



An Overview of U.S. DOE's Gasification Systems Program

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Gasification Program Goal

The goal of the Gasification Program is to reduce the cost of electricity, while increasing power plant availability and efficiency, and maintaining the highest environmental standards

“Federal support of scientific R&D is critical to our economic competitiveness“

Dr. Steven Chu, Secretary of Energy
November 2010



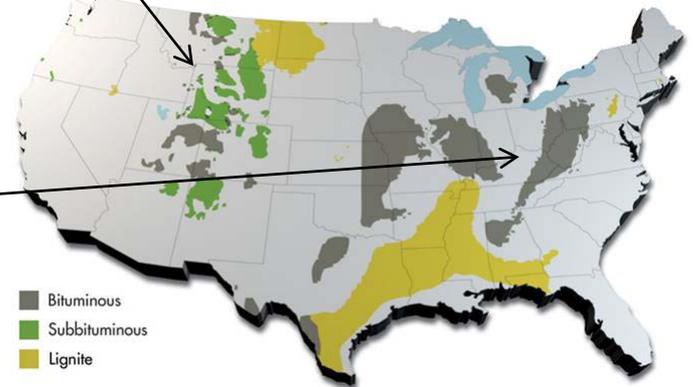
U.S. Coal Resources

Low rank: lignite and sub-bituminous coal

- About 50% of the U.S. coal reserves
- Nearly 50% of U.S. coal production
- Lower sulfur

Bituminous coal

- About 50% of the U.S. coal reserves
- Higher heating value
- Lower moisture and mineral content

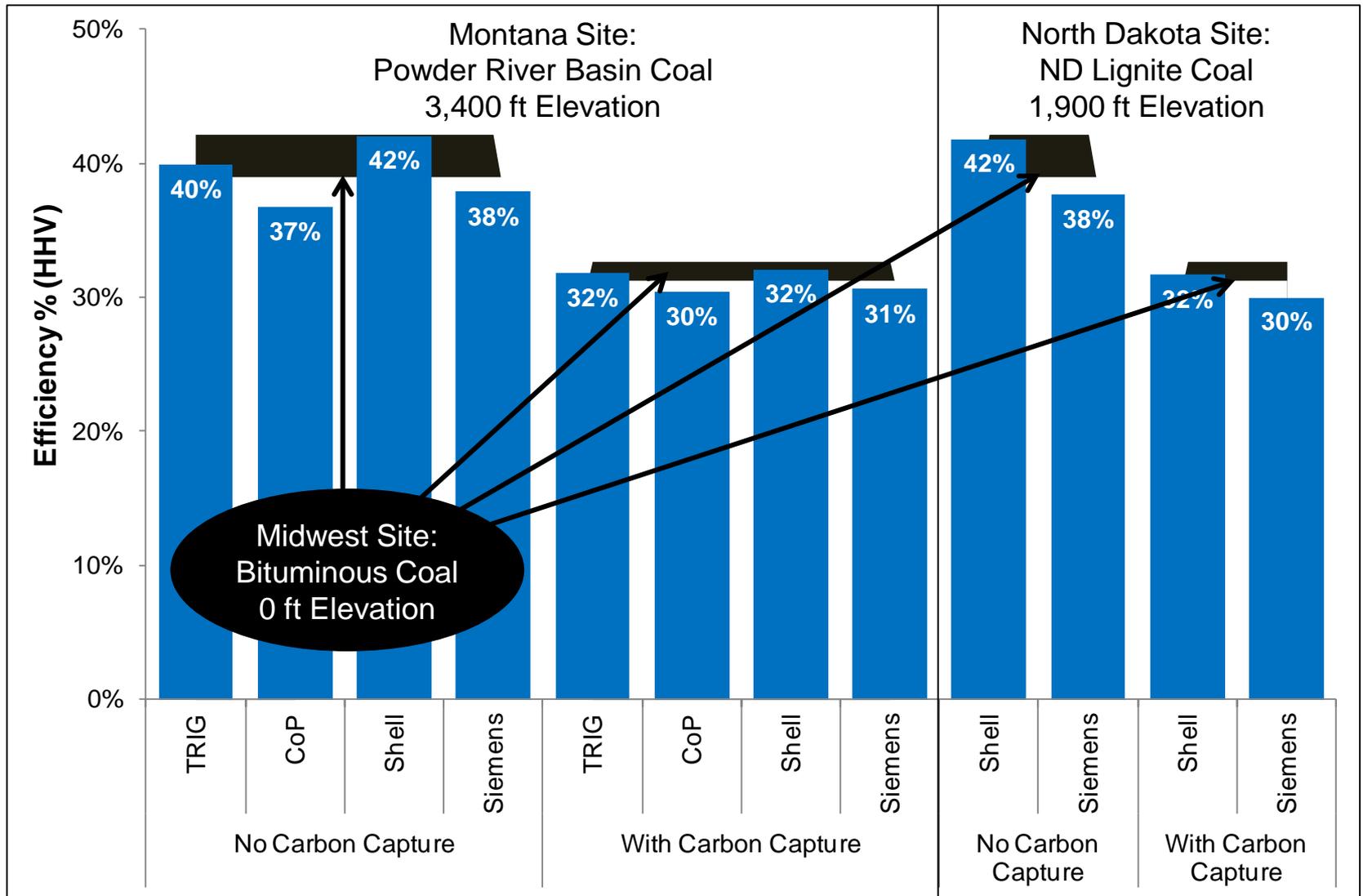


EIA forecasts significant growth in western coal production;
declining eastern coal production

Low rank western coal cost per Btu will stay at about half that
of eastern coal

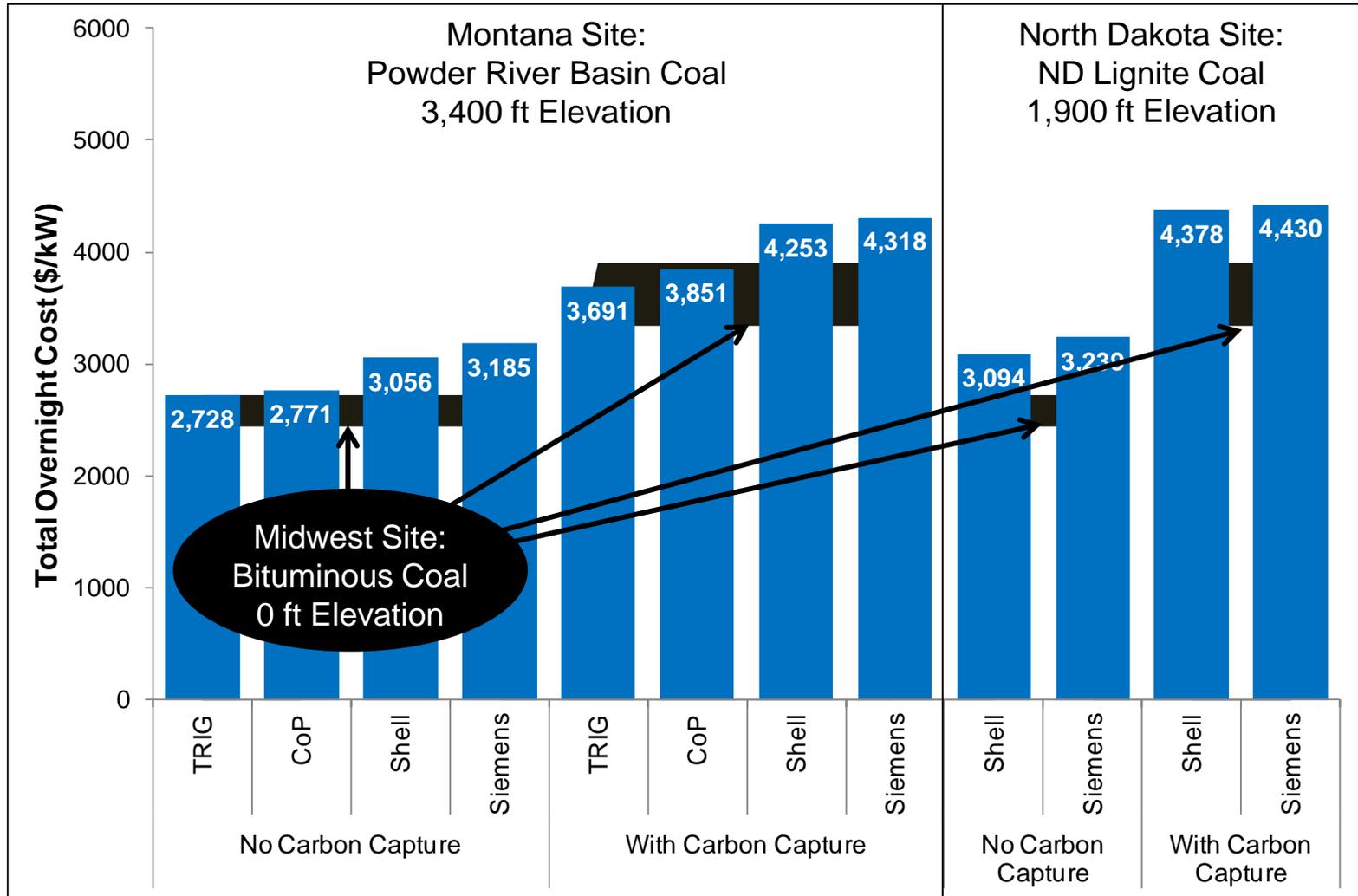
Low Rank Coal Baseline Study

IGCC Efficiency



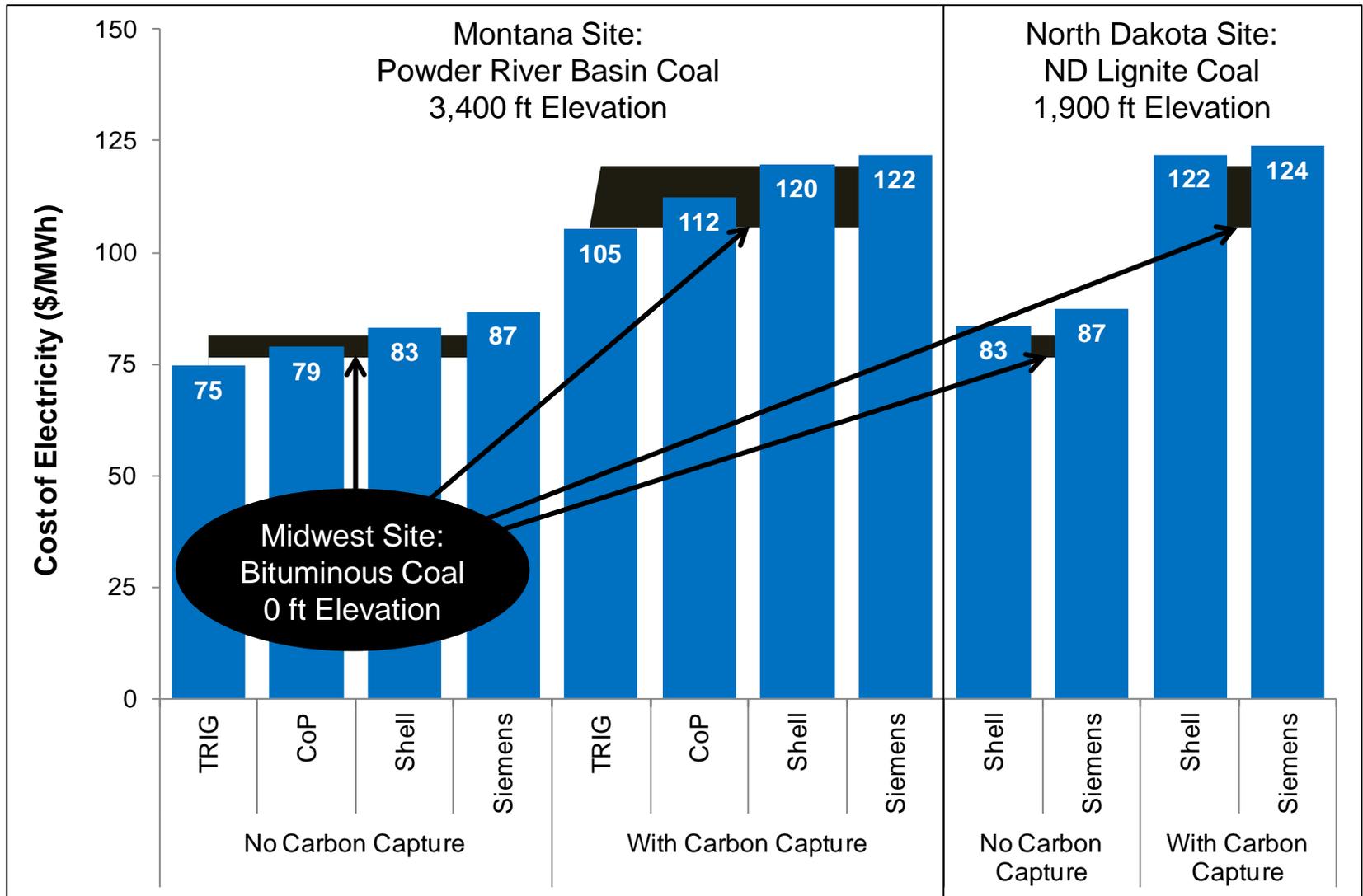
Low Rank Coal Baseline Study

IGCC Plant Cost



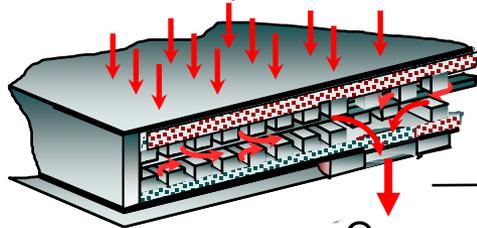
Low Rank Coal Baseline Study

IGCC COE



Key Gasification R&D Areas

Hot Compressed Air



Oxygen

APCI Oxygen Membrane

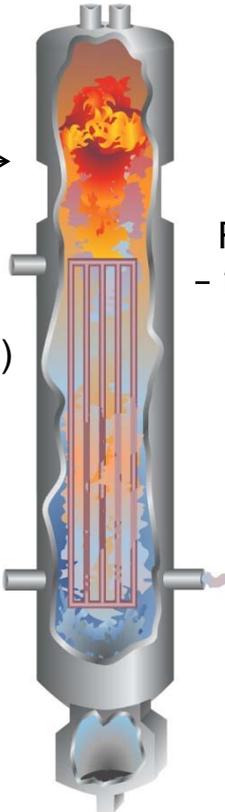
- 6.9% capital cost reduction (36.0% O₂ plant capital cost reduction)
- 5.0% COE reduction



Feedstock

PWR Coal Feed Pump

- 1.0% COE reduction



Raw
- fuel
gas



Clean fuel gas

Water
Gas Shift

- Process improvement and intensification

RTI Warm Gas Cleaning
in combination with
Eltron H₂-CO₂ Membrane

- 2.6 % pt efficiency increase
- 12.0% COE decrease



H₂ rich stream

CO₂

Advanced Gasification

Low-rank Coal

Alternative Feedstocks

- Energy security
- Carbon footprint reduction

Improve RAM

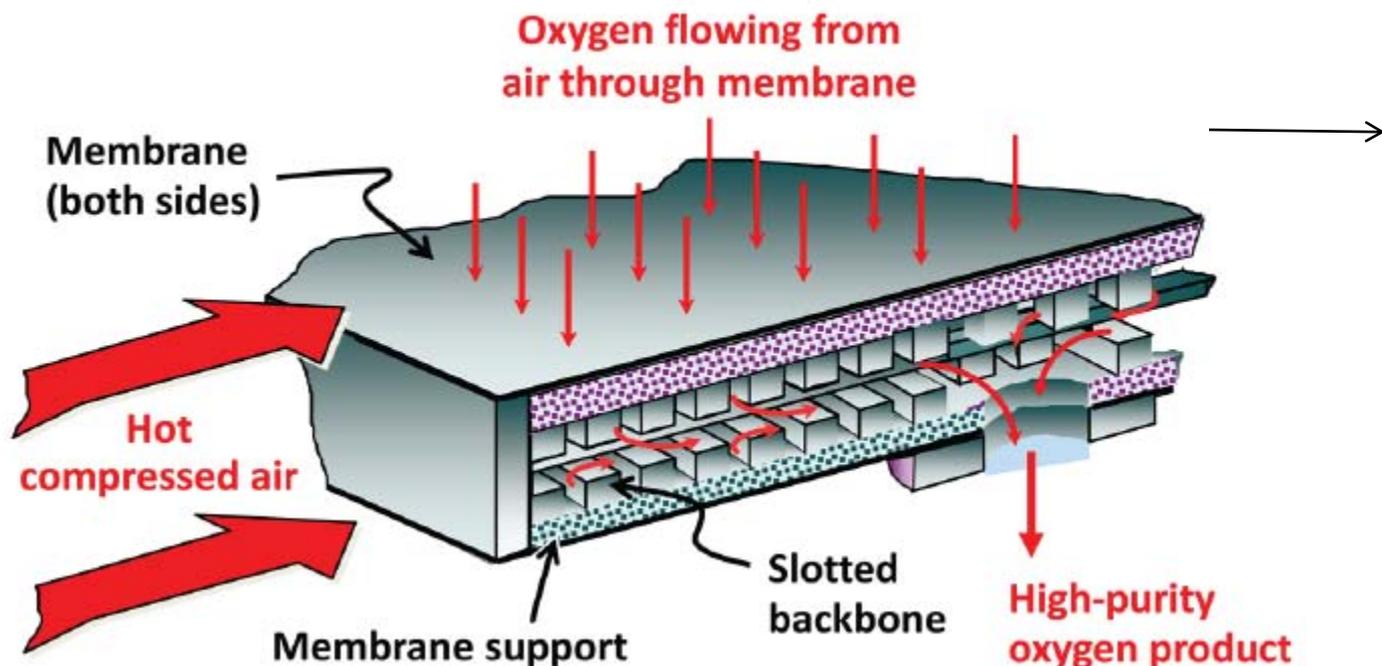
- Refractory durability
- Feed system reliability
- Heat removal/integration
- Temperature control & measurement
- Dynamic simulator
- CFD gasifier modeling
- Slag model development

APCI Ion Transport Membrane

Technology

Ion Transport Membrane (ITM)

- Supported thin-film, ceramic planar devices
- Fast, solid state electrochemical transport of oxygen
- Pressure-driven; compact
- All the layers are composed of the same ceramic material



1/2-TPD module
(multiple membranes)

APCI Ion Transport Membrane

Goal: Low cost oxygen production

Technology: O₂ separation from air utilizing perovskite ceramic membrane technology

Project tasks (planned completion date 9/30/2015)

- Perform module testing utilizing the 5 TPD Test System to evaluate lifetime performance against target values, and obtain membrane module performance data (complete)
- Construct ~100 TPD pilot system to demonstrate integrated operability and performance of ITM system (construction initiated)
- Construct and start-up the commercial scale ceramic wafer and module manufacturing facility (site chosen)
- Conduct process modeling and conceptual design of 2,000 TPD ITM oxygen production plant

RTI Warm Gas Cleanup Project

Previous Testing at Eastman Chemical

RTI Warm Gas Cleanup Technologies

- Cleans multi-contaminants from coal-derived syngas while creating pure sulfur product

High Temperature Desulfurization Process

- > 99.9 % removal of both H₂S and COS (to < 5 ppmv levels)
- > 3,000 hours of operation at 0.3 MWe

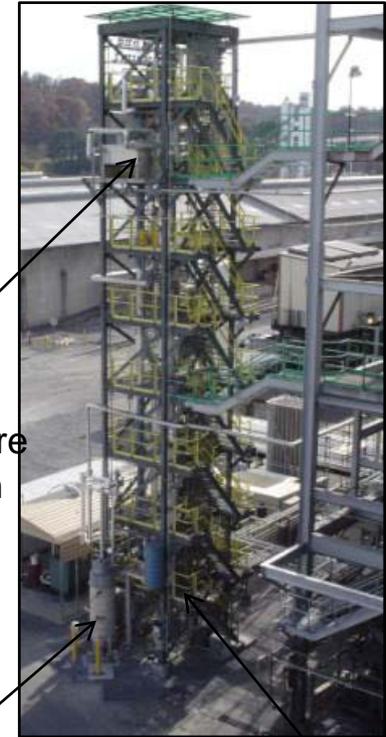
Direct Sulfur Recovery Process

- > 99.8 % SO₂ conversion to elemental sulfur
- 96 % ammonia removal
- 90 % mercury and arsenic removal

High Temperature
Desulfurization
Process

Direct Sulfur
Recovery Process

Multi-contaminant
Control Test System



*Pilot Plant Operation at
Eastman's Gasification Facility,
Kingsport, TN*

RTI Warm Gas Cleanup Project

Scale-up Testing at TECO

Goal: Higher efficiency, ultra clean syngas cleanup

Technology: Highly reactive sorbent in integrated transport reactor system

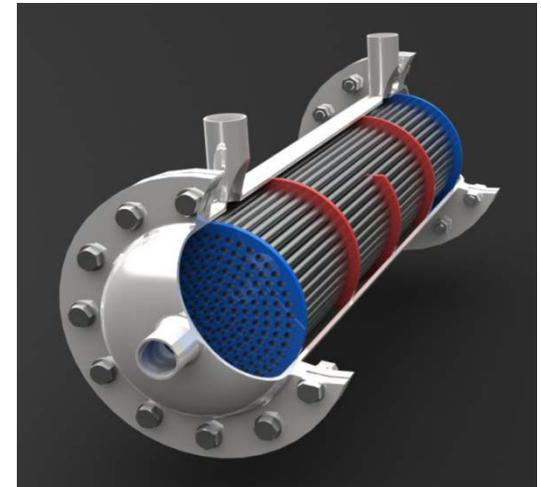
Project tasks (planned completion date 9/30/2015)

- Design and construct a 30-50 MWe prototype system
 - FEED completed
- Operate at commercial conditions
- Optimize water gas shift
- Capture 90% Carbon in syngas, up to 300,000 TPY CO₂, via integration of WGS and aMDEA into process
- Perform CO₂ sequestration with monitoring and verification

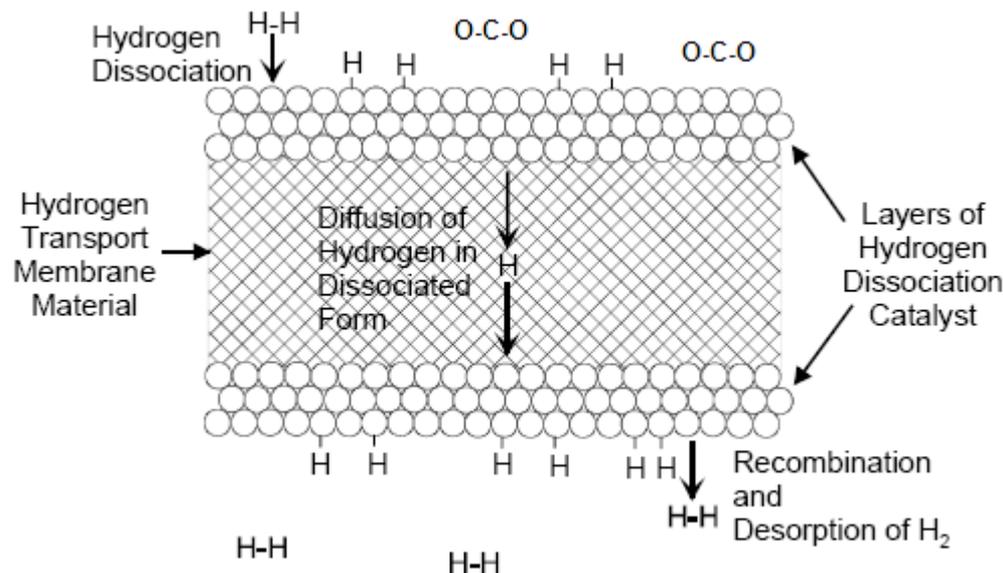
Eltron Hydrogen Transport Membrane

Hydrogen Transport Membrane

- High CO₂ retentate pressure
- Allows capture of high pressure CO₂
- High hydrogen recoveries >90%
- Essentially 100% pure hydrogen
- Low cost, long membrane life



Conceptual design of commercial membrane unit



Eltron Hydrogen Transport Membrane

Goal: Lower cost H₂ separation and CO₂ capture for IGCC

Technology: Dense metal membrane to separate H₂ from shifted syngas, leaving CO₂ at high pressure

Project tasks (planned completion date 9/30/2015)

- Complete testing of lab- and bench-scale units at Eltron (ongoing)
- Complete testing of 5-12 lb/day H₂ production unit using real coal-derived synthesis gas (ongoing)
- Design, construct, and evaluate performance of nominally 250 lb/day prototype development unit
- Design, construct and test a nominally 4-10 TPD pre-commercial module

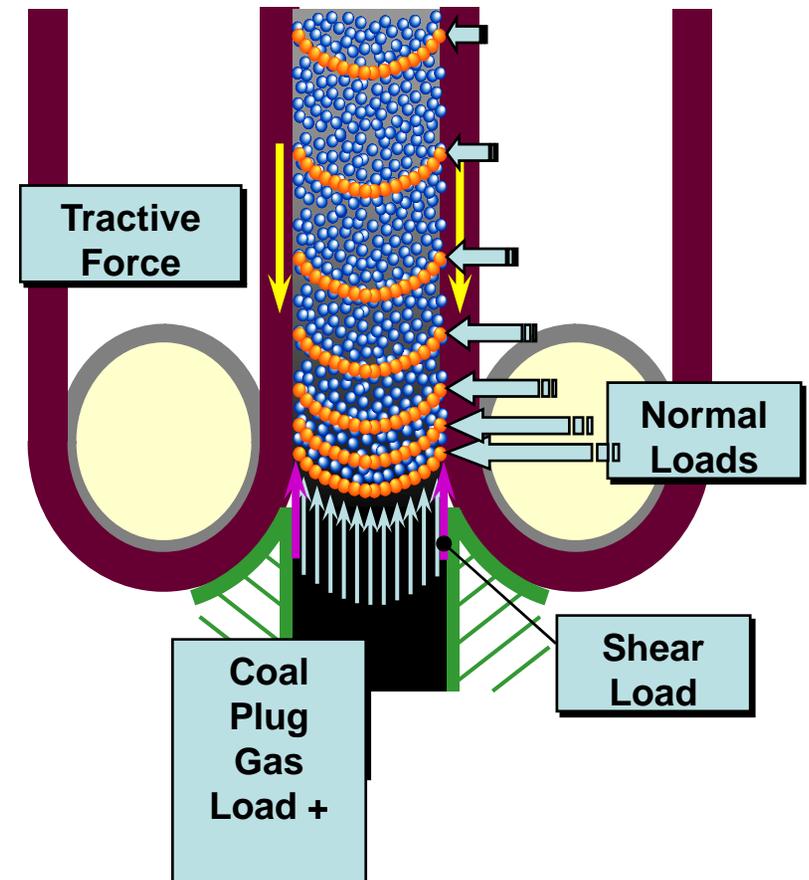
PWR High Pressure Solids Pump

Pump operation relies on ability of bulk solids to form multiple stable “bridges” or arch between parallel wall structure, bridges can support very large loads

Increasing load is transferred to sidewalls, making the bridge more stable, further increasing load will ultimately fail the sidewall

Extrusion or “pumping” occurs when sidewalls are moved mechanically and material is released by separating the walls

In “lock-up” there is no “slip” or relative motion between material and moving walls, device exhibits “positive displacement” with a volumetric displacement of unity



PWR High Pressure Solids Pump

Goal: Reliable and consistent dry feed for high pressure IGCC leading to lower cost

Technology: Bulk solids form multiple stable “bridges” between parallel moving walls to feed dry solids across 1,000+ psi pressure gradient

Project tasks (planned completion date 12/31/2012)

- Complete design and construction of 600 TPD prototype dry solids pump
- Complete performance and durability tests
- Perform pump cost benefit analysis

Reliability, Availability & Maintainability R&D

Recently Awarded Projects

Mitigation of Syngas Cooler Plugging and Fouling (Reaction Engineering International)

- Experimental Testing: Deposit bond strength and characterization
- Modeling: Investigate deposit behavior in the SC section, evaluate process conditions and equipment designs for mitigation of SC plugging/fouling
- Field Test: Validate specific means to implement mitigation methods

Feasibility Studies to Improve Plant Availability and Reduce Total Installed Cost in IGCC Plants (GE)

Work on tasks, with broad applicability to the IGCC industry

- Integrated operations philosophy
- Modularization of gasification/IGCC plant
- Active fouling removal
- Improved slag handling

Low Rank Coal R&D

Recently Awarded Projects

Liquid CO₂ Slurry for Feeding Low Rank Coal (LRC) Gasifiers (EPRI)

Study potential advantages of technology through:

- Techno-economic simulations
- Preliminary design and cost estimate of mixing system

Advanced CO₂ Capture Technology for LRC IGCC Systems (TDA Research)

Demonstrate technical/economic potential for integrated CO₂ scrubber/water gas shift (WGS) catalyst by:

- Optimizing sorbent/catalyst and process design
- Assessing integrated system in bench-scale & slipstream field demo

Scoping Studies to Evaluate the Benefits of an Advanced Dry Feed System on the Use of LRC in IGCC Technologies (GE)

Evaluate and demonstrate benefits by:

- Completing techno-economic studies of IGCC – w/ and w/o dry feeder

Sour PSA for Separation of CO₂, Sulfur, and Impurities from LRC (Air Products)

- Extensive testing in PSA and TSA modes
- Using experimental results to generate a high-level pilot process design
- Techno-economic assessment of applicability for low-rank coal use

NETL Office of Research & Development

Gasification Projects

Refractory Improvement

- Develop improved performance refractory liners that are carbon feedstock flexible (coal, western coal, petcoke)
- Model gasifier slag for refractory interactions, downstream phases and material interactions (syngas coolers)
- Manage slag viscosity and refractory wear, evaluate additives

Conversion and Fouling

- In slagging gasifiers using coal, petcoke or mixtures of them to:
 - Improve the carbon conversion efficiency to syngas
 - Reduce convective syngas cooler fouling
- Collaborate with industry to ensure proper technology development and transfer

NETL Office of Research & Development

Gasification Projects

Low-Rank Coal Optimization

- Pretreatment and kinetic co-feed experimental efforts to support and validate the development of a hierarchy of device scale gasifier models with uncertainty quantification (UQ).
- Demonstrate the models with UQ for the NCCC/TRIG under co-feed conditions and optimize co-feed performance.

Warm Syngas Cleanup

- Conduct both lab and pilot-scale R&D for cost efficient sorbents for trace contaminant capture of high efficiency coal gasification plant

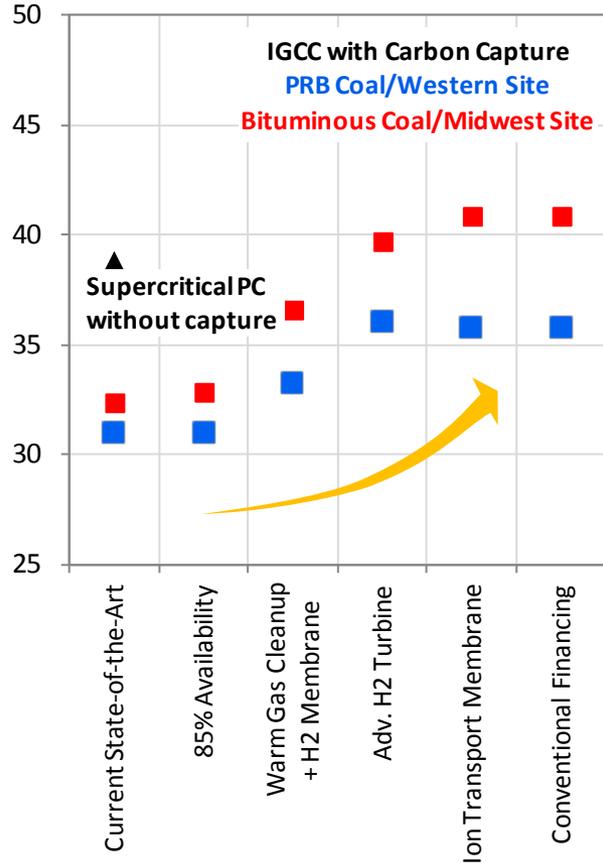
Advanced Virtual Energy Simulation Training And Research (AVESTAR™) Center

- Training Center: 3D virtual simulation of IGCC plant
- Establish the world-class center for addressing key operational and control challenges arising in IGCC plants with carbon capture.

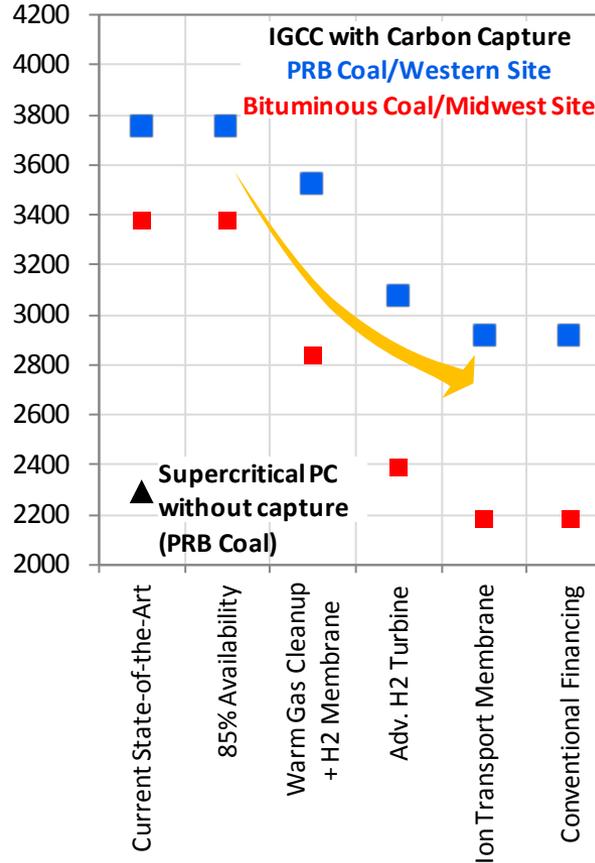
Pathway Study Results

Advanced IGCC Systems

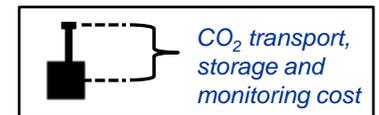
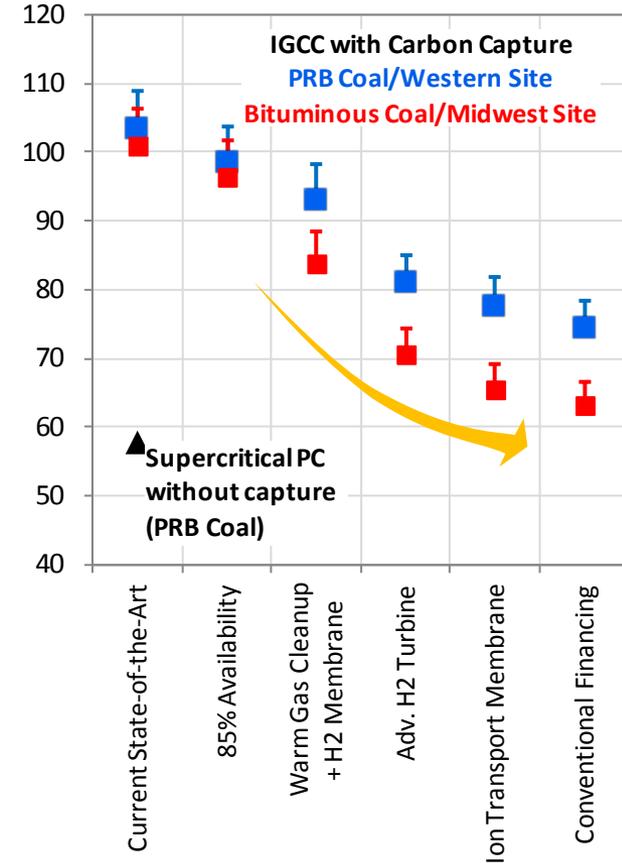
Efficiency (% HHV)



Total Overnight Capital (\$/kW)



First-Year COE (\$/MWh)



Visit NETL Gasification Website

www.netl.doe.gov/technologies/coalpower/gasification/index.html

Google the term “Gasifipedia”



or follow the links from the NETL site’s left-side menu...

Technologies > Coal & Power Systems > Gasification

A screenshot of the NETL website. The top header features the NETL logo (a sunburst with "NETL" inside) on the left, and the text "the ENERGY lab" and "Where energy challenges converge and energy solutions emerge" on the right. A "Site Map" link and a "GO" button are also visible. A left-side navigation menu is highlighted, with "TECHNOLOGIES" selected. Under "TECHNOLOGIES", "Coal & Power Systems" is selected, and "Gasification" is the active page. The main content area shows a breadcrumb trail: "Home > Technologies > Coal & Power Systems > Gasification Systems > Gasifipedia TOC". Below this, the heading "Gasification Gasifipedia" is displayed. The main text describes Gasifipedia as a resource for understanding gasification technology. A "Gasification Highlights" box on the right contains links to "Gasification Systems Program Home Page", "Request Gasification Technologies Information on a CD", "2010 Worldwide Gasification Database", and "Reference Shelf". Navigation arrows and a home button are mentioned in the text.