Update on IGCC Technology and Projects

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CH2M HILL, Inc.

McIlvaine Hot Topic Hour

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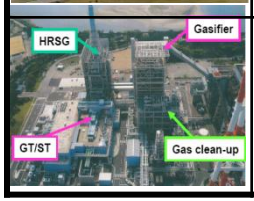
Topics

- Update on operating IGCC plants
- IGCC technology design enhancements
- Status of new IGCC projects
- Environmental performance
- CO_2 capture for IGCC
- Hybrid IGCC technology

Coal-based IGCC Power Plants

	Company	Facility	Location	Feedstock	Gasifier Technology	MW, net
	Nuon	Willem-Alexander Centrale	Buggenum, Netherlands	coal/biomass	Shell	253
	SG Solutions	Wabash River	W. Terre Haute, IN	coal/coke	Conoco Phillips	262
	Tampa Electric	Polk Power Station	Mulberry, FL	coal/coke	GE Energy	252
	ELCOGAS	Puertollano	Puertollano, Spain	coal/coke	Prenflo	260-280
	Multiple Japanese Utilities; MITI; CRIEPI	Clean Coal Power R&D Co.	Nakoso, Japan	coal	MHI	220

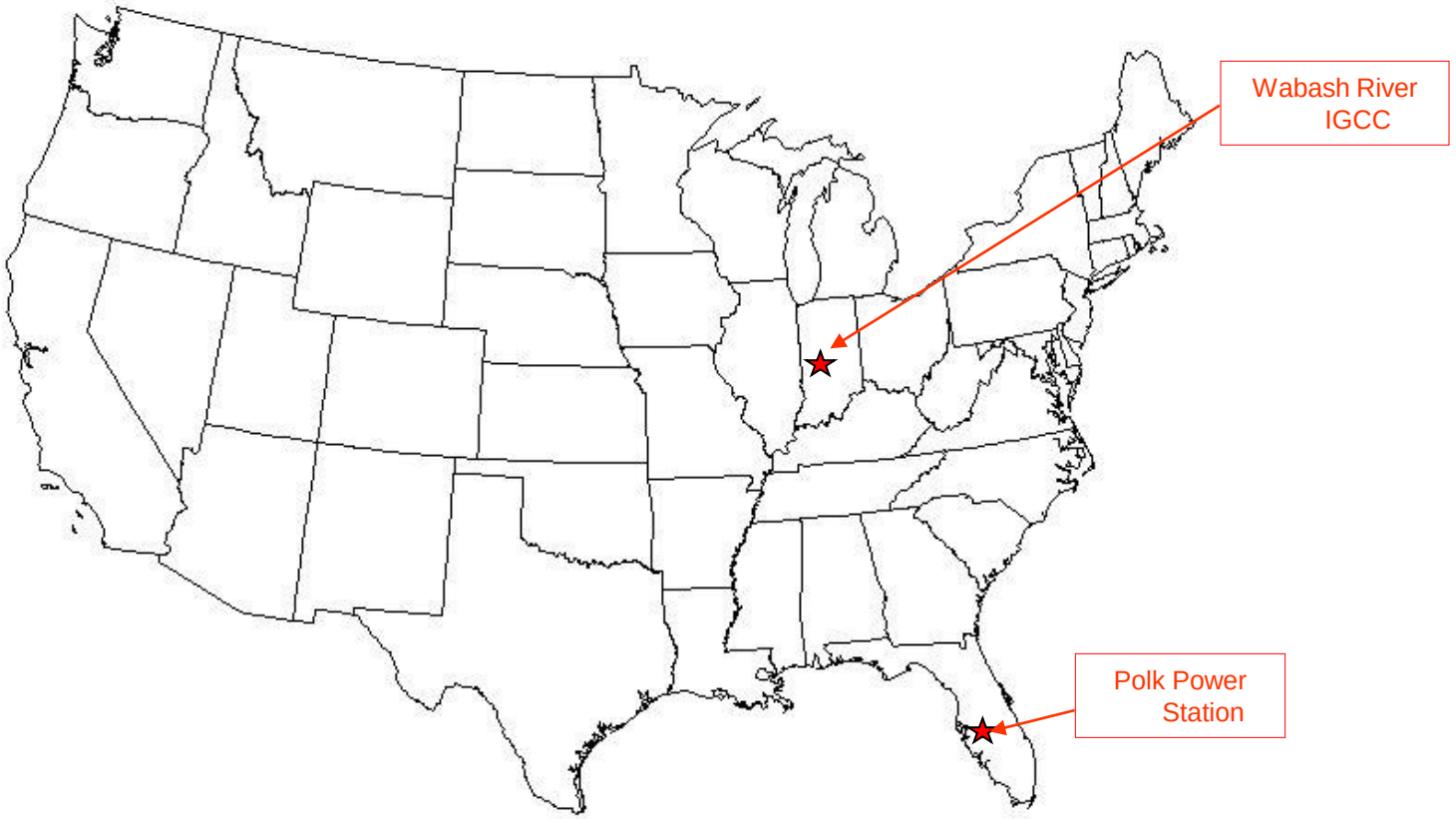
IGCC Plant Availability

- First generation of coal-based IGCC plants have only one gasification train
- 4-5 years of operation to reach availability goals
- Peak availability for one-train units is ~80%
- New IGCC designs: two 50% trains expected to provide ~85% availability for new fleet of IGCC units
  - Achieve availability goals much sooner

Design Enhancements for New IGCC Fleet

- Improvements to gasifier refractory
- Better gasifier “burners”
- Use of more corrosion resistant piping (chlorides)
- Slag char recycle to improve overall conversion/efficiency
- Sparing and sizing of major systems
  - 2x50% size gasification trains
- Air integration between gas turbine and ASU
- Higher % sulfur removal
- Mercury removal
- Adaptation of CO_2 capture technologies to IGCC
- Hydrogen-fired gas turbines

Operating IGCC Plants in the U.S.



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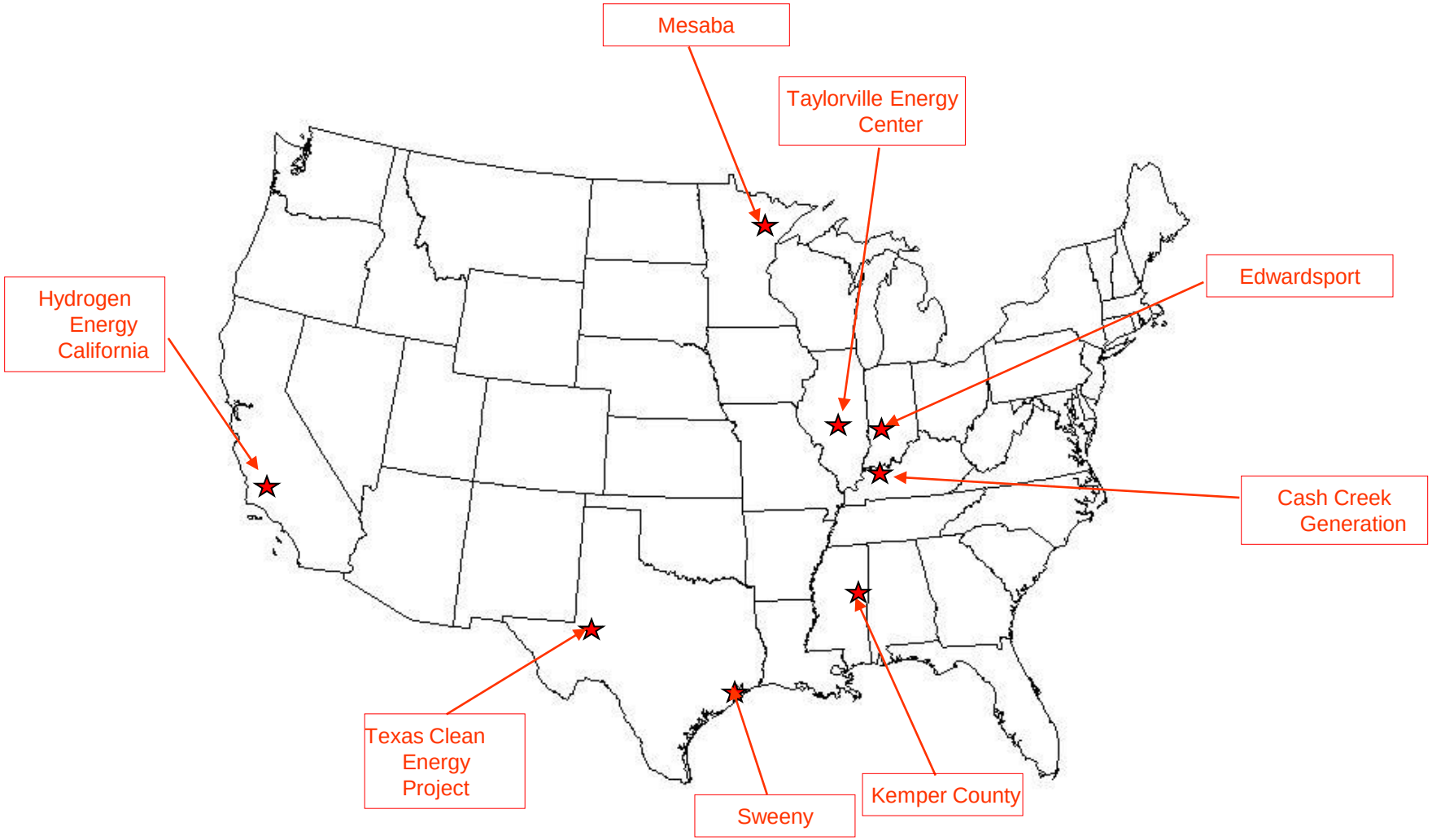
IGCC Projects Under Development in the U.S.



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IGCC Project Status

Project	Project Developer	Gasification Technology	Location	Status
Cash Creek Generation	Green Rock Energy/GE Energy Financial/ERORA	GE	Owensboro, KY	Permits for hybrid IGCC issued but under appeal
Edwardsport IGCC	Duke Energy Indiana	GE	Edwardsport, IN	~40% construction completed (July 2010)
Hydrogen Energy California	Hydrogen Energy (BP and Rio Tinto)	GE	Tupman, CA	Applications under review by California Energy Commission and state/local agencies
Kemper County IGCC	Mississippi Power Co.	TRIG™	Liberty, MS	Air permit received Mar. 2010; approval of project cost target by MPSC.
Mesaba Energy Project	Excelsior Energy, Inc.	Conoco Phillips E-Gas™	Taconite, MN	Certification issued by state of Minnesota. Final EIS issued by DOE.
Sweeny IGCC	ConocoPhillips	Conoco Phillips E-Gas™	Old Ocean, TX	Air permit application submitted Feb. 2010
Taylorville Energy Center	Christian County Generation, LLC (Tenaska and MDL Holdings)	Siemens	Taylorville, IL	FEED study during 2009 for hybrid IGCC. New air permit application submitted for hybrid IGCC April 2010.
Texas Clean Energy Project	Summit Power	Siemens	Odessa, TX	Air permit application submitted April 2010. FEED started July 2010.

Duke Energy Indiana
Edwardsport IGCC – Under Construction

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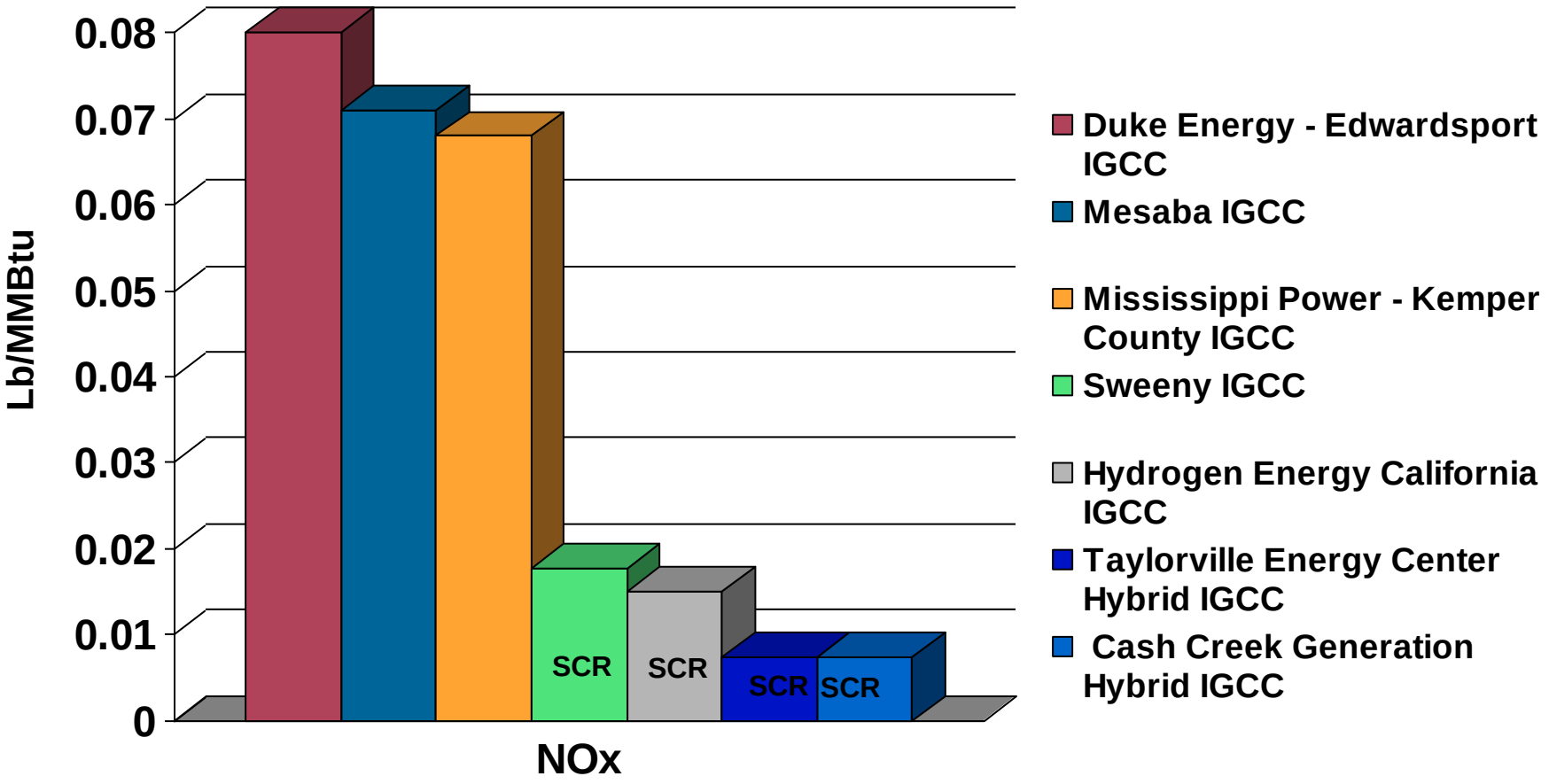
NOx Emission Rate Comparison
Gas Turbine Heat Input Basis



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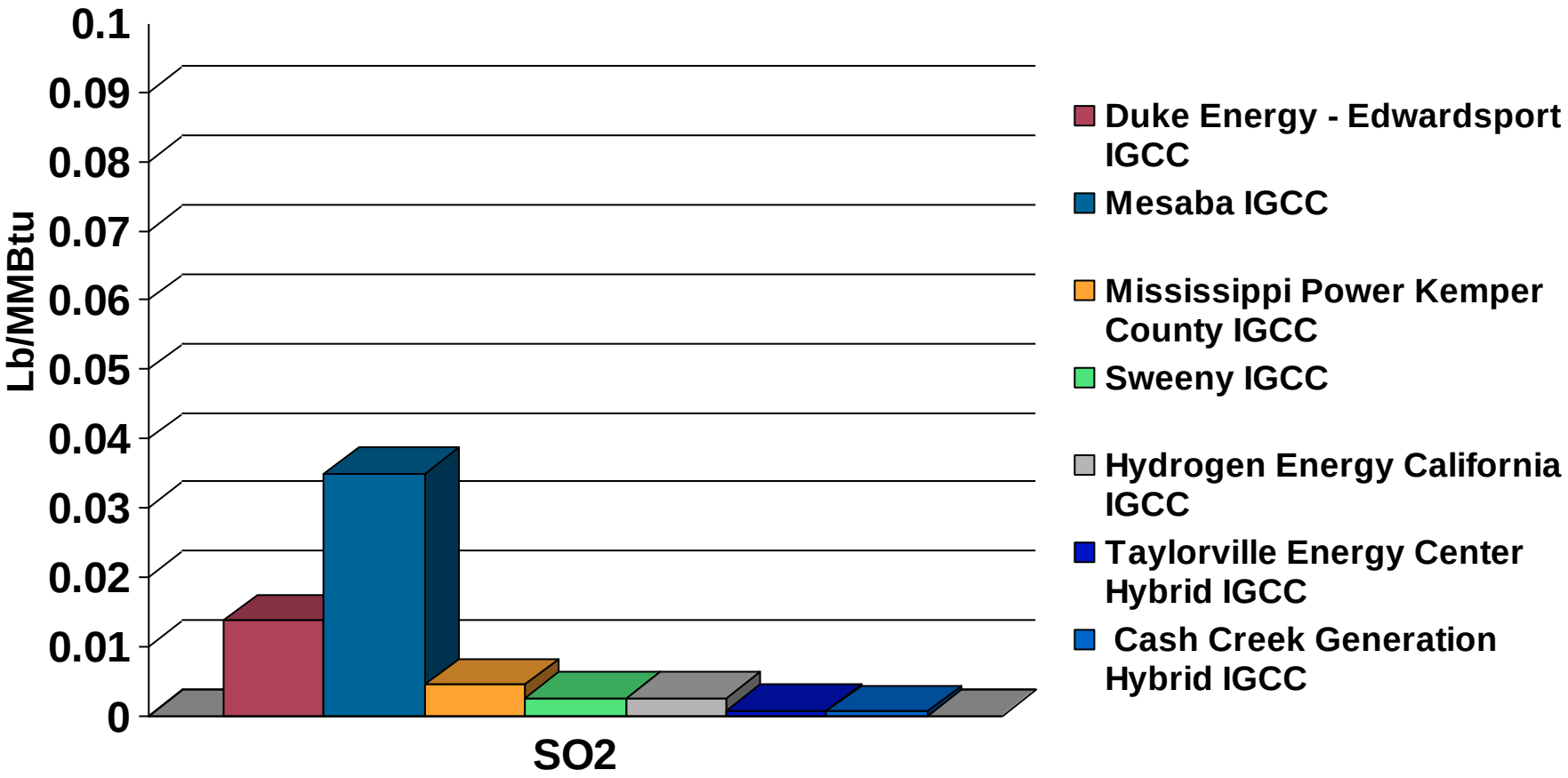
SO_2 Emission Rate Comparison Gas Turbine Heat Input Basis



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Mercury Removal

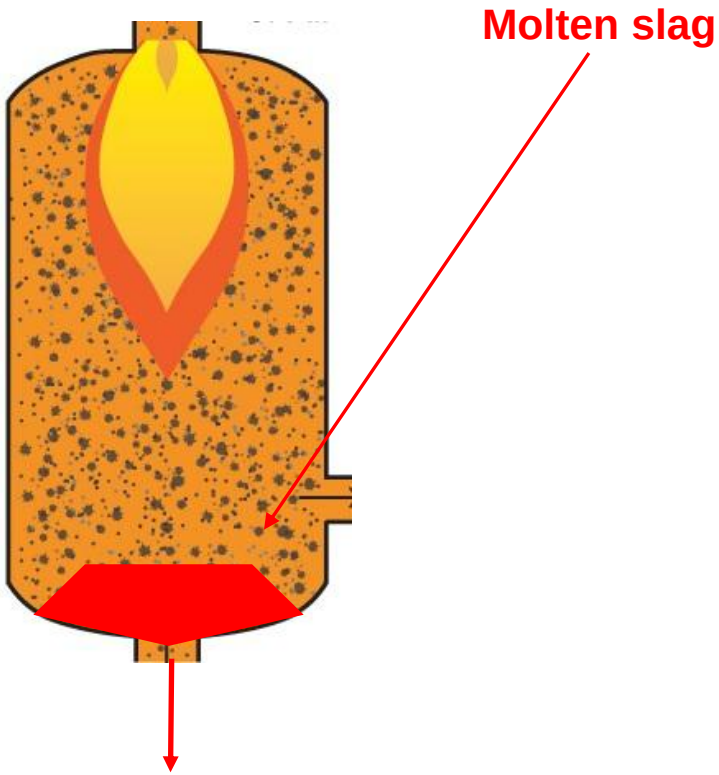
- Pre-sulfided activated carbon beds
- >94% removal of vapor-phase mercury at Eastman Chemical
- Spent carbon disposed of in drums
- Proposed IGCC plants will use this technology

Source: Eastman Chemical

Byproducts

Slag

- Ash is removed in molten form, then quench-cooled to form glassy, inert slag



Slag Use

- Used for making
  - Cement
  - Asphalt filler
  - Roofing shingles
  - Sand-blasting grit

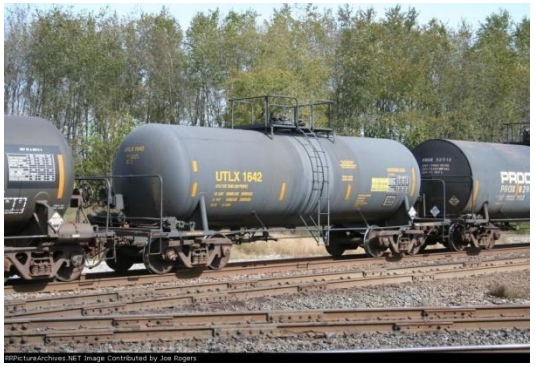
Gasification Slag is Different

- It is not regulated as a “coal combustion byproduct”
  - Gasification is not combustion
- It has a Bevill waste exemption from Subtitle C (hazardous wastes), as a “mineral processing waste”
  - Feedstock must be ≥50% coal to qualify
- EPA’s proposed “coal ash rule” does not apply to coal gasification slag/ash

Liquid Byproducts

- Sulfur
  - Recovered in molten form
  - Transported by rail or truck

- Sulfuric acid
  - Various concentrations can be produced, depending on local markets
  - Transported by rail or truck



CO_2 Capture Technology for IGCC

- IGCC does not "inherently" capture CO_2
- Capturing CO_2 requires extensive addition of equipment
  - increase in capital and O&M expense
  - decrease in unit output and efficiency
- Technologies proven in coal gasification plants will be applied to many new IGCC plants

CO_2 Capture - Water Shift Reaction

- Concentration of CO_2 in IGCC syngas is 2-14%
- By adding steam to the syngas, over a catalyst bed:

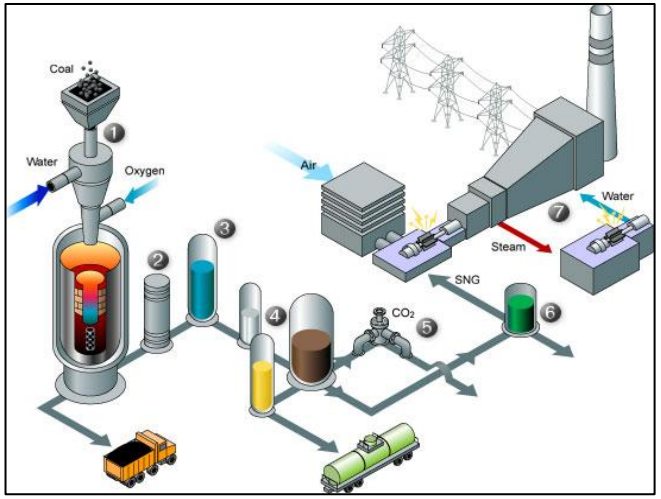
- The CO_2 can then be efficiently removed from the syngas prior to combustion in the gas turbine
- A commercially proven process used in refineries and chemical plants
- Resulting syngas has high H_2 content

Hybrid IGCC – an Option for IGCC with CO_2 Capture

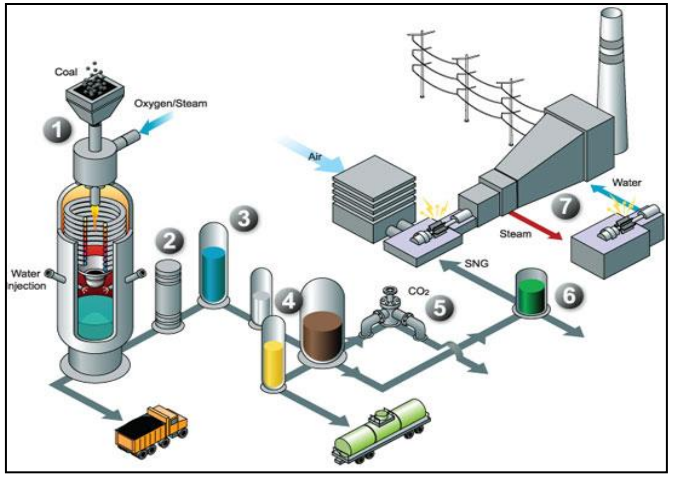
- Produce “normal” syngas in gasification area
- Use water shift reaction to produce higher concentration of H_2
- Capture the CO_2 from the syngas
- Methanate the shifted syngas to SNG
- Combust SNG in conventional NGCC or send to pipeline for sale
- Compress the CO_2 for sequestration or use in enhanced oil recovery

Hybrid IGCC Projects

- Cash Creek Generation
  - GE technology



- Taylorville Energy Center
  - Siemens technology



Sources: Taylorville Energy Center; Cash Creek Generation

Summary

- 16 years of improving IGCC operating experience worldwide
- Lessons learned have become design enhancements for higher efficiency, higher availability and improved environmental performance
- New fleet of units in development and construction
- Environmental advantages for coal-based IGCC
- CO_2 capture technologies being applied to new IGCC units

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