The Application of Gas Cleaning in an Electric Utility Environment

Presented at the
5th International Symposium on
Gas Cleaning at High Temperature
Morgantown, West Virginia

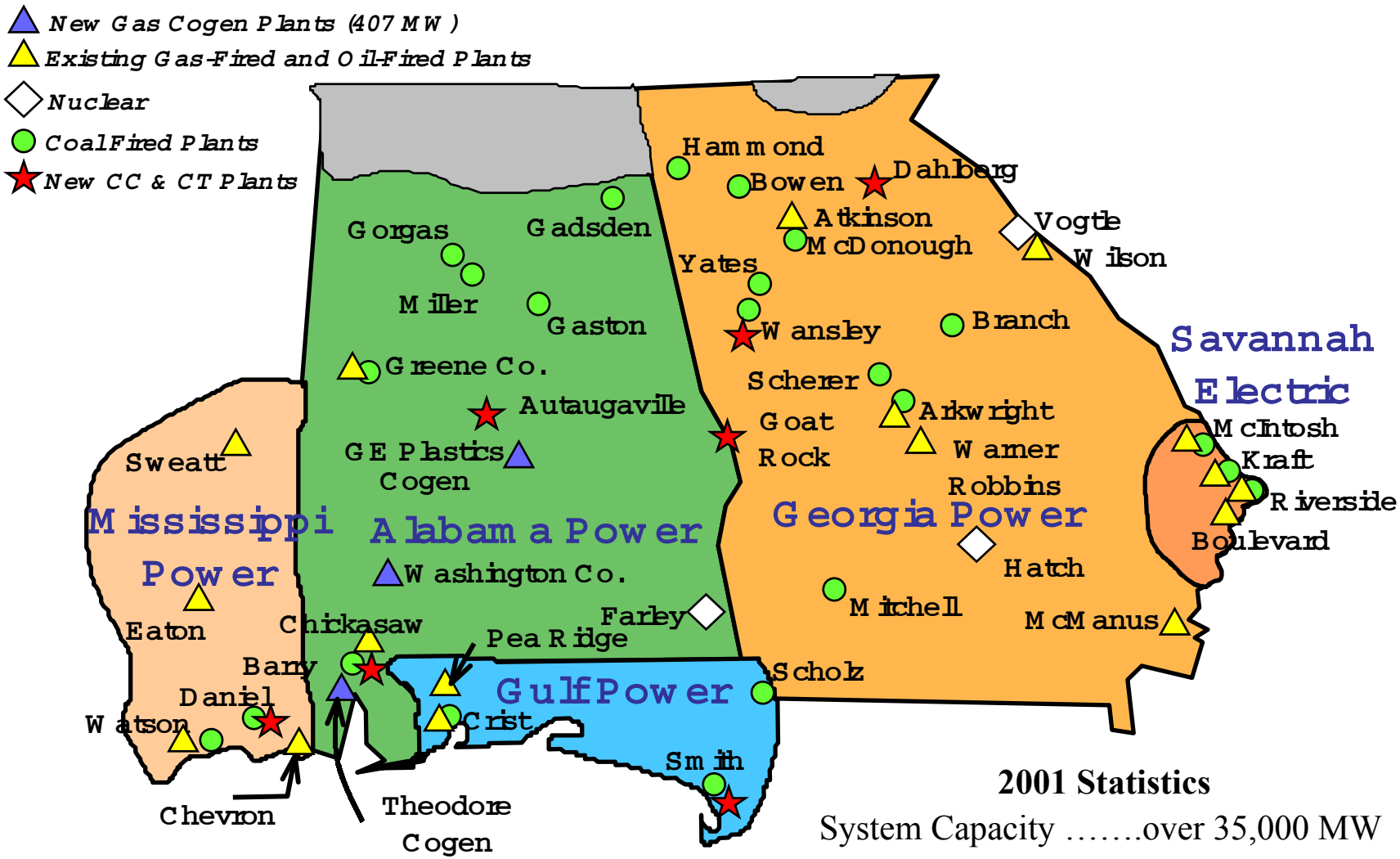
September 18, 2002

http:\\psdf.southernco.com

Outline

- Southern Company and the Power Systems Development Facility (PSDF)
- Near-term technologies for generating electricity
- Emissions from coal-based generating technologies
- Research needs and market opportunities
- Conclusion

The Southern Company



2001 Statistics

System Capacity …….over 35,000 MW

Coal Based Generation …….. 72%

PSDF

Power Systems Development Facility

SOUTHERN COMPANY

Energy to Serve Your World℠

Wilsonville
Power Systems Development Facility

"America's Advanced Coal Research Center"

Current Cost Share Partners at the PSDF

- US DOE - National Energy Technology Laboratory
- Southern Company
- Electric Power Research Institute
- Kellogg, Brown & Root
- Siemens Westinghouse Power Corporation
- Peabody Energy

Major Current Subsystems at the PSDF

- **Air-blown Transport Reactor**
  - Design - 2000°F, 350 psig
  - Design - 3,200 lb/hr gasifier coal feed, 1,000 acfm syngas
  - Actual - 5,500 lb/hr gasifier coal feed, 1,800 acfm syngas
- **Particulate Collection Device (PCD)**
  - Design - 91 candles, 1,000 acfm at 4 fpm, 1,800 °F, 25,000 ppm_w
- **Coal & limestone preparation, and feed subsystems design rates:**
  - Coal preparation 10,000 lb/hr
  - Pressurized feeder 6,000 lb/hr
  - Limestone preparation 2,000 lb/hr
  - Pressurized feeder 600 lb/hr
- **Ash and gas disposal subsystems**
- **Syngas slipstream Direct Sulfur Recovery Process (DSRP)**
- **4 MW Gas Turbine**

Transport Reactor Train Accomplishments

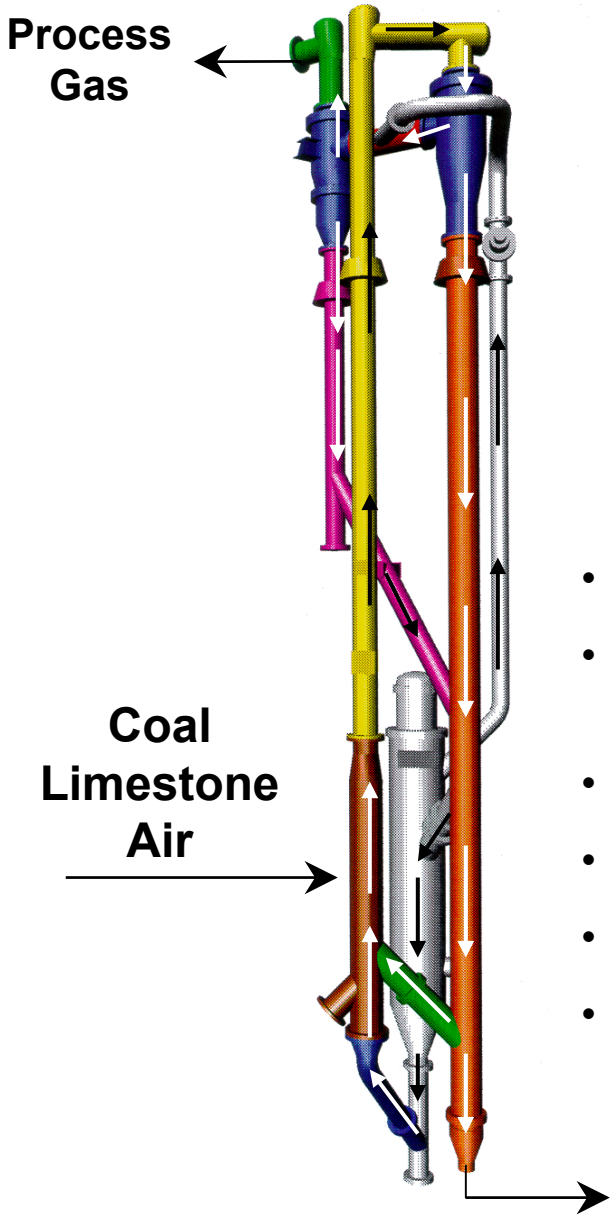
Pressurized Combustion

- System Operated Successfully on Coal and Pet Coke for 4,985 Hours
- 99.9+% Coal Conversion at Low (1600ºF) Reactor Temperature
- 99+% Sulfur Capture at Low 1.2-1.3 Ca/S Ratio (up to 5.3% Sulfur Fuel)
- Low NO_X - <0.10 1b/MBtu
- Demonstrated Reliability of Transport Reactor Design
  - Little or no Refractory Erosion with 10,000+ Hours Solids Circulation
  - Viable Design with No Refractory Expansion Joints

Gasification

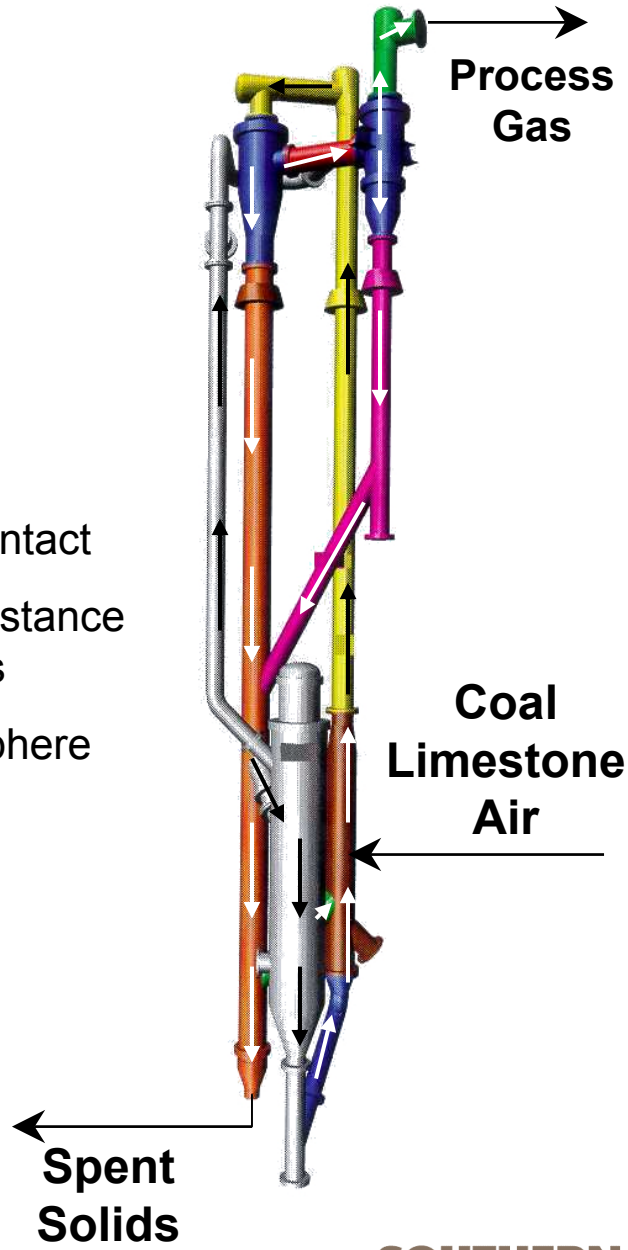
- System has been operated for 2800+ Hours (Including oxygen-blown operation)
- Robust control of reactor and oxygen content during startup, shutdown and emergency shutdown.
- With sub-bituminous coal.
  - Syngas heating value sufficient for a combustion turbine.
  - Acceptable carbon conversion.
  - Tar production manageable.
- Optimization of transport reactor continuing.
- Good filter operation with low pressure drop/stable baseline. (<0.1 ppm emissions)
- Testing on bituminous coal is underway

Transport Reactor



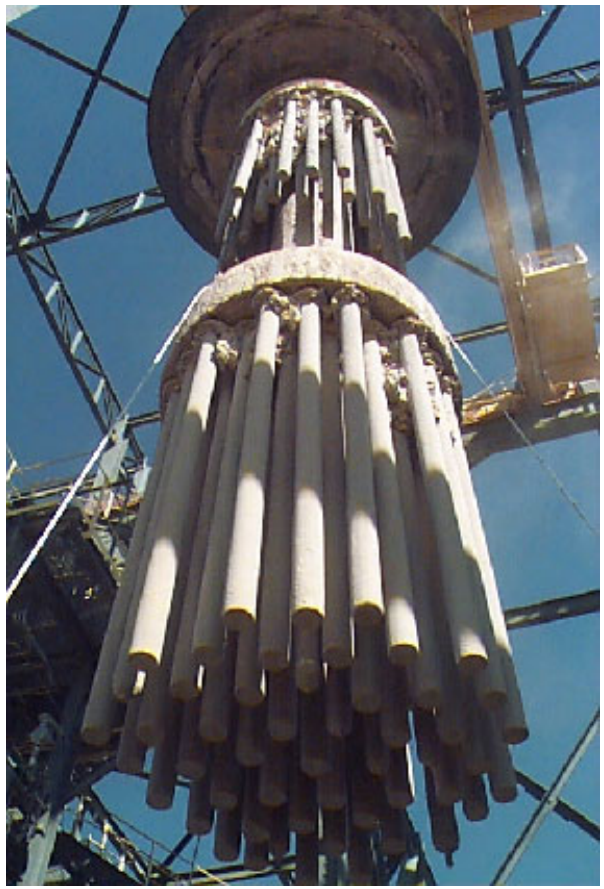
Advantages

- Excellent Gas-Solids Contact
- Low Mass Transfer Resistance Between Gas and Solids
- Highly Turbulent Atmosphere
- High Coal Throughput
- High heat Release Rate
- No Expansion Joints



Siemens-Westinghouse PCDs at the PSDF

1 Plenum - 91 Candles



3 Plenums - 273 Candles

Filter System Accomplishments

- Can meet turbine specifications for particulate
  - Outlet particulate loading below 0.1 ppm
- Combustion - acceptable candle life up to 1400°F
- Gasification - expect acceptable candle life up to 1000°F
- Good operation
- Reasonable pressure drop and stable baseline.
- Filter “safeguard” development and testing is improving reliability of these devices.

Major Proposed PSDF Test Items 2002 - 2006

- **Objectives:**
  - Support DOE Vision 21
  - Support Air Blown Transport Reactor Development
- **Proposed test items include:**
  - Continue air blown and initiate O_2 blown gasification development
  - Integrate O_2 blown gasifier with advanced air separation technology
  - Integrate gasifier with existing combustion turbine at the PSDF
  - Evaluate multi-contaminate (H_2S, Hg, HCl, etc.) controls
  - Evaluate novel CO_2 and H_2 separation systems
  - Test advanced materials (in gasifier and CT test section)
  - Evaluate high temperature gas/particle sensors
  - Improve system integration and controls
  - Improve gas cooling technology
  - Improve coal/limestone feed systems and ash cooling systems

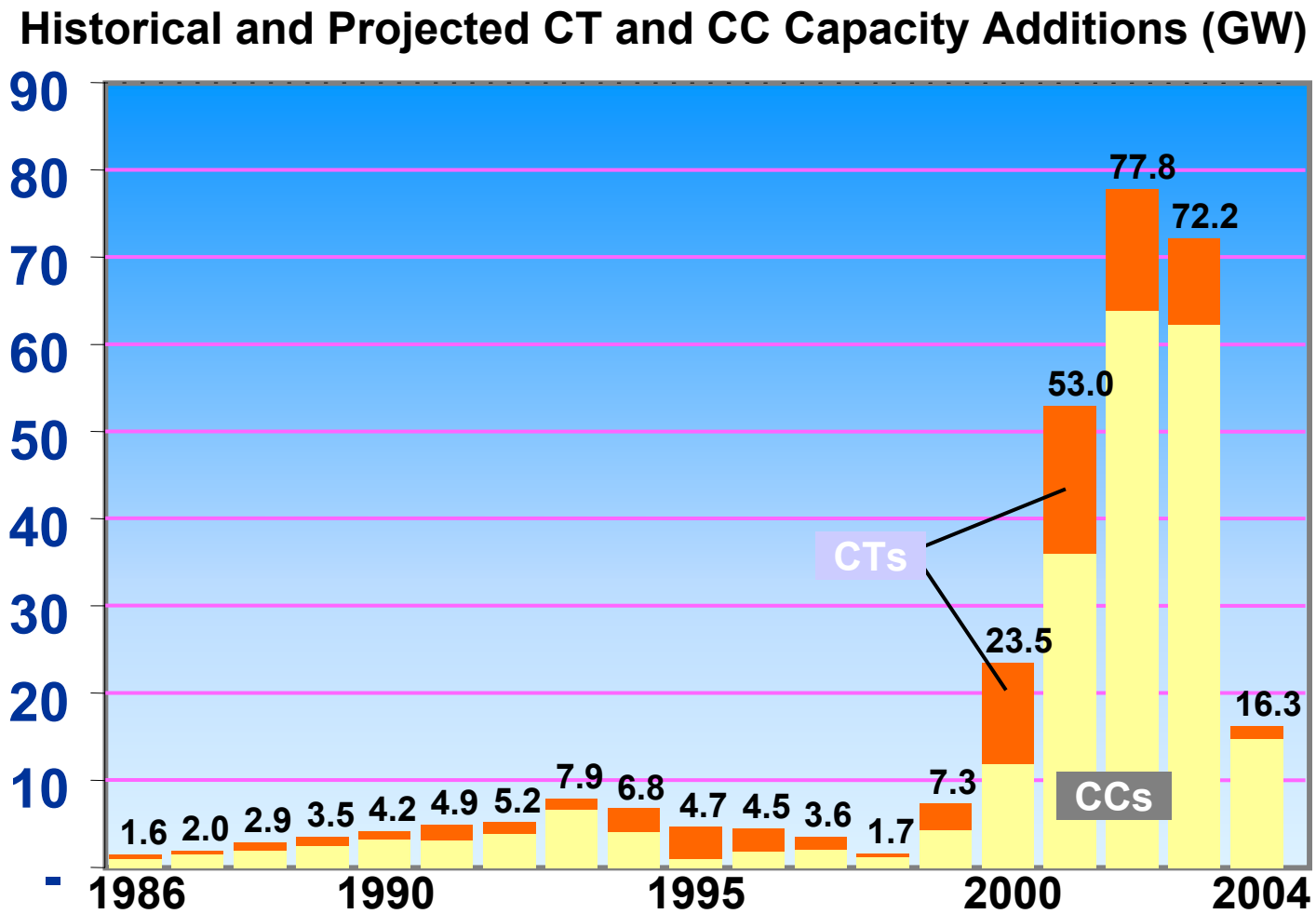
Utility Requirements For Generating Technology

- Low Capital Cost
- Low Cost-of-Electricity (COE)
- Emissions Below Current Environmental Regulations
- High Reliability
  - Southern Company's Overall Peak (Summer) Forced Outage Rate Is < 2%

Power Generation In The Near Future

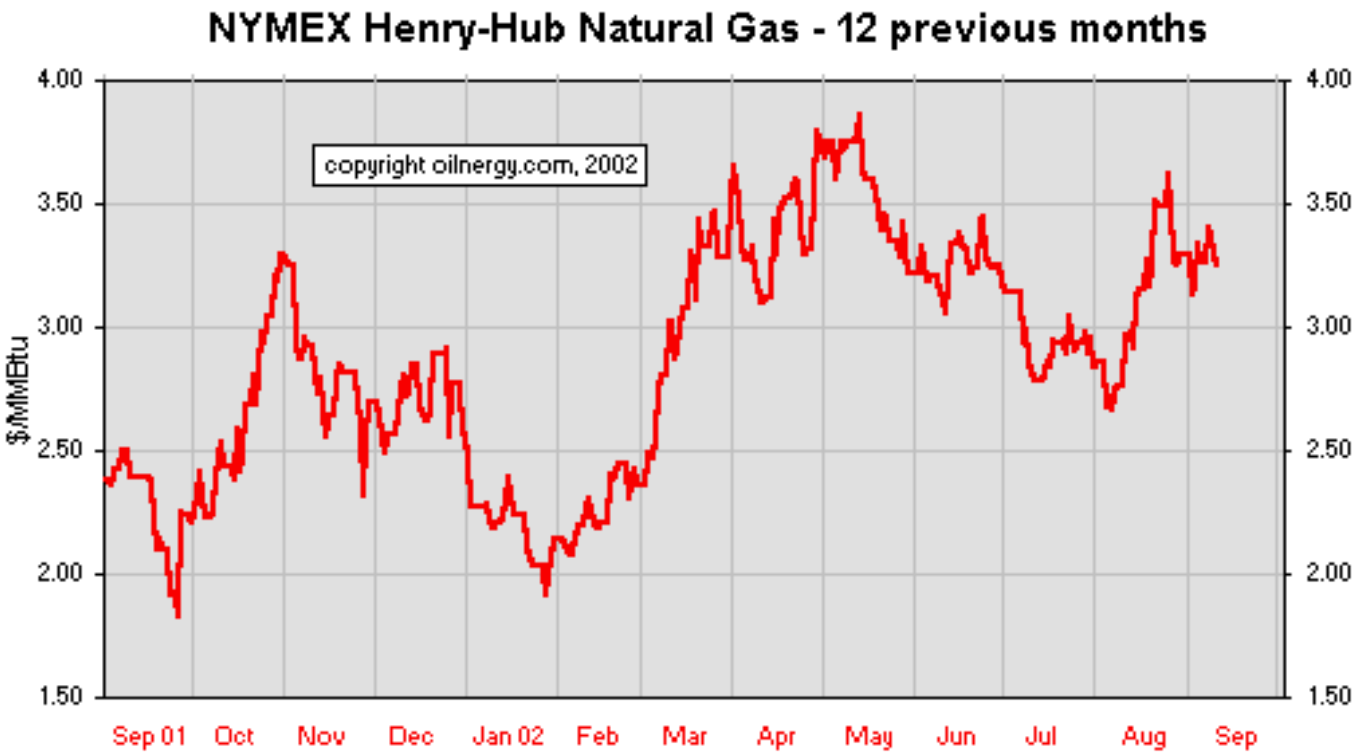
- The low capital cost, low COE, low emissions and high efficiency makes natural gas combined cycle the technology of choice in the near future.
- May be an over-capacity of electricity in certain markets due to recent construction and the downturn in the economy.
- Financial instability in electric markets may delay construction of new base-loaded generation.
- However, natural gas price is increasing to the point where coal-based technologies are almost competitive.
- In certain areas of the country coal-based technologies are currently competitive based on the local cost of coal and/or natural gas.

Natural Gas Is Currently The Technology Of Choice

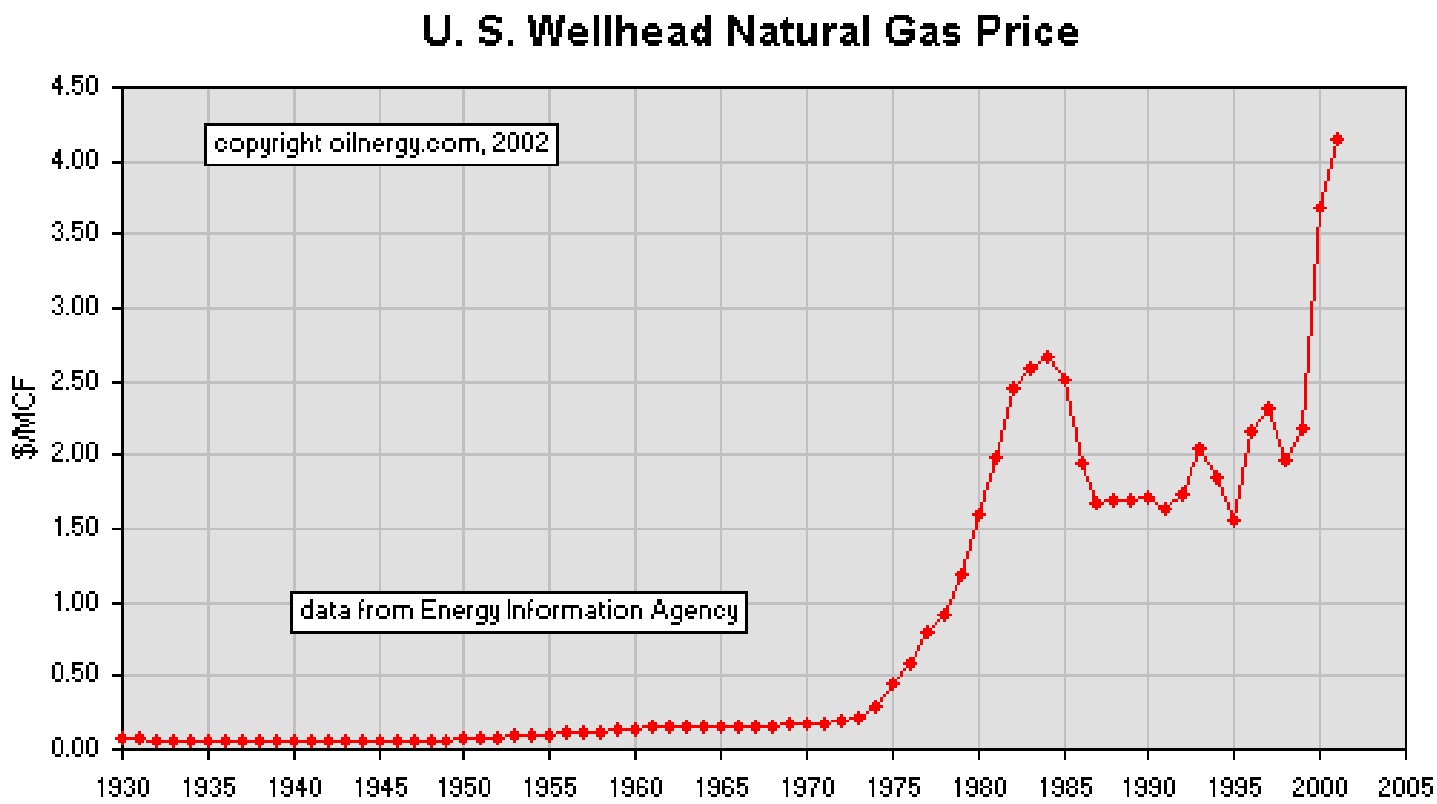


EVA, EIA and EEI

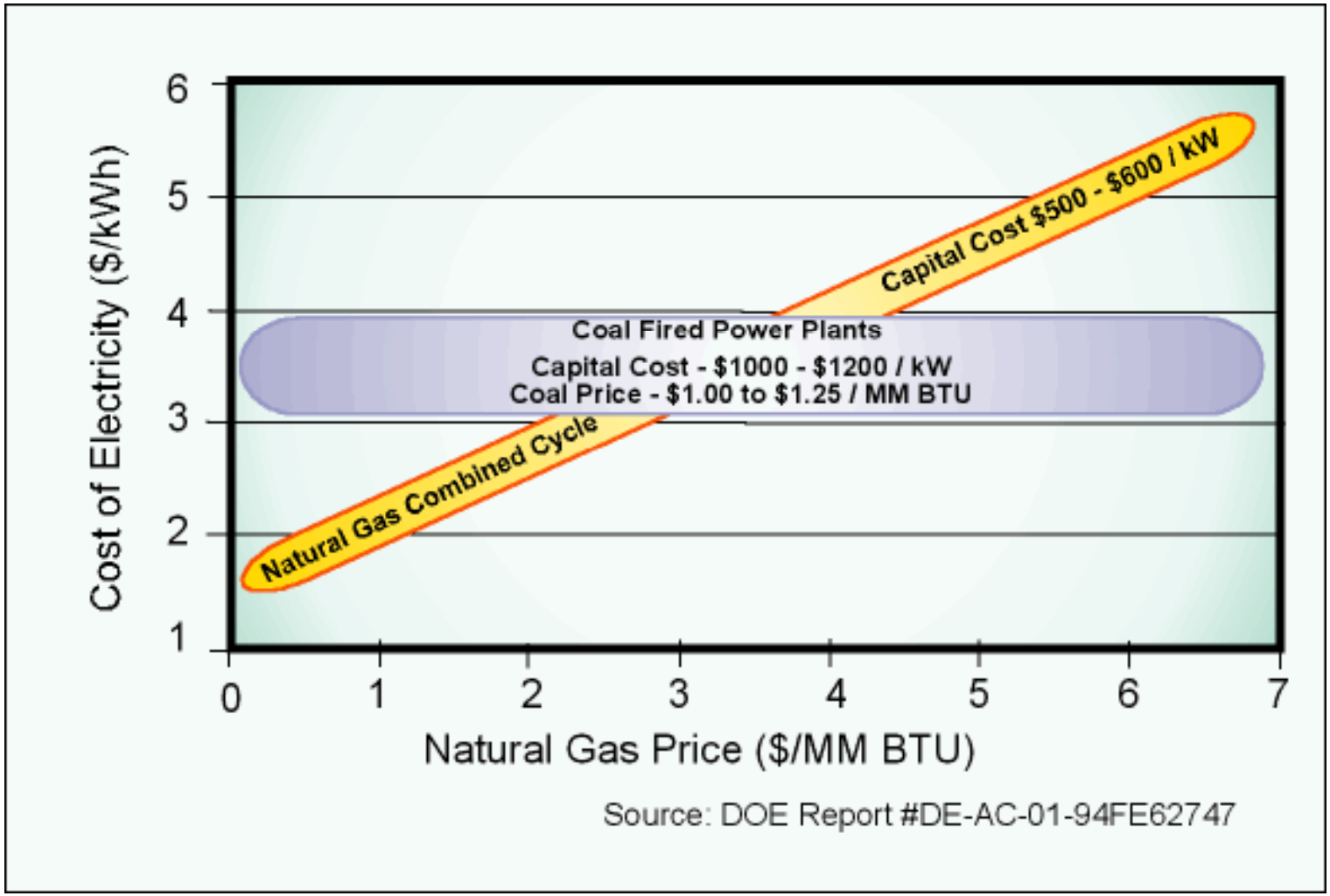
Natural Gas Price For Previous 12 Months



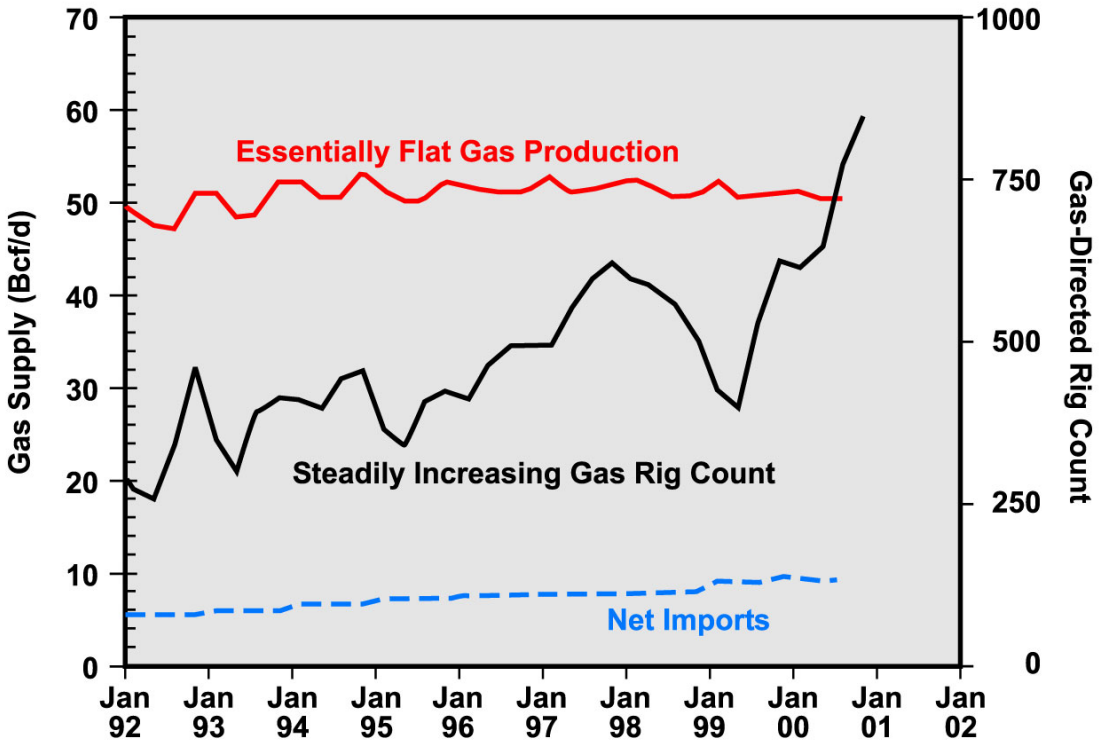
Mean Natural Gas Price



Coal Technologies Are Almost Cost Competitive



Natural Gas Supply "Growth???"



Source: Simmons and Company International

- Essentially NO Volume Growth Over Last Five Years
- Imports Increased
- Increasing Rig Count
- US & Canadian Well Decline Rates >25%

Unlocking the Natural Gas Riddle
By Matthew Simmons, President
Simmons & Company International
May 2002

…it now seems unlikely that conventional gas supplies can grow beyond the steady levels enjoyed over the past eight years at least through 2010. Whether supplies can even return to a 52 BCF per day level is also now a serious energy issue.

Emissions From Coal

- **Increasing environmental pressure on coal based generation technologies.**
- **Emissions of interest:**

  NO_x, N_2O, SO_2, SO_3, particulate, VOCs, CO, CO_2, mercury, HCl, HF, arsenic, cadmium, selenium, nickel, beryllium, lead, chromium, alkali, ammonia
- **Challenge to any coal-based generating technology will be to reduce emissions without significantly increasing capital cost, increasing COE, decreasing efficiency or sacrificing reliability.**

Emissions From Coal In Advanced Technologies

- Multi-contaminant control needs to be accomplished in a minimum number of vessels.
- Particulate and some contaminants can be removed in a particulate collection device (PCD). These devices can operate across a wide temperature range and have been demonstrated to meet gas turbine manufacturer's requirements.
- Mercury capture may set the operating temperature of the additional gas cleaning systems.
- Gas cleaning can occur before or after the gas turbine.

Gas Cleanup Before The Gas Turbine

- **Advantages**
  - Lower gas volumes due to higher pressures
  - Gas cleaning technologies proven at lower temperatures
- **Disadvantages**
  - Additional systems needed for sour water cleanup, sulfur recovery, sorbent regeneration, etc.
  - Low temperature gas cleaning decreases cycle efficiency
  - High temperature gas cleaning increases cycle efficiency, but has not been demonstrated commercially.

Gas Cleanup After The Gas Turbine

- **Advantages**
  - **Lower temperature and pressure**
  - **Can utilize developing technology from pulverized coal units.**
  - **Increases cycle efficiency vs. cold gas cleanup.**
- **Disadvantages**
  - **Larger gas volumes**
  - **Lower Temperature and Pressure**
  - **Effect of gas-phase constituents on turbine and HRSG**

Further Development Needed For Emissions Control

- **Additional development is needed for emission control technologies - both before and after the gas turbine.**
- **Focus must be on:**
  - **Minimizing capital cost**
  - **Minimizing maintenance cost**
  - **High reliability**

Department of Energy's Clean Coal Power Initiative

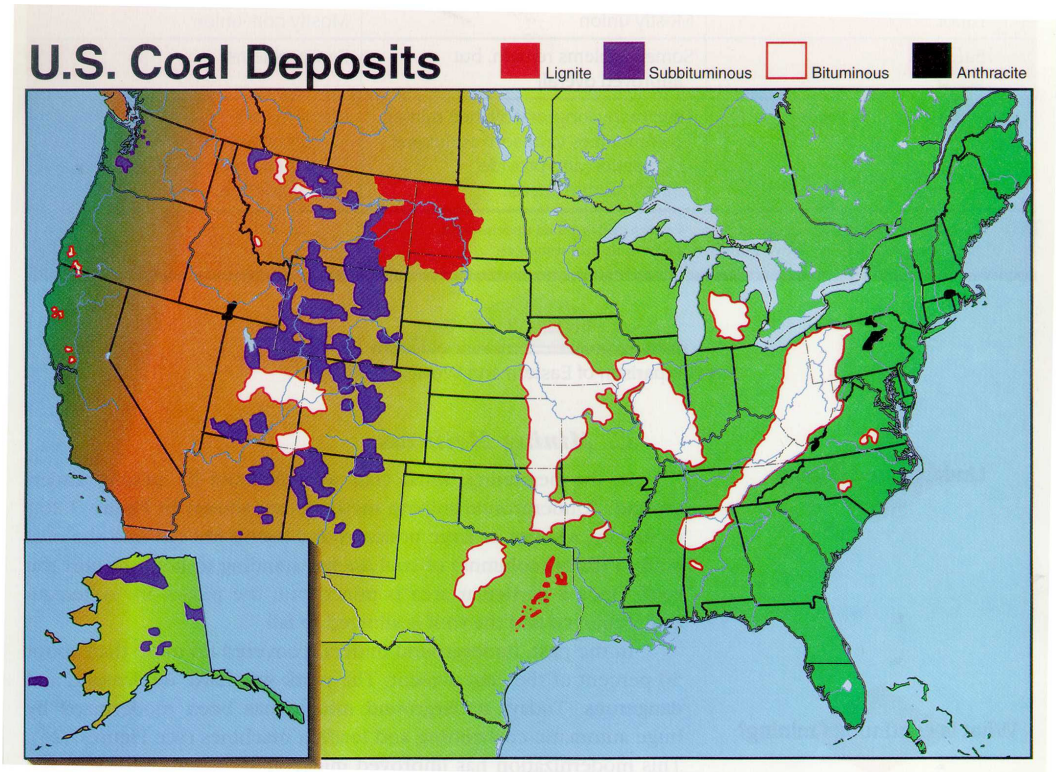
- 36 proposals submitted for 2002 round of the CCPI.
- Projects valued at over $5 billion dollars, requesting over $1 billion in federal cost sharing support.
- Department of Energy expected to have approximately $330 million in matching funds for the 2002 round of the CCPI.
- Department of Energy will announce selections in January 2003.
- Bush Administration has pledged to invest $2 billion over the next 10 years to advance technologies that can help meet the nation's growing demand for electricity while simultaneously protecting the environment.

Conclusions

- Natural gas combined cycle is currently the technology of choice for utilities.
- In the near term, over-capacity in the energy markets will delay construction of some new baseload capacity.
- Rising natural gas prices may increase opportunities for coal based generating technologies in the near term.
- Environmental issues present a challenge for coal-based technology.
- Additional R & D is needed to develop gas cleaning technologies that will meet environmental standards, but not adversely affect coal plant capital cost, COE, efficiency and reliability.

Why Focus on Coal?

It's our <u>most plentiful domestic energy resource</u> -- enough to last at least 275 years, at current rates of use.



(Map courtesy of Global Science, Fifth Edition, and Mineral Information Institute).

<u>304.6</u>

<u>Billion Tons</u>

Recoverable Reserves

(Based on 60 % recovery rate and U.S. Energy Information Administration coal reserve data).