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Pathways to Improved IGCC Performance and Economics with CO_2 Capture & Storage

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Gasification Technologies Conference
Washington, DC
November 2, 2010

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- Founded by and for the electricity industry in 1973
- Independent, nonprofit center for public interest energy and environmental research
- **Collaborative** resource for the electricity sector
- 450+ participants in more than 40 countries
- EPRI members generate more than 90% of the electricity in the United States
- International funding of more than 18% of EPRI's research, development and demonstrations
- Programs funded by more than 1,000 energy organizations

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Our Role…

Help Move Technologies to the Commercialization Stage…

Technology Accelerator!

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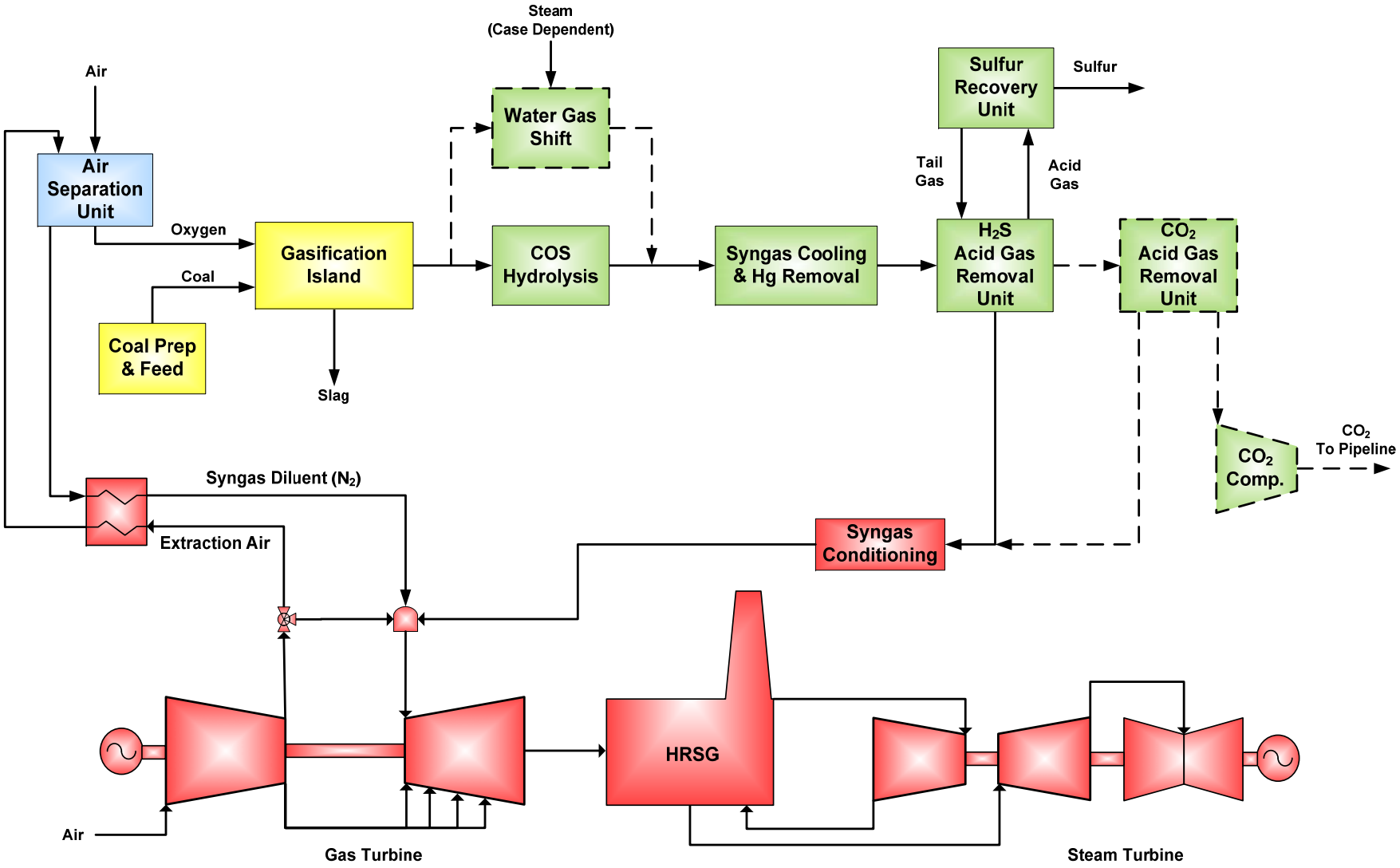
IGCC with CO_2 Capture

Process Flow Diagram



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IGCC with CO_2 Capture
Plant Performance and Cost Analysis

Average IGCC from recent EPRI Studies (Report 1019669):

Gross Power:	750 MWe
Auxiliary Power:	215 MWe
Net Power:	535 MWe
Net Plant Efficiency:	30.5% HHV
Total Plant Cost (TPC)*:	$2.0B

	Aux. Load	TPC	Improvements Identified
Air Separation	55%	15%	Larger cryogenic ASU, ITM
Gasification Island	4%	25%	Coal slurry/drying, high η gasifier
Syngas Processing	30%	20%	WGCU, H_2 Membrane, other?
Power Block	3%	15%	G/H/J GT, Higher η ST (SC steam?)
Balance of Plant	8%	25%	None identified to date

*TPC assumes Nth plant w/10% Engineering, 10% Project & 0% Process Contingency

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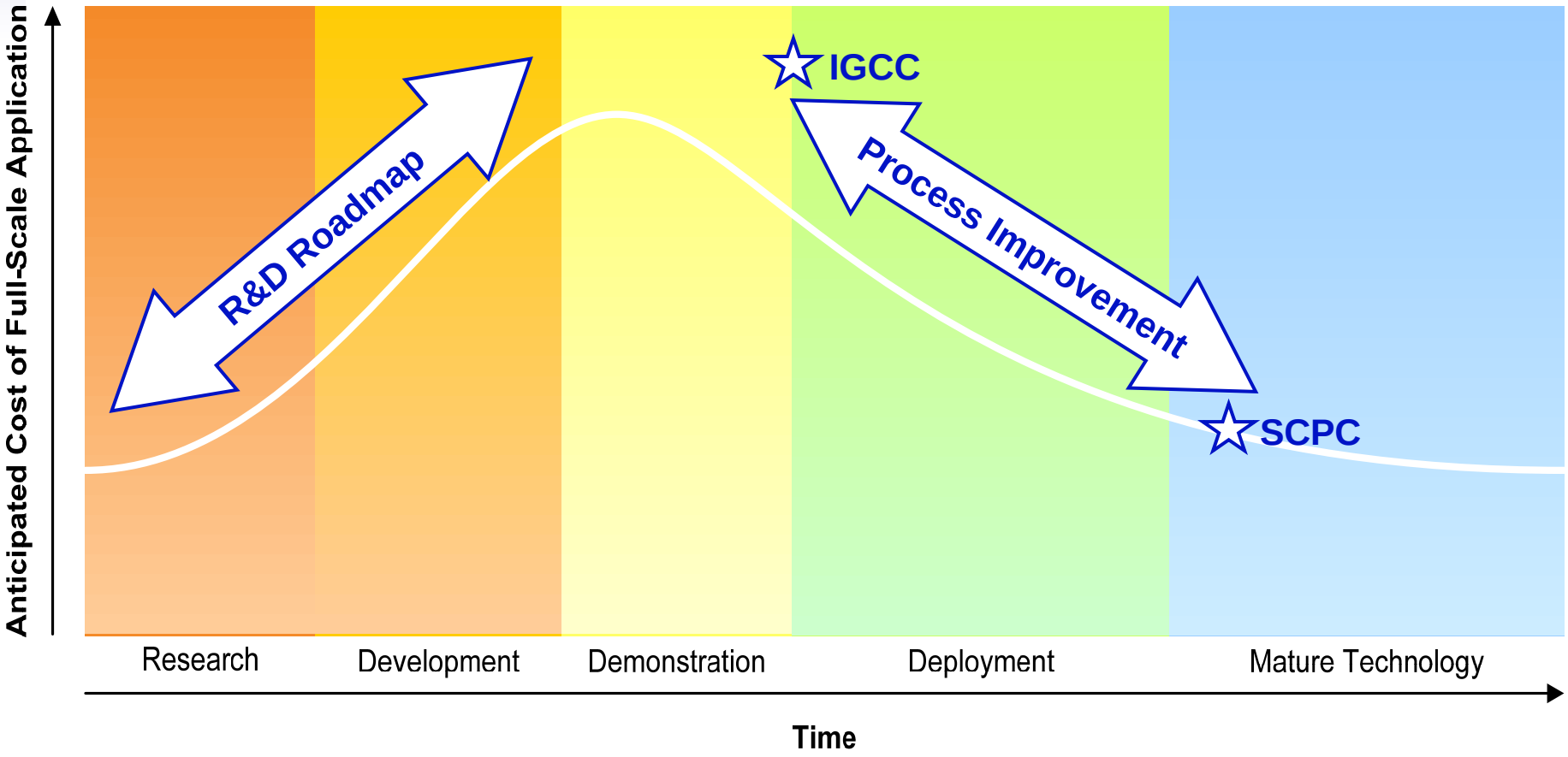
New Technology Deployment Curve

(Current State of the Art)



R&D Roadmaps Are Critical to Improving Cost Competitiveness

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Coal Preparation & Feeding

- Beneficiation
- Drying
- Slurrying
- Dry coal feed pumps

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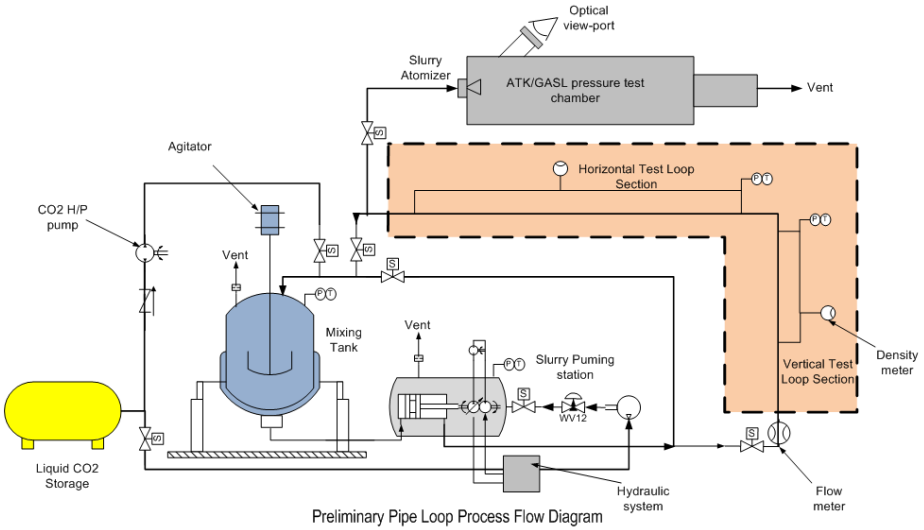
Coal Preparation & Feeding

CO_2-Coal Slurry Concept

- Captured CO_2 is compressed to ~700 psi (48 bar)
- The CO_2 is condensed to a liquid at ~ 40°F (4°C)
- Liquid CO_2 is used as coal slurrying medium

	Liquid CO_2 vs. Water
Viscosity	Lower
Heat of Vaporization	75–80% lower
Atomization	Finer



Laboratory pipe loop to investigate the rheological behavior of coal/liquid CO_2 slurry mixtures

- Higher solids loading vs. water slurry
- Less oxygen required to maintain gasifier temperature
- Better carbon conversion at same gasifier temperature

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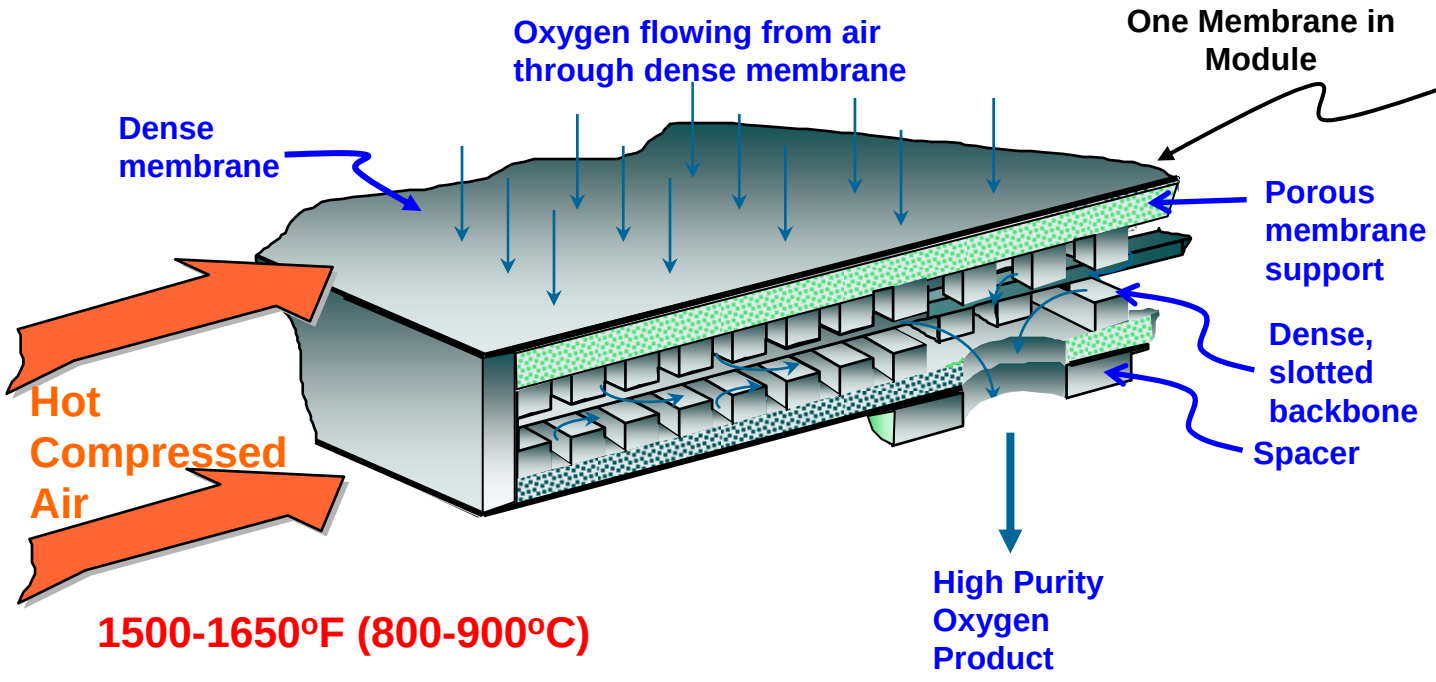
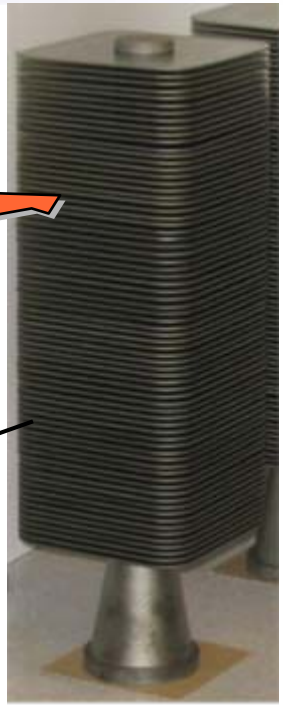
ITM Oxygen Membranes

- Single-stage high-purity oxygen
- Extremely selective and very fast transport for oxygen
- Very compact



0.5 ton/day module

One Membrane in Module



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EPRI Due Diligence *(TI Report # 1020202)*

Cryo ASU vs. ITM in IGCC w/ CCS (G-Frame GT)

	Cryo Reference Case	ITM Case
Gas Turbine Power	1.00	1.00
Steam Turbine Power	1.00	1.02
Gross Power	**1.00**	**1.01**
ASU Auxiliary Power	**1.00**	**0.81**
Total Auxiliary Power	**1.00**	**0.94**
Net Power Output	**1.00**	**1.03**
Thermal Input	1.00	1.01
Net Plant Heat Rate, Btu/kWhr	Base	-230
Net Plant Efficiency, HHV	**Base**	**+0.8% point**

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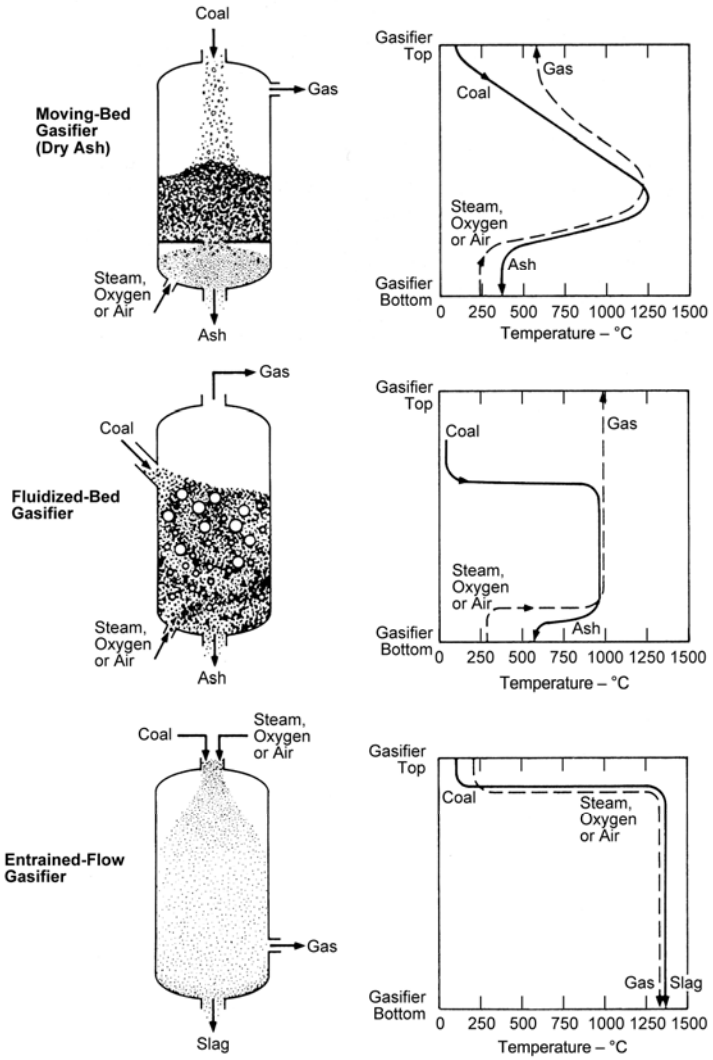
Gasification Island

- Improved gasification performance
  - Efficiency, availability, etc.
  - Day one presentations
- Heat recovery design
  - Syngas cooler designs
  - Water quench
- New gasifiers in development



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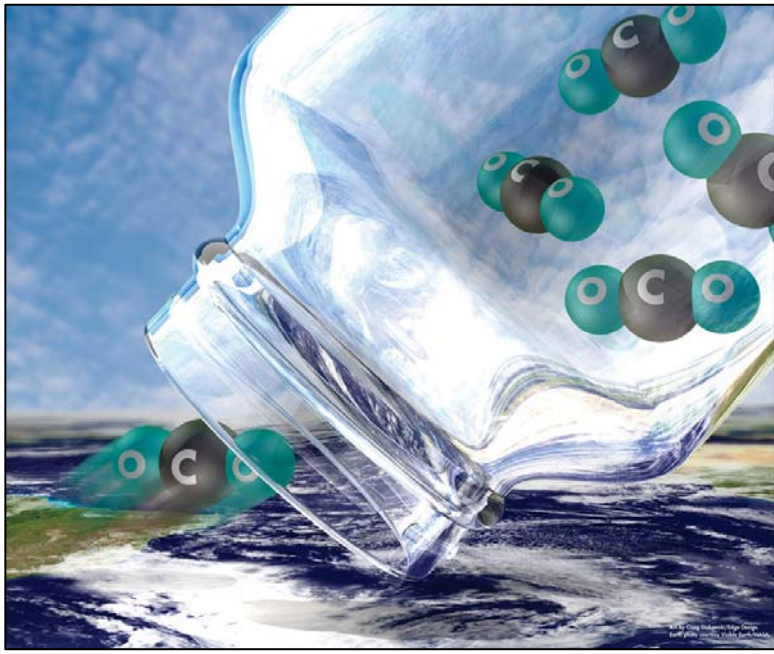
Syngas Processing

Water-Gas Shift, Sulfur Capture, CO_2 Capture and Processing

- Water-Gas Shift
  - Efforts to reduce steam requirements
- High-temperature and -pressure sulfur recovery
  - RTI demonstration at TEC Polk
  - Bechtel Pressure Swing Claus
- CO_2 Capture & Processing
  - Hydrogen separation
  - CO_2 Purification
  - Ramgen CO_2 compression



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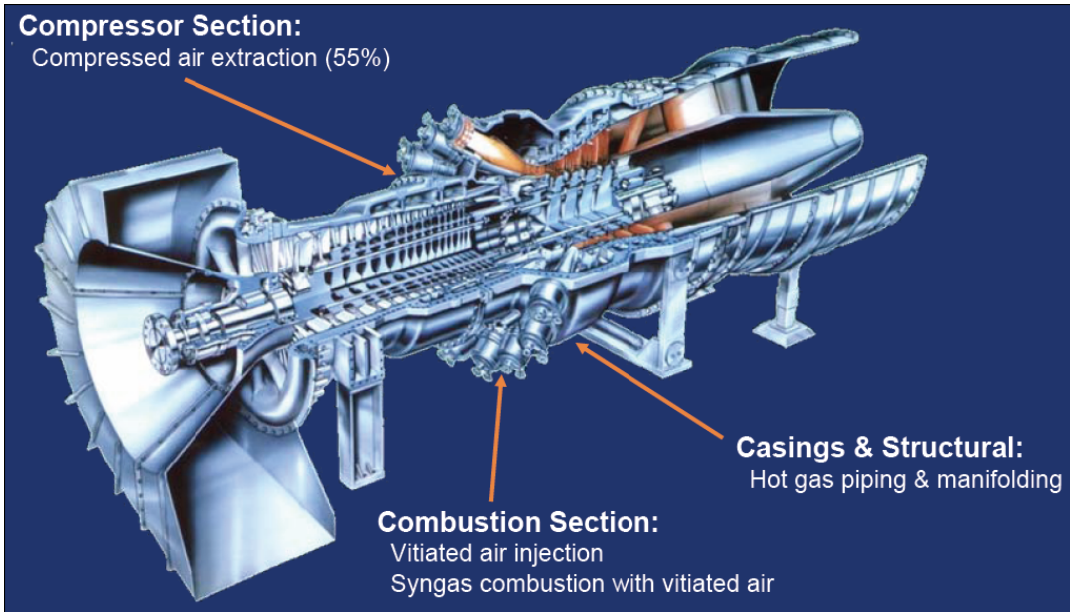
Power Block
Advanced Gas Turbines

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



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IGCC R&D Improvement Potential

Current Status

Carbon Management

- Commercially available and operating CO_2 capture technology
- CO_2: 300 lb/MWh with full capture

Emissions (with CCS)

- NO_X: 0.135 lb/MWh
- SO_X: Nil
- PM: 0.138 lb/MWh

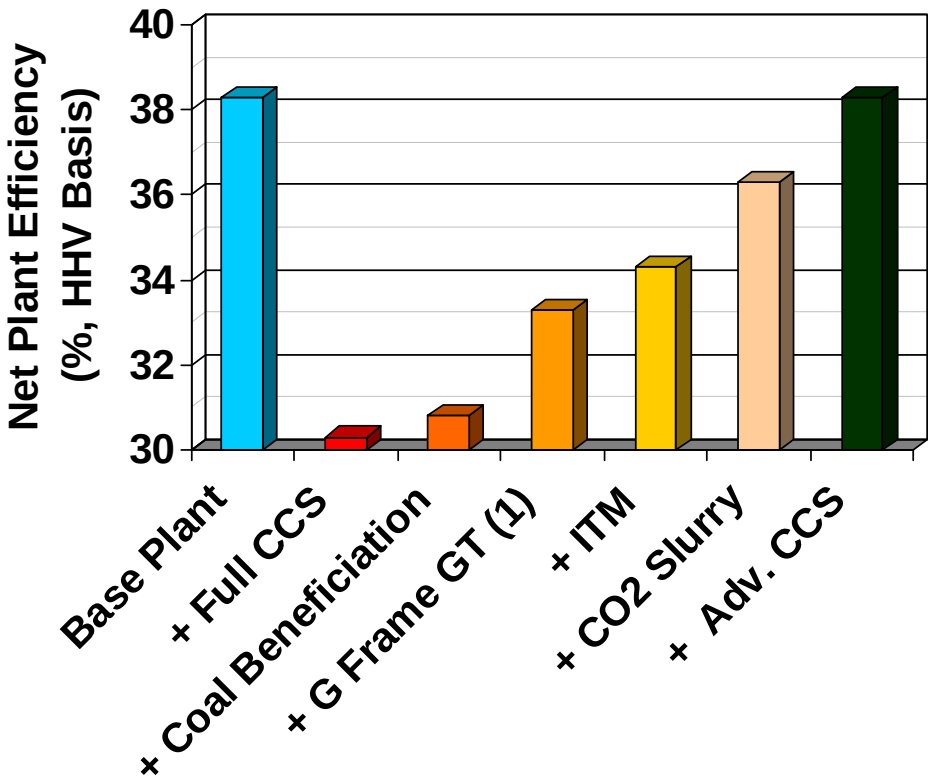
Water Usage (with CCS)

- 6500 gpm (1/3 less than PC)

Solid Waste

- Slag (suitable for landfill or used in roads)
- Sulfur or sulfuric acid

Future Potential



Notes:

1. G-Frame GT case includes full air-side GT-ASU integration
2. Efficiency improvements are cumulative

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Closing Thoughts

- Significant thermodynamic potential in new tech
- Many development projects underway (mainly supported by U.S. DOE/NETL)
- Critical to the future of the technology for power

- U.S. DOE/NETL IGCC Pathway study V2 update on NETL website
- Canadian Clean Power Coalition pathway study on low rank coal is forthcoming

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