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Advanced Coal-Fired Power Systems ’96

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Morgantown Energy Technology Center
July 16, 1996
Overview

• Product Lines
• Product Goals
• Product Development Strategy
• This Year’s Successes
• Barrier Issues
• Key Plans For Next Year
• Technical Status
• Market Opportunities
Vision

Worldwide, most new and repowered electric generating capability will use IGCC and PFBC technologies due to their superior environmental performance, cost and efficiency.
Product Lines

"The Future of Coal Based Power Generation"

IGCC

PFBC
Integration Gasification Combined Cycle (IGCC)
Pressurized Fluidized Bed Combustion (PFBC)

Diagram of PFBC process:
- Carbonizer/Partial Gasifier
- Hot Gas Filtration
- PFBC
- Hot Gas Filtration
- Topping Combustor
- Kalina Cycles, Advanced Bottoming Cycles
- HRSG
- Steam Turbine
- Water
- Steam
- Flue Gas
- Air
- Water
- Coal
- Limestone
- Char
- Non-Topped PFBC
- Topped PFBC
- Super clean, super efficient PFBC's
Goals

• Coal Based Power Systems
  - Environmental Performance
  - Efficiency
  - Cost
IGCC Goals

- **Adv. Gas**
  - NO\(_x\): 0.08
  - SO\(_2\): 0.02
  - Part.: 0.02
  - Eff.: 45%
  - Cost: $1350
  - COE: 3.4¢

- **Filters**
  - NO\(_x\): 0.07
  - SO\(_2\): 0.17
  - Part.: 0.015
  - Eff.: 52%
  - Cost: $1150
  - COE: 2.6¢

- **HGD**
  - NO\(_x\): 0.06
  - SO\(_2\): 0.15
  - Part.: 0.01
  - Eff.: 60%+
  - Cost: $1100
  - COE: 2.5¢

- **GT**

- **Adv. Cycles**

- **Years**
  - 2000
  - 2010
  - 2020
PFBC Goals

- **Topped Cycle**
  - NO\textsubscript{x} 0.3
  - SO\textsubscript{x} 0.2
  - Part. 0.02
  - Eff. 45%
  - Cost $1250
  - COE 3.4¢

- **Filters**
  - NO\textsubscript{x} 0.26
  - SO\textsubscript{x} 0.18
  - Part. 0.015
  - Eff. 50-52%
  - Cost $1000
  - COE 2.6¢

- **GT**
  - NO\textsubscript{x} 0.24
  - SO\textsubscript{x} 0.16
  - Part. 0.013
  - Eff. 56%
  - Cost $850
  - COE 2.5¢

- **Adv. Cycles**

2000 2010 2020
Product Development Cycle

- **Concept Development**
  - Cooperative Research and Development
  - Systems Studies
  - Bench Scale Tests
  - PDU / Pilot Scale Tests

- **Subsystem / Component Advances**

- **Demonstration Plants**

- **Commercial Plants**

**METC In-House R&D**

**Contractor R&D**

**Clean Coal Technology (CCT) Programs**

**Industry Share**

**Government Share**
Product Development Cycle

- Government Share
- Industry Share

Total Installed Costs

- "Early Optimism"
- "Hard Reality"
- "Value Engineering"
- "Replication"

- Concept (Lab)
- Bench & POC
- Pilot
- Demo
- No. 1 Commercial
- No. 2 Commercial
- No. 3 Commercial

Time
Technical Status

• Key R&D Activities
• Product Development
• Demos and R&D
Key R&D Activities

Sorbents
- ICCI
- GEESI
- METC
- RTI

Filters
- EERC
- MGCR
- KARHULA
- METC

Air Toxics
- LGTI
- AMES
Power Systems Development Facility Consists of Two Separate Reactor Systems

- Limestone
- Coal
- Pulverizer
- Carbonizer
- Char
- Sulfur and Ash
- Transport Gasifier/Combustor
- Hot Gas Cleanup
- Gas Disposal
- Fuel Cell Test Skid
- Hot Fuel Gas
- Pressurized Combustor
- Hot Gas Cleanup
- Hot Flue Gas
- Gas Turbine
- Stack
- 4 MW of Electric Power
Power Systems Development Facility at Wilsonville, AL
Samples of Fresh, Sulfided, and Regenerated Sorbents
METC
Desulfurization PDU
Transport Reactor with Hot-Gas Filter System

- Primary Cyclone
- Disengager
- Coal Feed Hopper
- Hot-Gas Filter Vessel and Ash Hopper
- Riser
- Steam Superheater
- Quench System
- Air Preheater
- J-leg
- Mixing Zone
Westinghouse Cold Flow Filter Module
- Conduct large-scale engineering tests of ceramic filter systems for commercial 1st & 2nd Generation PFBC
  - Demonstrate 5,000 hours of operation

- $20 million program separate from Clean Coal
- Test filters on 2nd & 3rd years of operation
- Westinghouse ceramic candle filters first system to be tested
- Potential for a different filter in 2nd test period
Particulate Filter Module at TIDD
KARHULA
Barrier Issues

• Technical
  - Filters
  - CO$_2$
  - S and other gases
  - Materials

• Market
  - Domestic capacity growth
  - Capital cost
  - Incentive for risk
IGCC R&D Issues

(1) Overall System
- Process simulation
- Instrumentation
- Capital Cost/COE evaluation

(2) Ash Disposal
- Disposable solid waste - MWK

(3) Advanced Gasifier Concepts
- Transport Reactor
- Pulsed Gasifier

(4) Hot Particulate Removal
- Filters life/reliability
- Chemical durability in reducing gas
- Solids loading removal/cleaning recovery
- Particle morphology
- Temperature

(5) Hot Gas Desulfurization
- Proof of process concepts
- Process control
- Sorbent capacity, attrition resistance and life cycle costs
- Chemical attack

(6) Other/Combined Contaminant Control
- Chloride removal
- NH₃/NO₂ control
- CO₂ reduction/control

(7) Gas Combustion
- Low Btu gas

(8) Trace Emissions
- HAPs measurement & modeling

(9) Sulfur Recovery
- DSRP
- Advanced sulfur recovery concepts

M96001815W
PFBC R&D Issues

Hot Particulate Removal
- Filters life/reliability
- Solids loading removal/cleaning recovery
- Particle morphology
- Temperature

Other/Combined Contaminant Control
- Chloride
- Alkali

Gas Combustion
Low Btu gas
- Stability
- NOx issues

Trace Emissions
- HAPs measurement and modeling

Advanced Carbonizer Concepts/ Sulfur Removal
- Transport Reactor
- Pulsed Gasifier

Ash Disposal/ Reuse

Overall System
- System studies
- Components
- Instrumentation & control

Advanced Steam Cycles
- Kalina Cycle
- Materials Issues
Key Plans

• Startups
  - Tampa
  - Piñon
  - PSDF

• Construction
  - Lakeland
  - Seward

• Testing
  - Filter Materials
Wabash River Coal Gasification Repowering Project
Piñon Pine IGCC Power Project
City of Lakeland
McIntosh Power Plant
Lakeland, Florida
March 4, 1996
List of IGCC Projects in the World
IGCC Plants and Projects
List of PFBC Projects in the World

Non-topped PFBC's
- 130 MWe + 210 MWe, Vartan, Sweden
- 79 MWe, Escatron, Spain
- 71 MWe, Tidd, USA
- 60 MWe, Grimethorpe, UK
- 40 MWe, Aachen, FRG
- 15 MWe, Finspong, Sweden
- 15 MWe, Friedrichsfeld, FRG
- Nanjing, PRC
- Delft, Netherlands
- British Coal, UK
- Helsinki, Finland

Topped PFBC's
- 500 MWe (2-250 Units), Chugoku Electric, Japan
- 350 MWe, Teruel, Spain
- 340 MWe, Mountaineer, USA
- 175 MWe, Lakeland, USA
- 85 MWe, Hokkaido, Japan
- 75 MWe + steam, Cottbus, Germany
- 57 MWe + 99 MWe, Trebovice, Czech
- Grimesthorpe Topping, UK
- 15 MWe, Jiawang, PRC
- 8 MW, Wilsonville, USA

Year
- 1980
- 1985
- 1990
- 1995
- 2000
- 2005
Marketplace Opportunities

- U.S. repowering
- Global demand
- Co-production
- Opportunity fuels
- Environmental drivers
- Advanced systems
Global Demand

**World Electricity Consumption**

**1970 - 2015**

- **History**
- **Reference Case**
- **Low Economic Growth**
- **High Economic Growth**
- **Projections**

**Non-OECD Electricity Consumption**

**By Region, 1993 - 2015**

- **Asia**
- **EE/FSU**
- **Central & South America**
- **Africa**
- **Middle East**

U.S. Repowering

Plants Over 40 Years Old

Coal Plants
All Plants
Coal %

Capacity, GW

Year

% of Installed Capacity

1995 2005 2015

0 100 200 300 400 500
Co-Production

COAL

Electricity

Steam

Chemicals
Opportunity Fuels

- Plastic
- Biomass
- Sewage
- RDF
- Petcoke
- Waste Fuel
Environmental Drivers

- $\text{SO}_2$
- $\text{NO}_x$
- $\text{CO}_2$
- Particulates
- HAPs