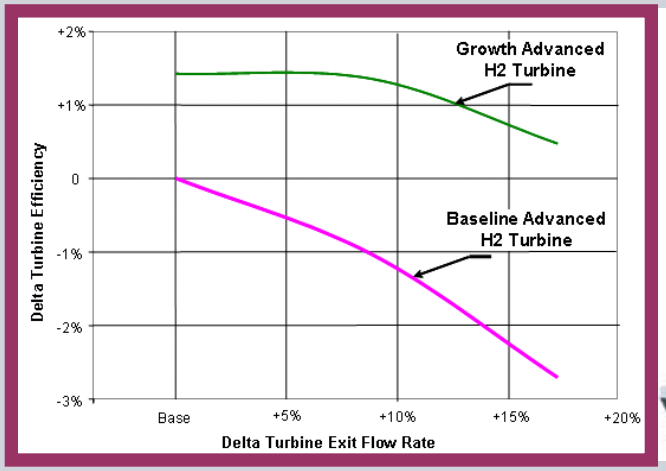
Turbine Development



Challenges:

- Reduced cooling at elevated temperature
- High moisture content with H2 fuel
- Increasing mass flow with low BTU fuels



Aerodynamic, cooling, and manufacturing concepts are being evaluated and developed to produce a turbine design with excellent mechanical integrity and high efficiency

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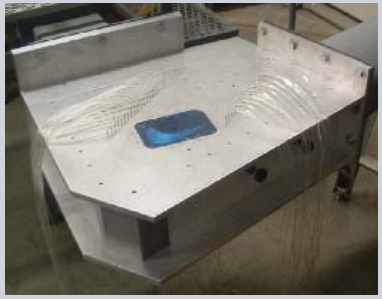
Fundamental Research and Development

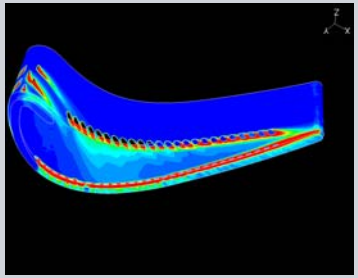
Improved Aerodynamic and Heat Transfer Predictions

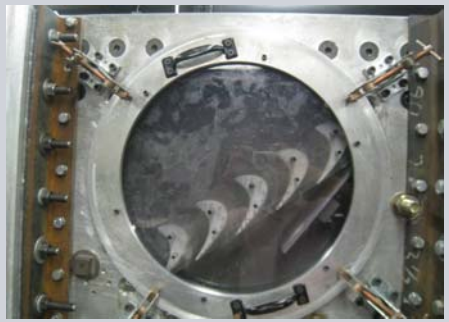
Advanced 3D CFD Modeling

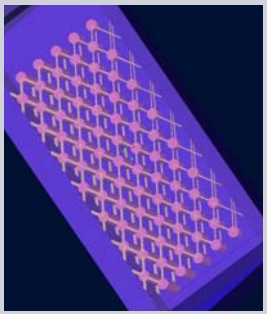
Rapid Design Iterations. Rapid Prototyping

Sealing technology and validation









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Materials & Coatings Development

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Baseline	Experiments	Validation
Leveraging IGCC and NGCC Experience	• Literature Search • Initial Hypotheses • Design of Experiments • Target Setting	• Target Demonstration • Design data generated • Design tools updated • Environmental Testing

Challenges:

- High Temperature Low Conductivity TBC
- Environmental Issues with Syngas & High Hydrogen Fuels
- Corrosion & Oxidation Capability

Advanced or novel materials and coatings are critical to the successful advanced engine components and systems development

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High Temperature Materials & Coatings Systems

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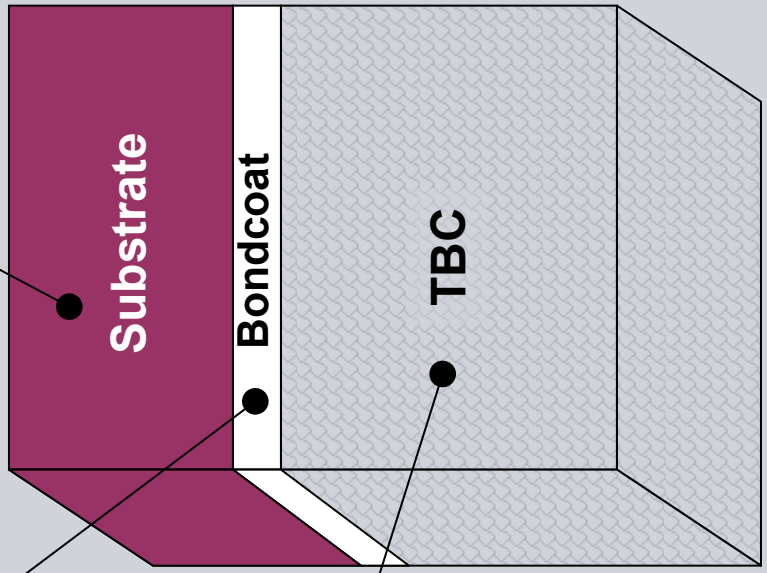
Modified Superalloys
- Better coating compatibility,
- 30% increase in coating life.
- Improved Oxidation Resistance



High-temp bond coats
- 40% increase in spallation life compare to current bond coats.
- Compatible with high H_2O environment

High-Temperature, Low K TBC
- Phase stability tests complete.
- Intermediate temperature goal (2010) achieved

TBC – Thermal Barrier Coating

K – Thermal Conductivity

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Our Relationships

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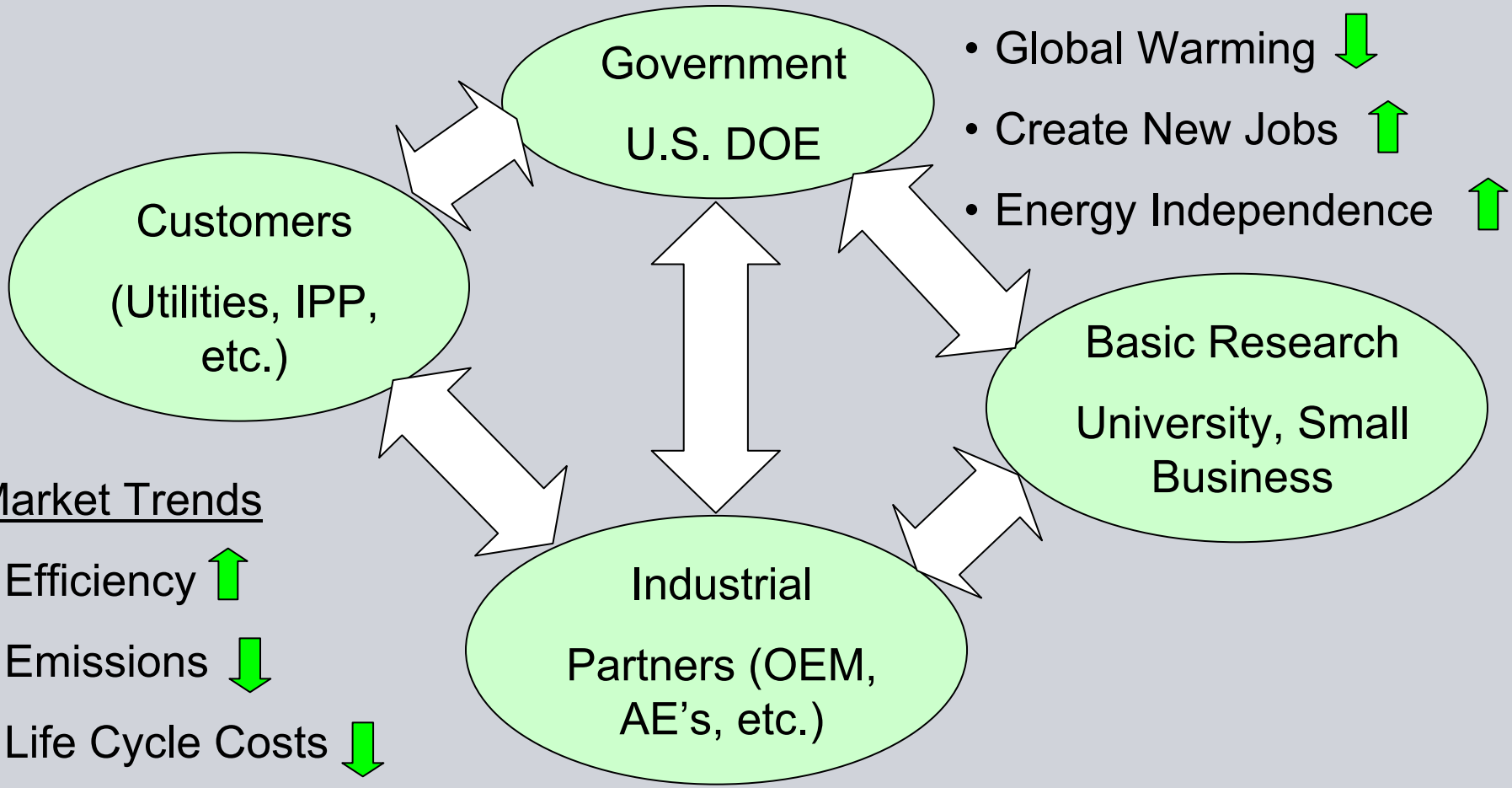

Energy Policy

- Global Warming ⬇
- Create New Jobs ⬆
- Energy Independence ⬆

Market Trends

- Efficiency ⬆
- Emissions ⬇
- Life Cycle Costs ⬇

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Serving Future and Near Term Product Enhancements

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Technology

- Increased compressor efficiency
- Improved turbine cooling and sealing
- High temperature materials and coatings
- High temperature, low emissions combustor
- Next generation sensors and diagnostics

High Efficiency IGCC

High Efficiency NGCC

NOx

η_{CC}

CO_2

η_{CC} – combined cycle efficiency

The adaptation and integration of advanced technologies into current & future Natural Gas Turbines will lead to increased efficiency, lower CO_2 and NOx emissions.

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Ensuring Commercial Viability

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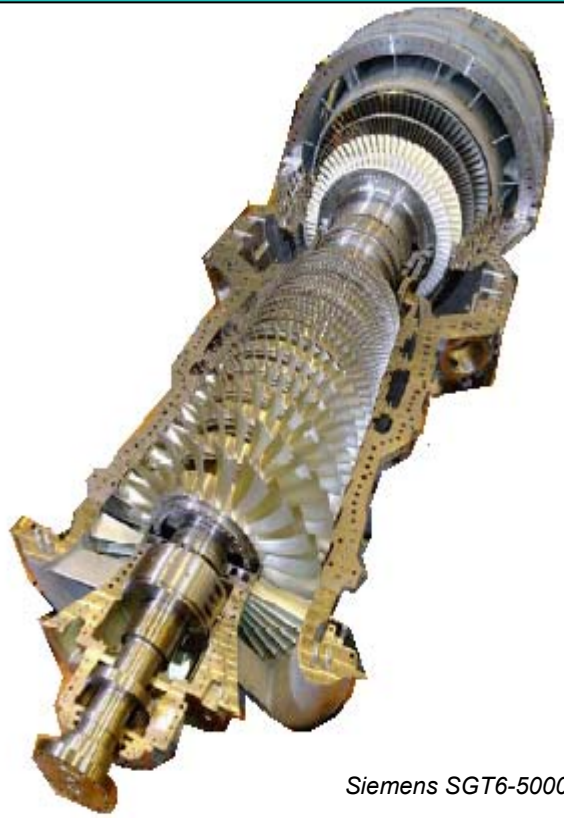
Through advanced technology we will be able to offer a more attractive, state of the art turbine, that is aligned with future industry drivers.

Advanced Gas Turbine Technology which….

- Is carbon capture and sequestration ready
- Supports **clean coal** technology initiative
- Improves gas turbine and combined cycle **efficiency**
- Provides **near term** technology infusion into current engines
- Lowers **$/kw** cost with increased output and efficiency
- Significantly reduces **CO_2** and **NO_x** emissions
- Enables greater reliance on national resources
- Must Be **Reliable**



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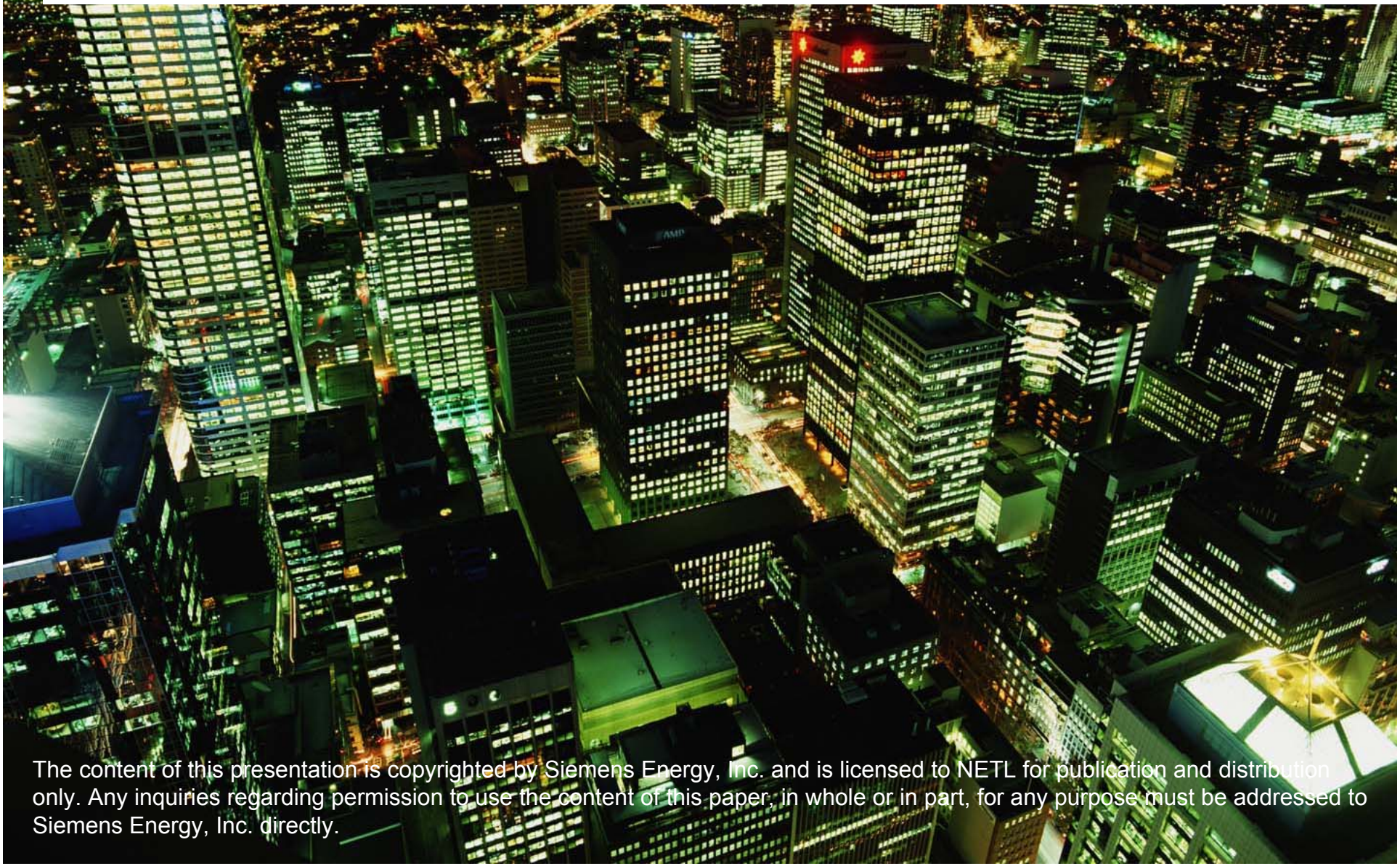
Questions?



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