



Gasification Technologies Advances for Future Energy Plants

Jenny B. Tennant

Technology Manager - Gasification



Gasification Program Goal

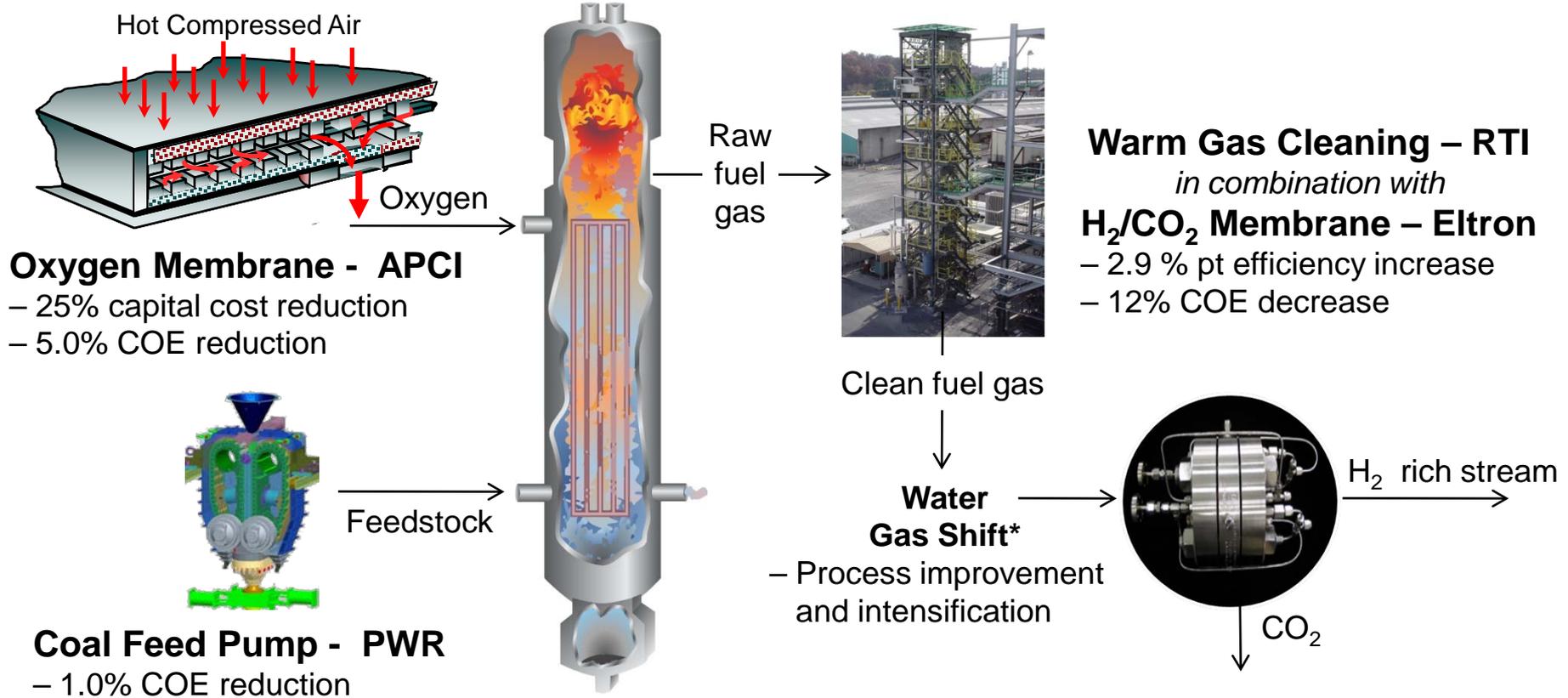
The goal of the Gasification Program is to reduce the cost of electricity, while increasing power plant availability and efficiency, and maintaining the highest environmental standards

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

Dr. Steven Chu, Secretary of Energy
November 2010

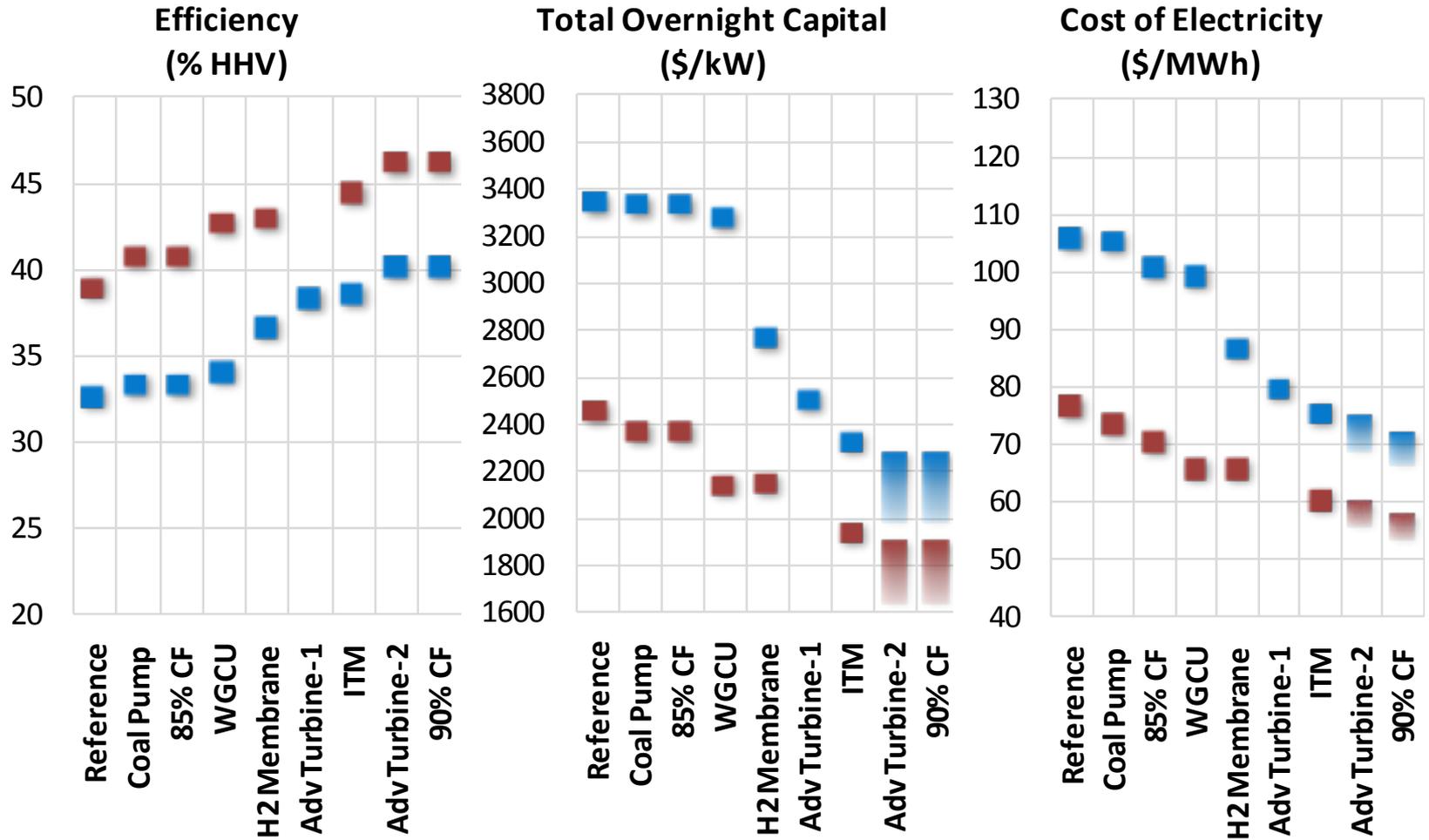


Key Gasification R&D Areas



Advanced Gasification	
Low-rank Coal	Improve RAM
Alternative Feedstocks	– Refractory durability
– Energy security	– Feed system reliability
– Carbon footprint reduction	– Heat removal/integration
	– Temperature control & measurement
	– Dynamic simulator
	– CFD gasifier modeling
	– Slag model development

Advanced IGCC Technologies Pathway



Advanced IGCC Pathway: Cumulative incorporation of advanced technologies

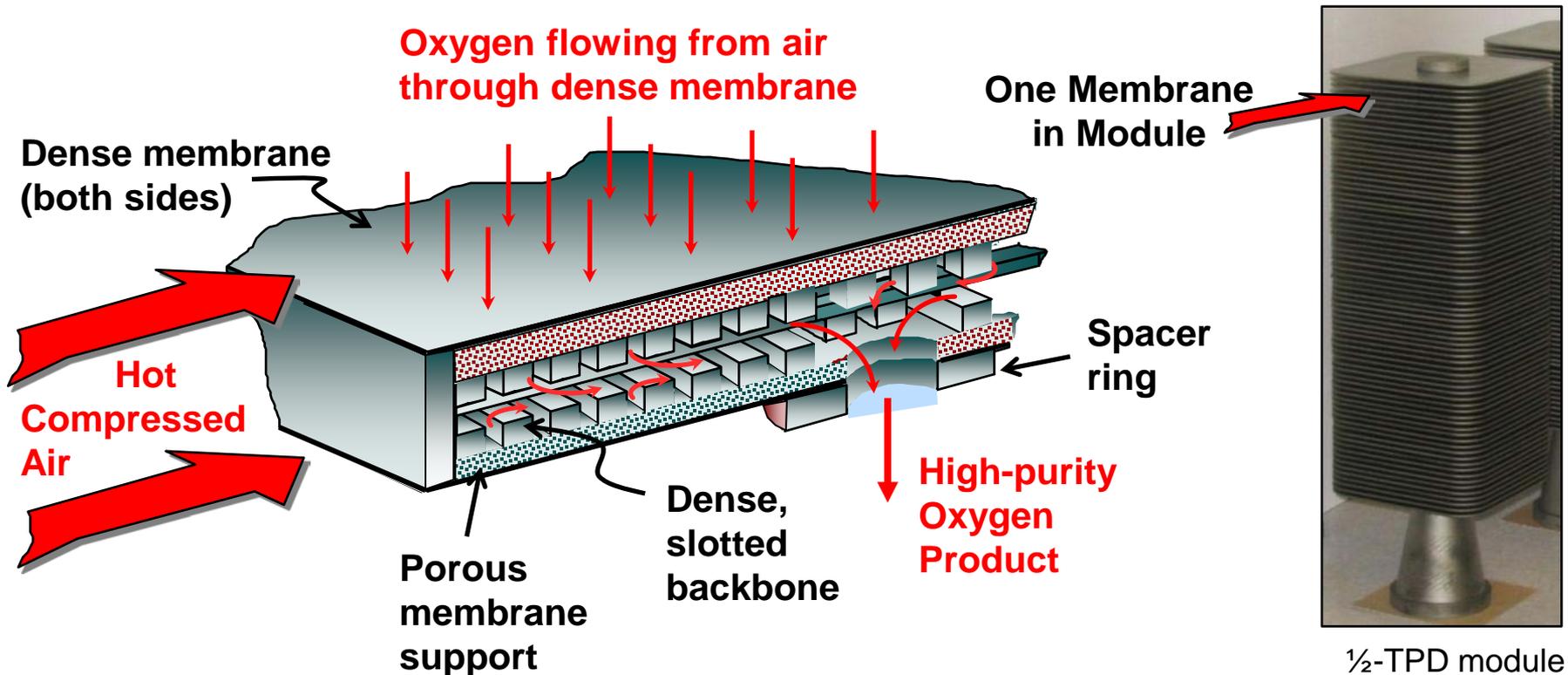
- Carbon Capture
- Non-capture

CF = capacity factor WGCU = warm gas cleanup ITM = ion transport membrane IGFC = integrated gasification fuel cell

ITM Oxygen Membrane Technology

ITM Oxygen membranes

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



Ion Transport Membranes

Air Products and Chemicals, Inc

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 (ongoing)
- Construct 100 TPD pilot system to demonstrate integrated operability and performance of ITM system, construction to initiate in FY2011 (design and most procurements complete)
- Construct and start-up the 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

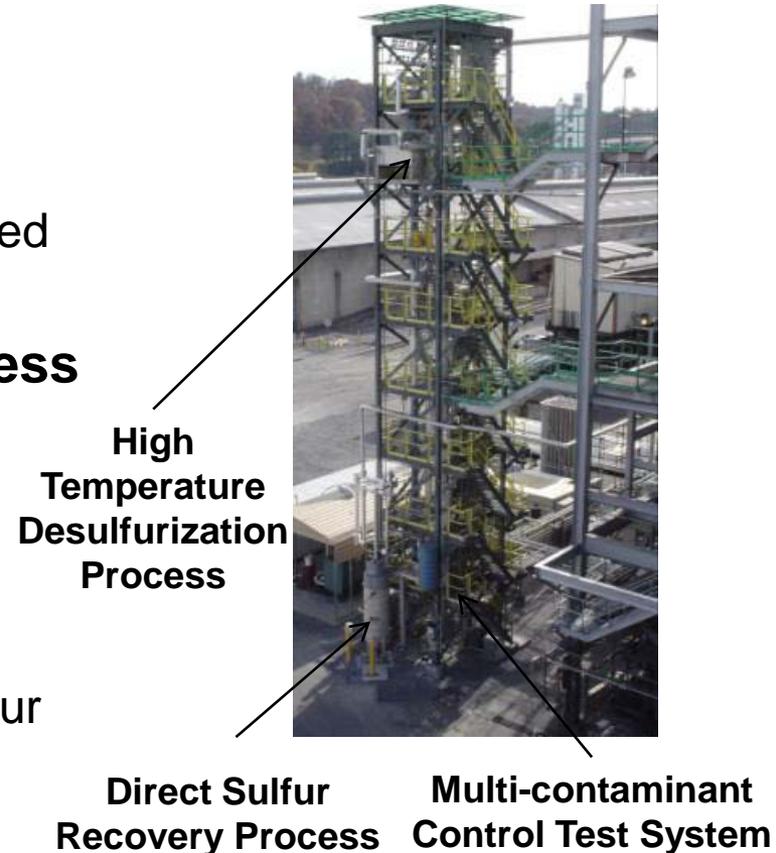
- Cleans multi-contaminants from coal-derived syngas while creating pure sulfur product

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



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

Scale-up of Warm Syngas Cleanup

RTI International

Goal: Higher efficiency, ultra clean syngas cleanup

Technology: Highly reactive sorbent in integrated transport reactor system

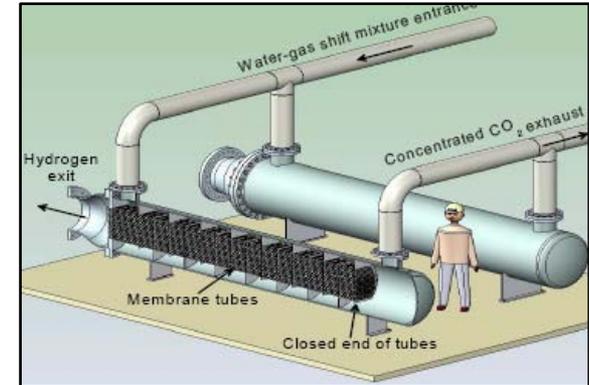
Project tasks (planned completion date 9/30/2015)

- Design and construct a 30-50 MWe prototype system (FEED ongoing)
- Operate at commercial conditions
- Optimize water gas shift
- Remove up to 300,000 TPY CO₂ using aMDEA
- Perform CO₂ sequestration with monitoring and verification

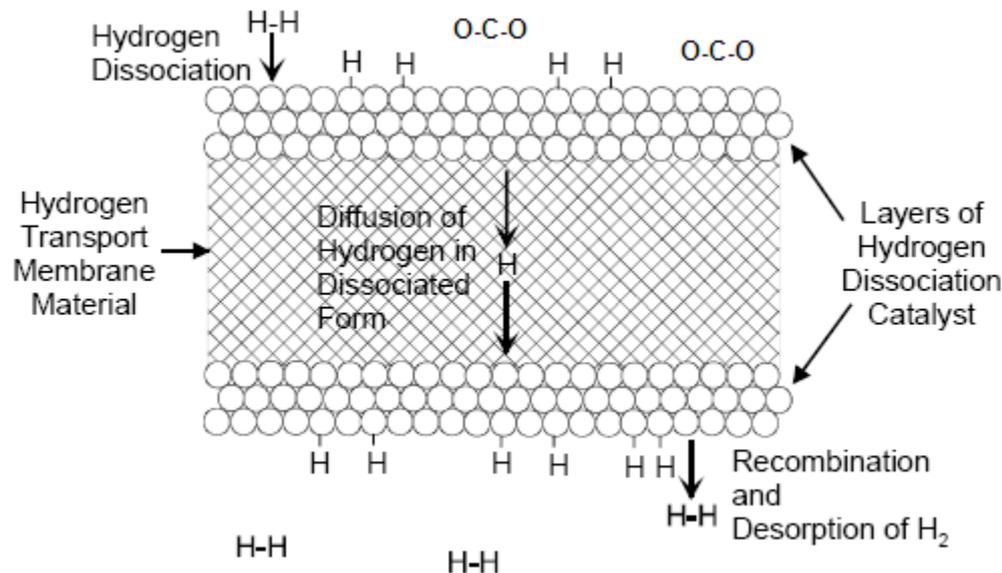
ELTRON Hydrogen Transport Membrane

Eltron Hydrogen Membrane

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



Commercial membrane unit conceptual design



Scale-up of Hydrogen Transport Membranes

Eltron Research & Development, Inc

Goal: Lower cost H₂ separation and CO₂ capture for IGCC

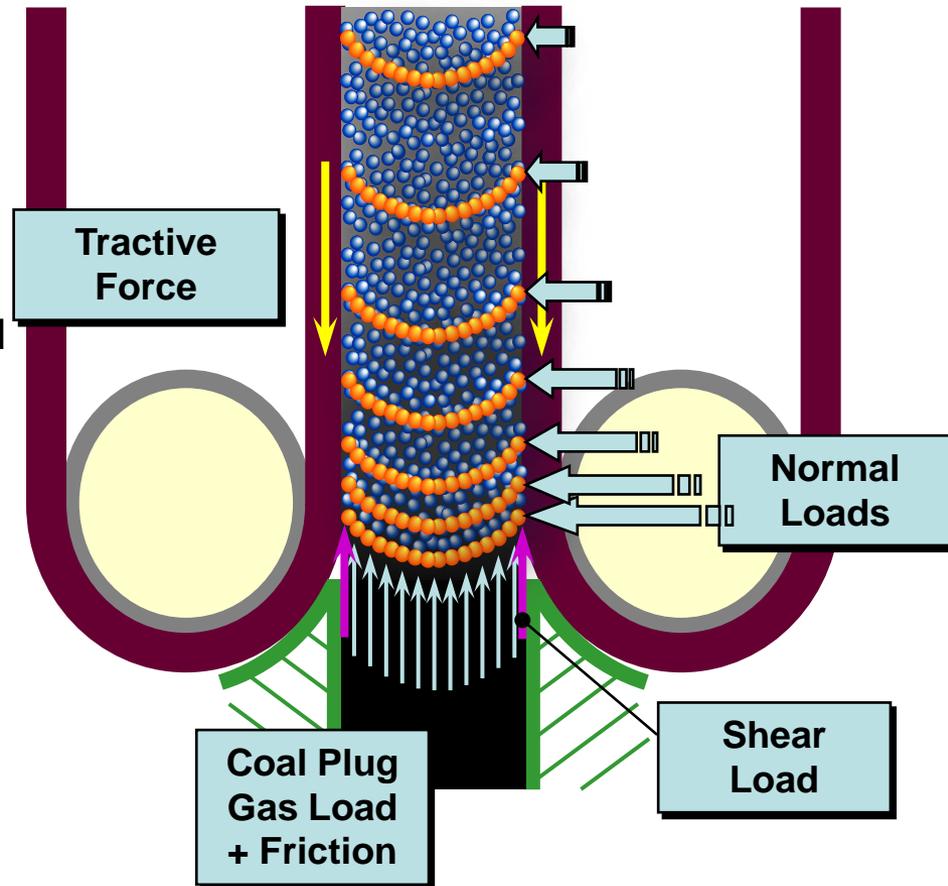
Technology: Dense metal membranes to separate H₂ from shifted syngas leaving CO₂ at high pressure

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

- Complete testing of 1.5 lb/day test unit at Eltron (ongoing)
- Complete testing of 12 lb/day unit at Eastman using real coal-derived synthesis gas (ongoing)
- Construct and test 250 lb/day unit at Eastman, construction to begin FY11
- Design, construct and test 4-10 TPD facility

Solids Pump Theory of Operation

- 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
- Material between walls is in “lock-up” condition
- 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



High Pressure Solids Pump

Pratt & Whitney Rocketdyne

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

AVESTAR™ Center

Advanced Virtual Energy Simulation Training And Research

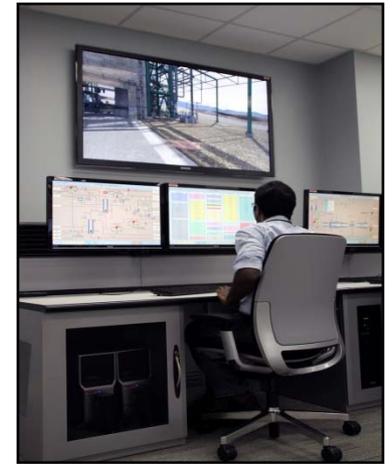
R&D, training, and education for the operation and control of advanced energy systems with CO₂ capture and storage

Real-time dynamic simulators with Operator Training System (OTS) capabilities

3D virtual Immersive Training Systems (ITS)

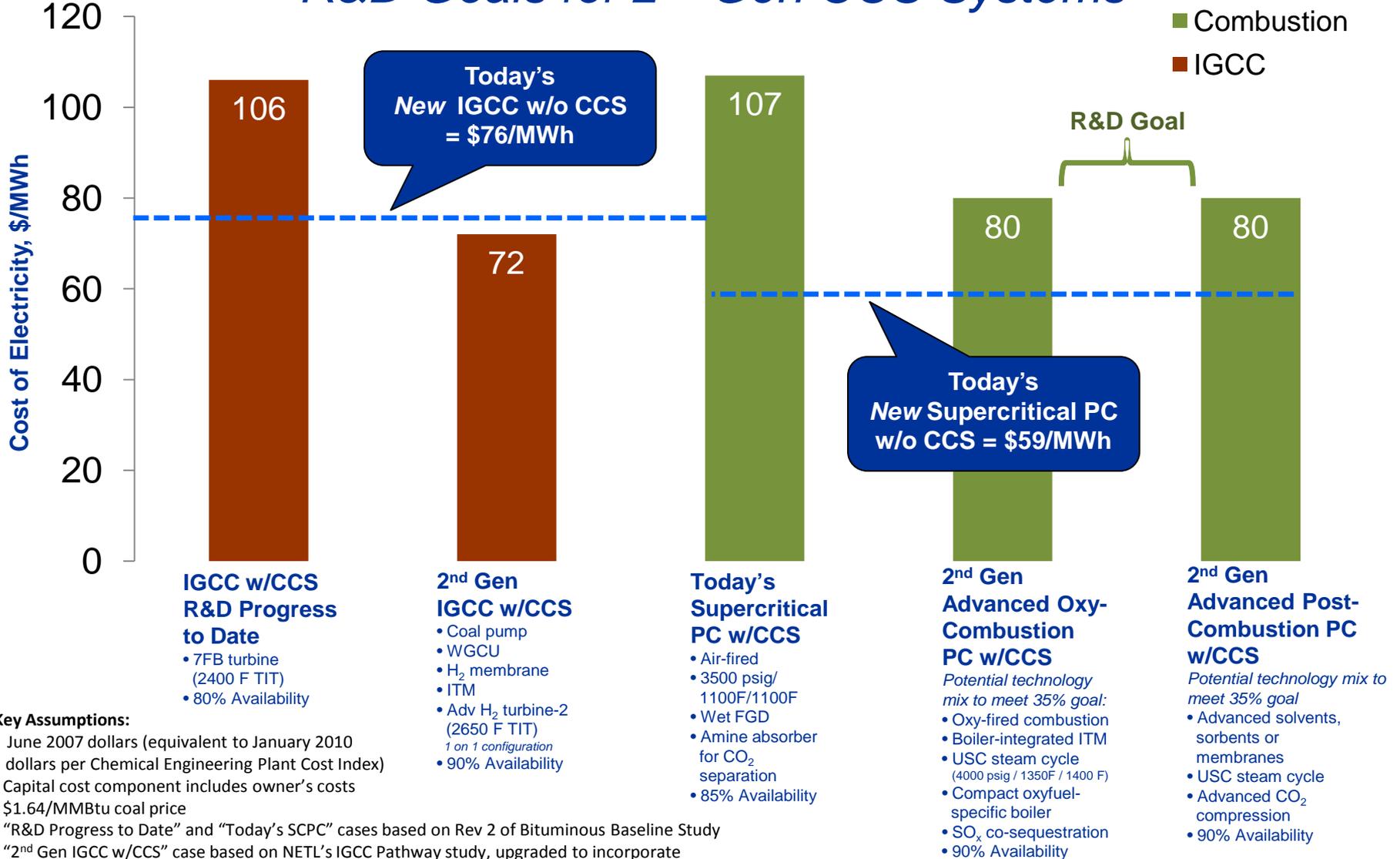
Benefits

- OTS for normal and faulted operations as well as plant start-up, shutdown, and load following/shedding
- ITS for added dimension of plant realism
- OTS/ITS for training both control room and plant field operators, promoting teamwork
- Work force development in IGCC plant and CO₂ capture operations
- Advanced R&D in process dynamics, model predictive control, sensors, RT optimization, 3D virtual plants, and more



New Plants

R&D Goals for 2nd Gen CCS Systems



Cost of Electricity

NETL IGCC Baseline Studies

	PRB mine mouth				lignite mine mouth		bituminous delivered *		
Elevation (ft)	3400				1900		0		
Gasification Technology	TRIG	CP	Shell	Siemens	Shell	Seimens	GE	CP	Shell
CO ₂ Capture	83%	90%			90%		90%		
COE (\$/MWh)	105	112	120	122	122	124	106	110	119

* Coal cost includes additional 25% for transportation

Gasification Funding Opportunity Announcement

Review Underway

Advanced Gasification: Improvements in Existing Systems Availability, Novel CO₂ Utilization Systems, and Low Rank Coal IGCC Optimization

Topic Areas

- Novel gasification technology exploiting the availability of (pressurized) CO₂ within the gasification plant
- Scoping studies for novel low rank coal IGCC technologies
- Gasification plant availability and cost improvements

NETL's Program Analysis Support

On-going and Planned Gasification Studies

Cost and Performance Baseline for TRIG™ Air Blown IGCC

IGCC with CCS Pathway Study: Low Rank Coal

IGCC availability studies

- Identifying gaps for conventional technologies
- Setting targets for advanced technologies

Coal-biomass IGCC feasibility study

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's Gasification page. The page features a dark blue header with the NETL logo and the text "the ENERGY lab" and "Where energy challenges converge and energy solutions emerge". A navigation menu on the left side is highlighted, with "TECHNOLOGIES" selected. Under "TECHNOLOGIES", the "Gasification" link is circled in red. The main content area displays the "Gasification Gasifipedia" section, which includes a description of the resource and a "Gasification Highlights" box containing three links: "Request Gasification Technologies Information on a CD", "2010 Worldwide Gasification Database", and "Reference Shelf". The "Request Gasification Technologies Information on a CD" link is also circled in red. At the bottom of the page, there is a disclaimer: "Gasifipedia is for informational purposes only. Disclaimer".