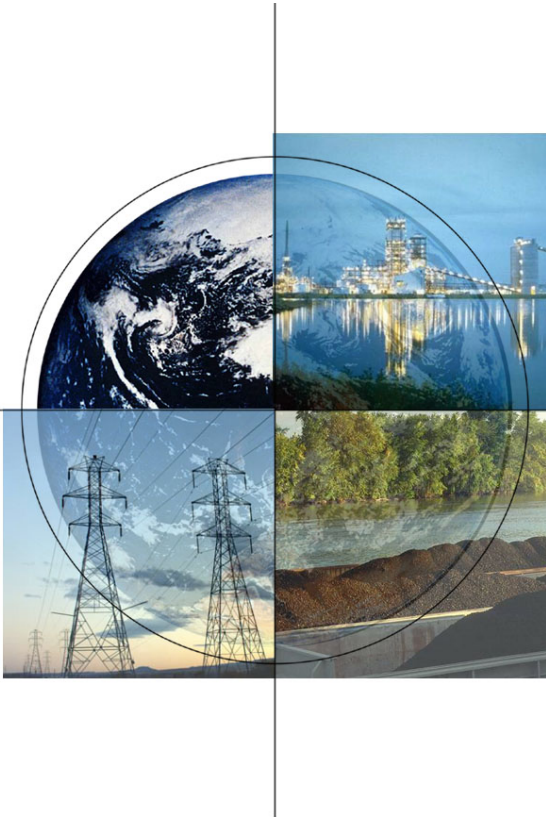


Power Plant Water Usage and Loss



*Workshop on Gasification
Technologies*

Denver, Colorado

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Fossil Energy Power Plant Water Study

-Cases Included-

Pulverized Coal

- Subcritical

- Supercritical

Integrated Gasification Combined Cycle

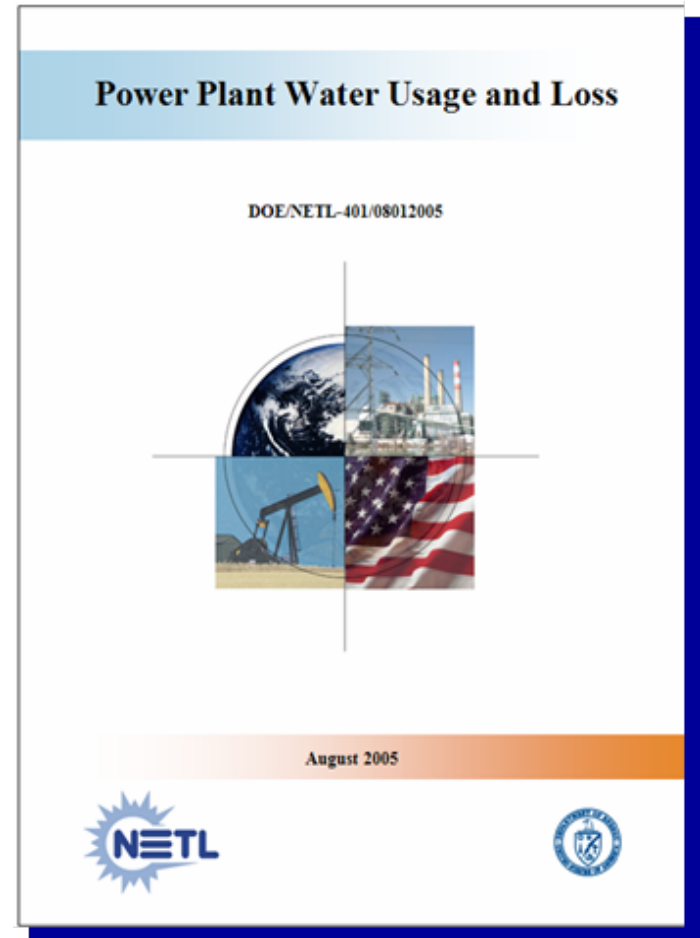
- ConocoPhillips E-Gas™

- GE Energy Radiant-Convective

- GE Energy Quench

- Shell

Natural Gas Combined Cycle



Study Objectives

- 1. To compare water usage and losses for IGCC, PC and NGCC power plants on a common basis**
 - Evaluate current usage and loss issues
- 2. Develop a methodology and ‘water accounting system’ to enable credible assessment of water usage and loss in all future power plant studies**

Assumptions

Site Characteristics	
Location	Mid USA
Elevation	500 ft
Design Air Pressure	14.4 Psia
Design Temperature	63°F
Relative Humidity	55%
Transportation	Rail Access
Water	Municipal (on-site)
Ash Disposal	Off-site

Pittsburgh #8 Coal Ultimate Analysis	
	As Rec'd (weight %)
Carbon	69.36
Hydrogen	5.18
Nitrogen	1.22
Sulfur	2.89
Ash	9.94
Oxygen	11.41
HHV (Btu/lb)	12,450

Cooling System	
Closed recirculating, evaporative mechanical draft cooling towers	
Dry bulb max. ambient temperature (°F)	89
Wet bulb max. ambient temperature (°F)	75
Cooling tower approach (°F)	5
Cooling tower range (°F)	25
Cold circulating water to condenser (°F)	80
Hot circulating water from condenser (°F)	105
Cooling tower drift (% of CW flow rate)	0.01%



Defining Water Usage and Water Loss

Water Usage

Total amount of water to be supplied from local water resources to provide the needs for the plant

cooling tower makeup

condenser makeup

slurry preparation makeup

ash handling makeup

syngas humidification

quench system makeup

FGD system makeup

Water Loss

Overall “loss” of water to the environment

process

evaporative

flue gas

“Other” Water Inputs to System

fuel water content

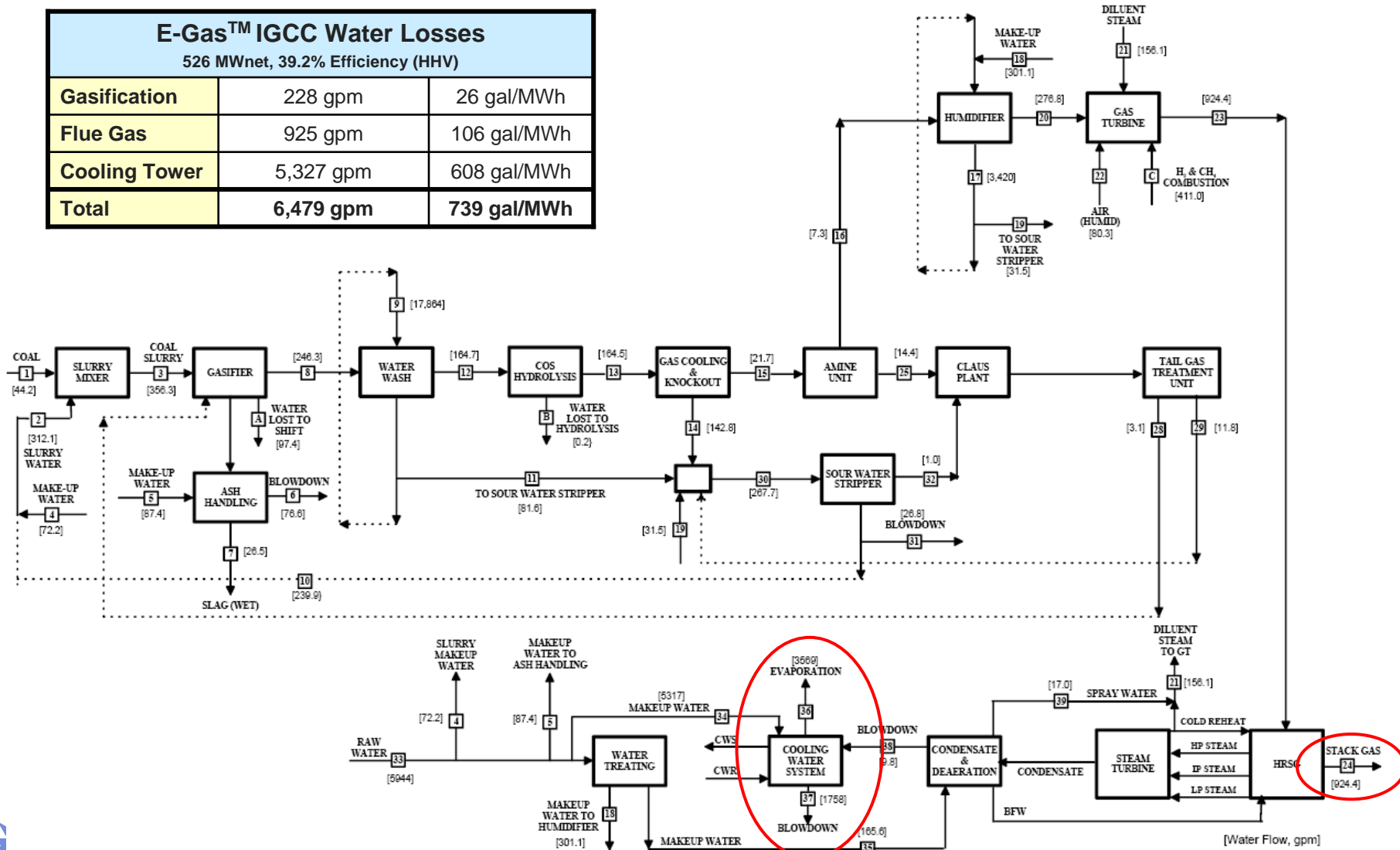
humid air intake

gasification/combustion reactions

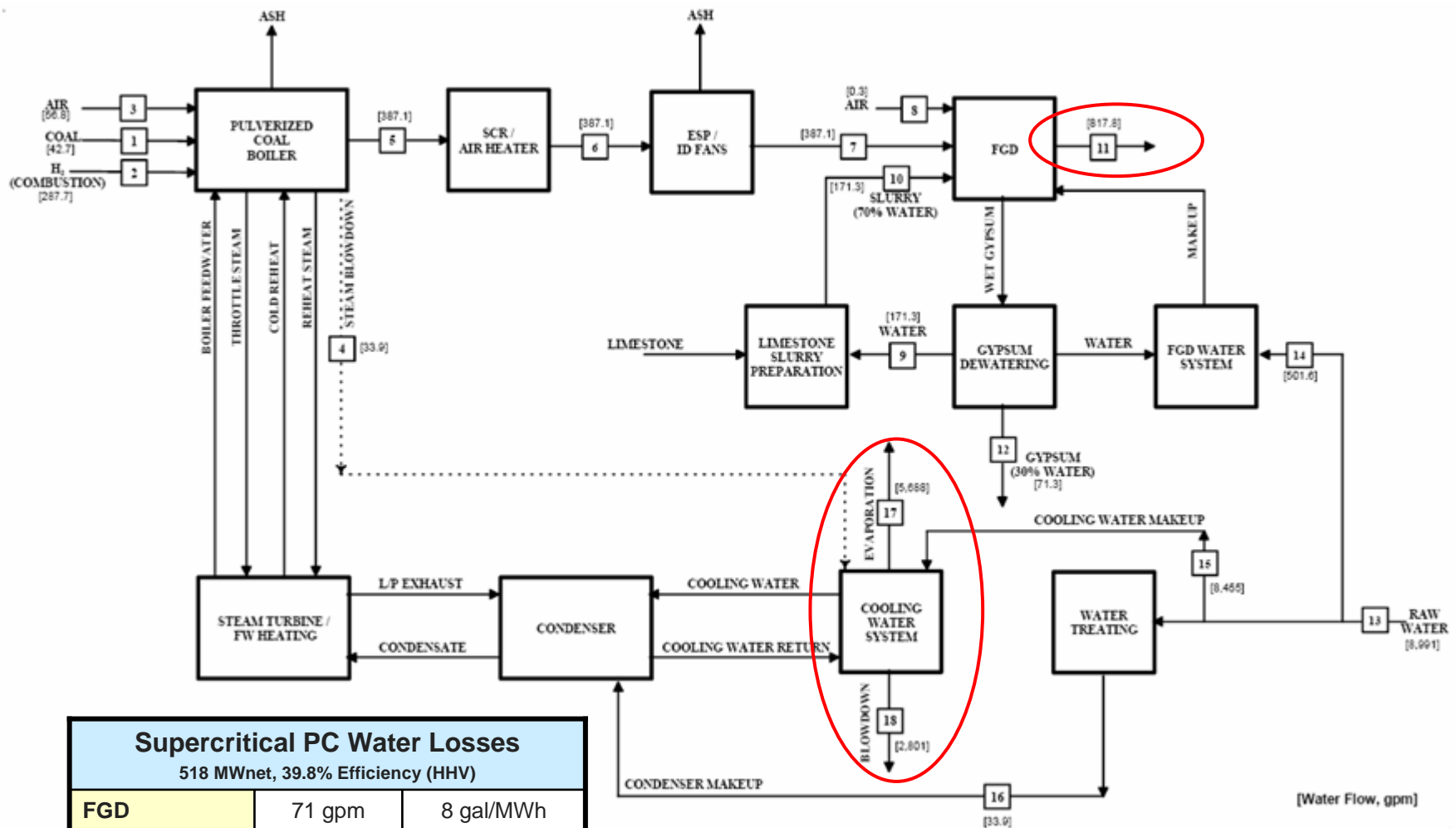


IGCC (E-Gas) Water Balance

E-Gas™ IGCC Water Losses		
526 MWnet, 39.2% Efficiency (HHV)		
Gasification	228 gpm	26 gal/MWh
Flue Gas	925 gpm	106 gal/MWh
Cooling Tower	5,327 gpm	608 gal/MWh
Total	6,479 gpm	739 gal/MWh



Supercritical PC Water Balance

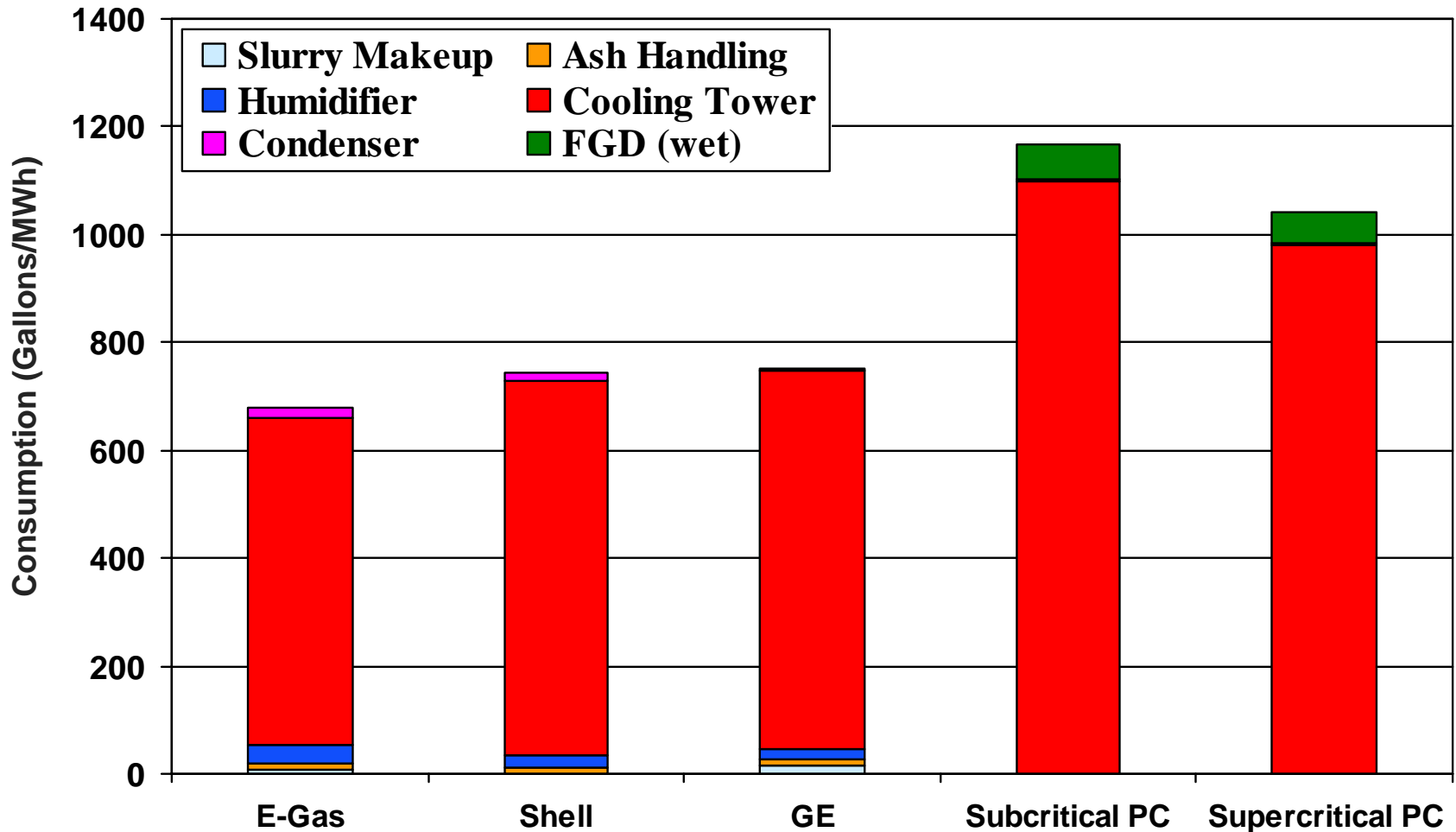


Supercritical PC Water Losses		
518 MWnet, 39.8% Efficiency (HHV)		
FGD	71 gpm	8 gal/MWh
Flue Gas	818 gpm	95 gal/MWh
Cooling Tower	8,489 gpm	984 gal/MWh
Total	9,379 gpm	1,087 gal/MWh



Representative Water Requirements

Coal Based Power Generation w/o CO₂ Capture



Note: Cost and performance impacts based on nominal 500 MW net output baseline plant with mechanical draft wet cooling towers

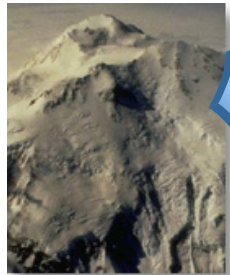
Reference: Klett, M.G. et. Al, Power Plant Water Usage and Loss Study, Prepared for DOE/NETL by Parsons Corporation, August 2005



Carbon Sequestration

An Important Option to Address Climate Change

Direct



Unmineable
Coal Seams



Capture and
Disposal of CO₂



Deep Ocean
Injection



Depleted Oil /
Gas Wells,
Saline Aquifers



Modeling and
Assessments

Indirect



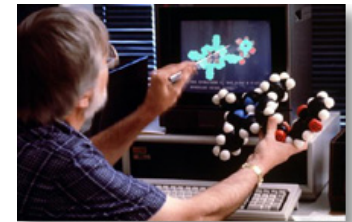
Enhancing
Natural CO₂ Sinks



Forestation



Iron or Nitrogen
Fertilization of
Ocean

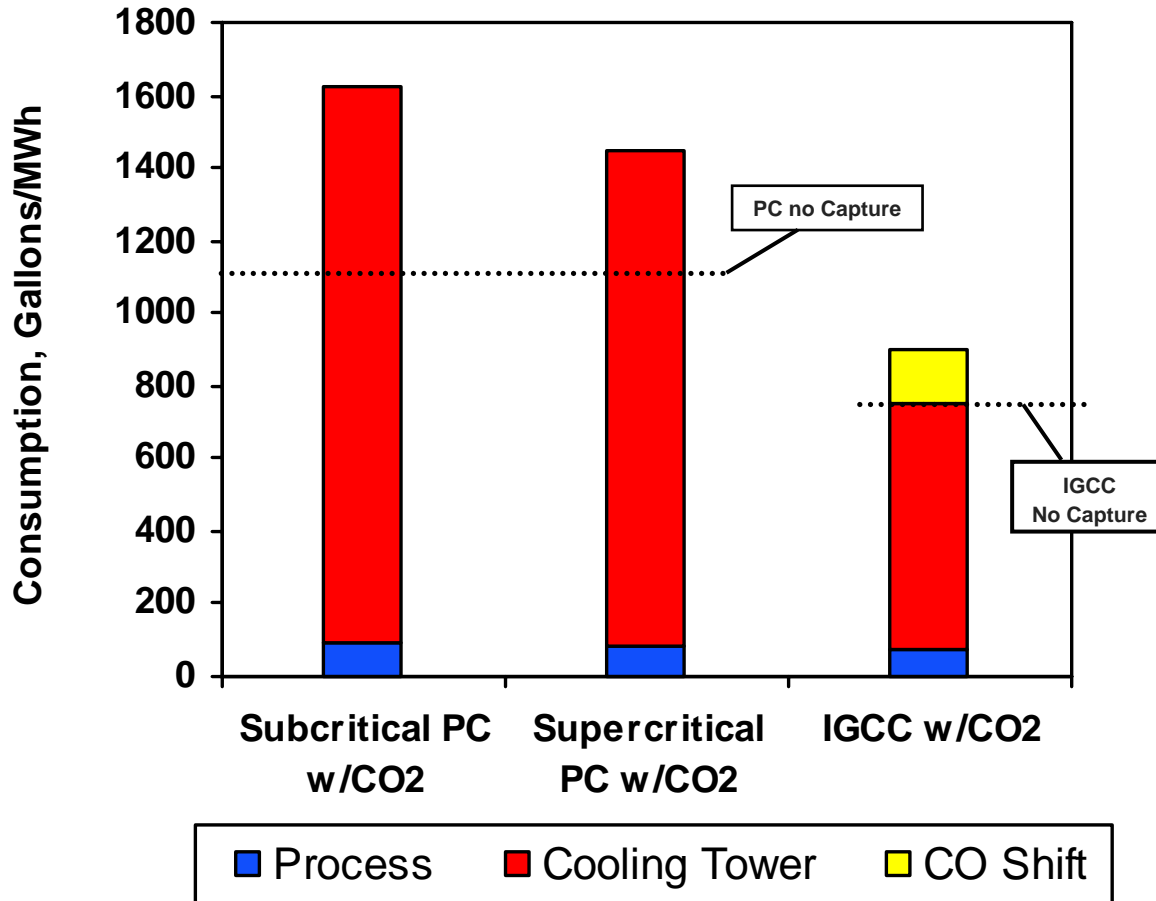


Enhanced
Photosynthesis



CO₂ Capture Impact on Water Usage

Increase in “Water Footprint”



PC CO₂ Capture

- 40% increase in consumption on a net output basis
- High parasitic loads (steam + auxiliary power)
- Amine CO₂ scrubbing neutral

IGCC CO₂ Capture

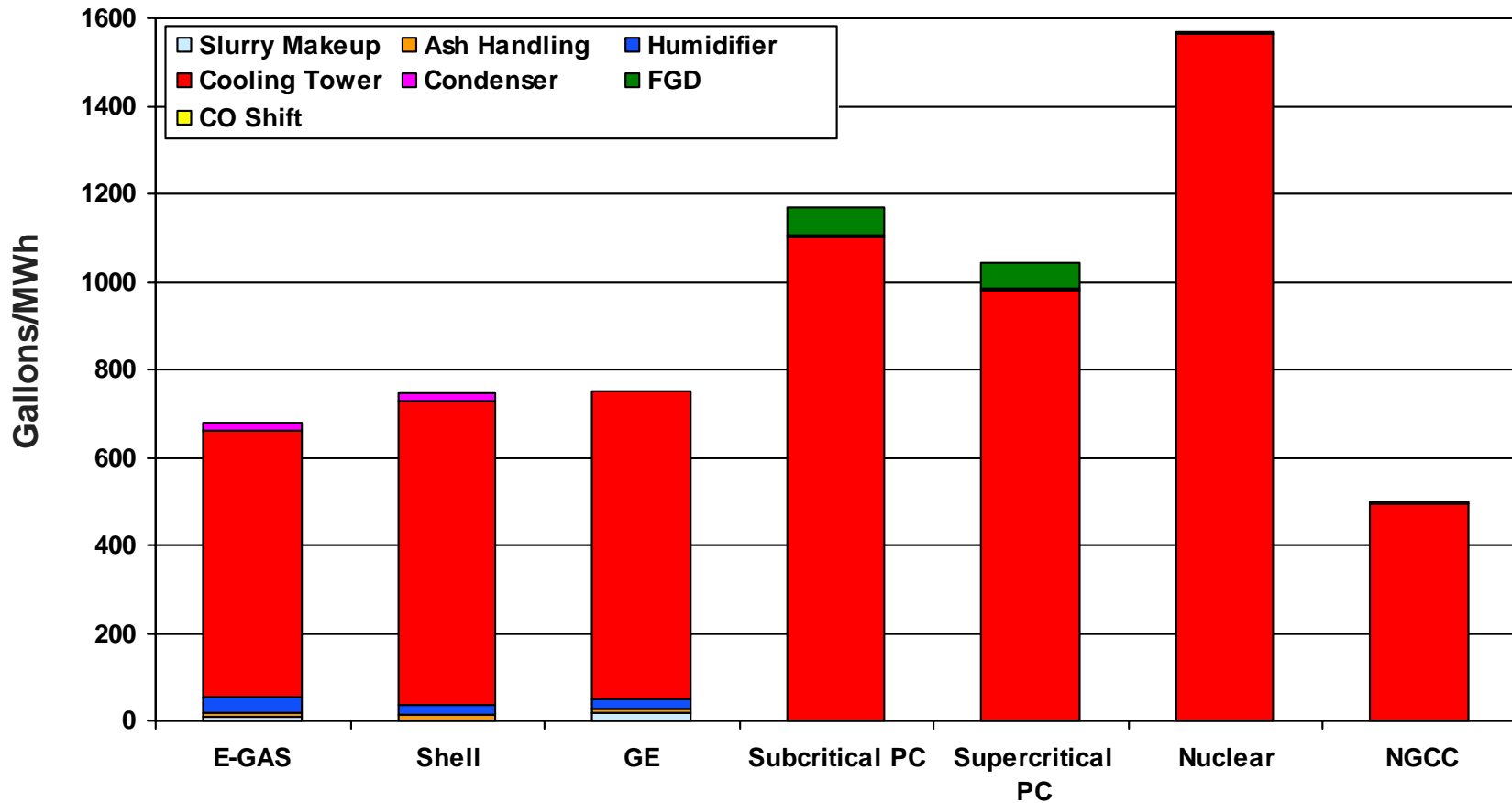
- Increased steam consumption (WGS reaction)

Note: Cost and performance impacts based on nominal 500 MW net output baseline plant with mechanical draft wet cooling towers

Source: DOE/NETL Calculations



Non-Coal Thermoelectric Based Generating Technologies Also Have Substantial Water Needs



Note: Cost and performance impacts based on nominal 500 MW net output baseline plant with mechanical draft wet cooling towers

Reference: Klett, et. al; GateCycle for Windows Version 5.61.0.r

Key Points

- **Process Losses**

- Smallest category of water losses (8-29 gal/MWh)
- More pronounced in IGCC plants (gasification reactions, shift process)
- No process losses with NGCC

- **Cooling Tower Losses**

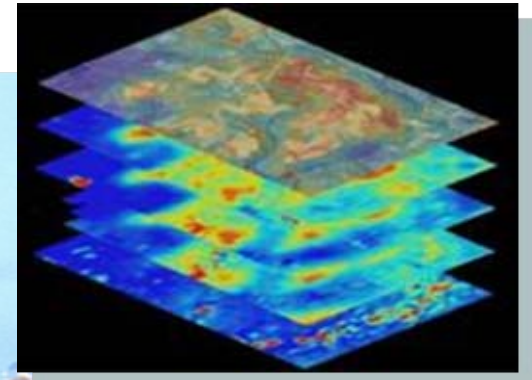
- 80 to 90% of total water consumption

- **Carbon Dioxide Capture**

- Increases PC water consumption by ~40% (on a net power output basis)
- Increases IGCC water consumption by ~18% (on a net power output basis)



Energy/Water Research Opportunities



Advanced Water Management Opportunities for Water Conservation

- **Hybrid / Dry Cooling**
 - Potential to reduce baseline water consumption up to ~ 75%
- **Alternative Combustion Turbine Strategies (IGCC)**
 - Eliminate syngas humidification
 - Alternative NOx mitigation strategies (e.g., SCR)
 - Potential to reduce baseline water consumption up to ~ 5%
- **Stack Gas Moisture Recovery and Recycle**
 - FutureGen Concept Plant ~1.2 Million gallons / day moisture in stack
 - Potential to reduce baseline water consumption up to ~ 20%

Water conservation opportunities may be attractive where supplies are limited and “value of water” is high. Added technology will have cost and performance impacts.



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The third in a series of Department of Energy-sponsored public education forums on liquefied natural gas has been scheduled for Thursday, June 1, 2006, at the Los Angeles Convention Center in Los Angeles, California. Read more >

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Vice President Cheney presented DyrMcDermitt Petroleum Operations Company, operator of DOE's Strategic Petroleum Reserve, with the 2005 Malcolm Baldrige National Quality Award. They earned the honor, in large part, for their outstanding performance in moving crude oil to the market in response to the devastation of Hurricanes Katrina and Rita. Read more >

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2005 NETL Accomplishments Report

We are pleased to announce the release of NETL's 2005 Accomplishments Report, a summary of the result of NETL's work over the past fiscal year.

A Clarification: In order to ensure that the public is presented a clear understanding of the U.S. Department of Energy's perspective on the current status of mercury control technologies for coal-fired power plants and their associated costs, DOE/NETL, in cooperation with the PA Federation of Sportsmen's Clubs, has issued the subject clarification to the PFSC's April 18 press release that U.S. Department of Energy Says Mercury Control Technology Available, Costs Low; Sportsmen Urge Legislators to Protect Pennsylvania's Environment.

NEWS & FEATURES

- Preference Economic Analysis of Activating Carbon Injection (PCI) - I (2005)
- Validation for "Clean Cities Transportation Sector Petroleum Reduction Technologies Commercial Deployment"
- NETL, the newest NETL installation, is now available
- Tap, Coast Certification Questions

EVENTS CALENDAR

- 21st International Technical Conference on Coal Utilization & Fuel Systems
- 2006 International Coalbed Methane Symposium
- Symposium on Wet Conversion 2006
- Society of Petroleum Engineers 2006 Annual Technical Conference & Exhibition
- 2006 Environmental Controls Conference

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