



EERC

EERC Technology... Putting Research into Practice

Assessment of Lignite Resources and Utilization Options for the State of Arkansas

Presented at the State Capitol as Part of the Joint
Committee on Energy to Discuss the Status of the
Arkansas Lignite Resources Pilot Program

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Outline

- EERC
- Status of Gasification
- Economic benefits of Lignite Development in ND
- Proposed Work to Evaluate Arkansas Lignite

What Does the EERC Do?



- The EERC is recognized as one of the world's leading developers of:
 - Cleaner, more efficient and innovative energy technologies to guarantee clean, reliable energy supplies for the United States and the world.
 - Environmental technologies to protect and clean our air, water, and soil.
- The EERC is a research, development, demonstration, and commercialization center.
- The EERC vigorously maintains a nonadvocacy position.
- The EERC enhances any guarantee.

EERC Facilities



EERC Facilities



Providing Strategic Solutions to Real-World Problems

The EERC provides practical, cost-effective solutions to today's most critical energy and environmental issues and challenges.

Our research portfolio includes:

- Clean coal technologies
- Coalbed methane
- Underground coal gasification
- Emission control
 - SO_x, NO_x, air toxics, fine particulate, and CO₂
- Mercury measurement and control
- CO₂ sequestration
- Global climate change
- Energy and water sustainability
- Energy-efficient technologies
- Distributed power generation – various fuels
- Hydrogen technologies
- Alternative fuels
 - Ethanol, biodiesel, biojet, and strategic fuels for the military
- Biomass
- Wind energy
- Water management
- Flood prevention
- Waste utilization
- Contaminant cleanup
- Advanced analytical technologies/ extraction technologies
- Pesticides and neurological diseases

Invention vs. Innovation

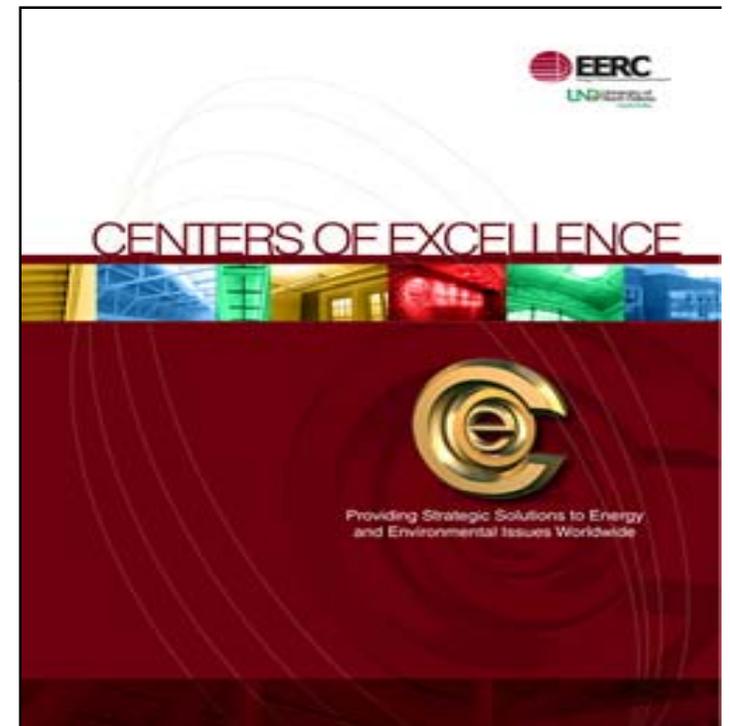
**“Don’t invent something
that nobody wants!”**

– Thomas Edison

EERC Centers of Excellence

The EERC's Centers of Excellence are leading the world in providing expertise in scientifically advanced energy systems and the prevention and cleanup of air, water, and soil pollution.

- Coal Utilization Technologies Center
- Emission Control Technologies Center
- The National Center for Hydrogen Technology
- Center for Climate Change and CO₂ Sequestration
- Center for Air Toxic Metals[®] (CATM[®])
- Centers for Renewable Energy and Biomass Utilization
- Water Management Center
- National Alternative Fuels Laboratory[®] (NAFL[®])
- Supercritical and Subcritical Extraction Technologies Center
- Coal Ash Research Center



EERC Quick Facts

- Total value of current EERC contract portfolio is over \$189 million.
- The EERC had 442 active contracts in FY07.
- In FY07, 93% of contracts were with nonfederal clients.
- In FY07, over 64% of clients were repeat customers.
- Total employment of over 300 highly skilled scientists, engineers, and support personnel, with about 20 new open positions.
- Current facilities include more than 245,000 square feet of laboratory, demonstration, and office space.
- The EERC sends out an average of nearly one funding proposal per calendar day.
- Total expenditures for FY07 were more than \$27 million, with an estimated regional economic impact of \$94.5 million.
- Fourteen spin-off companies have evolved from EERC programs.

Selected Gasification Activities at the EERC

Research and Development

CABRE III – Systems Engineering modeling – design of future systems

CABRE II – Computer model for entrained flow gasifiers

CABRE I – Ash behavior Entrained flow gasifiers

Dakota Gasification Support

Coal water slurries

Lignite Gasification – ash behavior

Gasification Kinetics

Refractory and slag flow

Trace elements in gasification

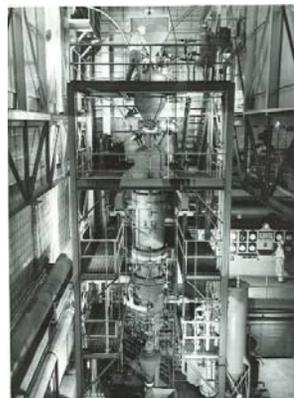
Lignite properties – moisture friability

1945 1955 1965 1975 1985 1995 2005 2010

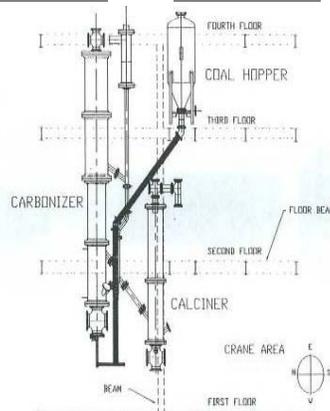
Technology Demonstrations



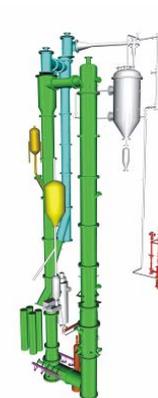
Annular Externally Heated Retort



Slagging Fixed-Bed Gasifier



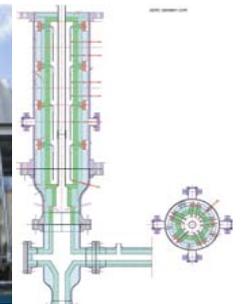
Catalytic Gasification/SOFC Mild Gasification



Transport Reactor Development Unit



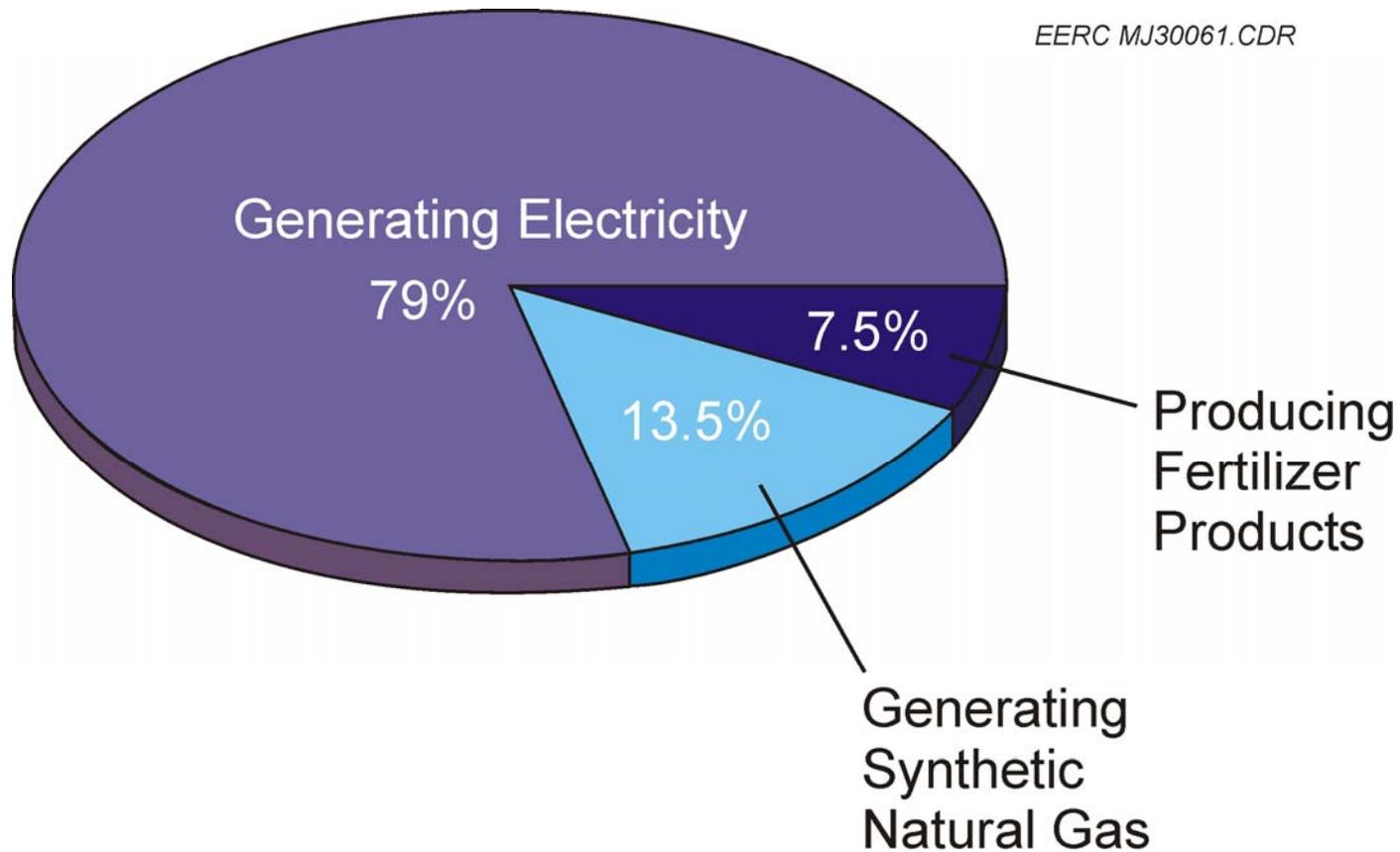
Microgasifier



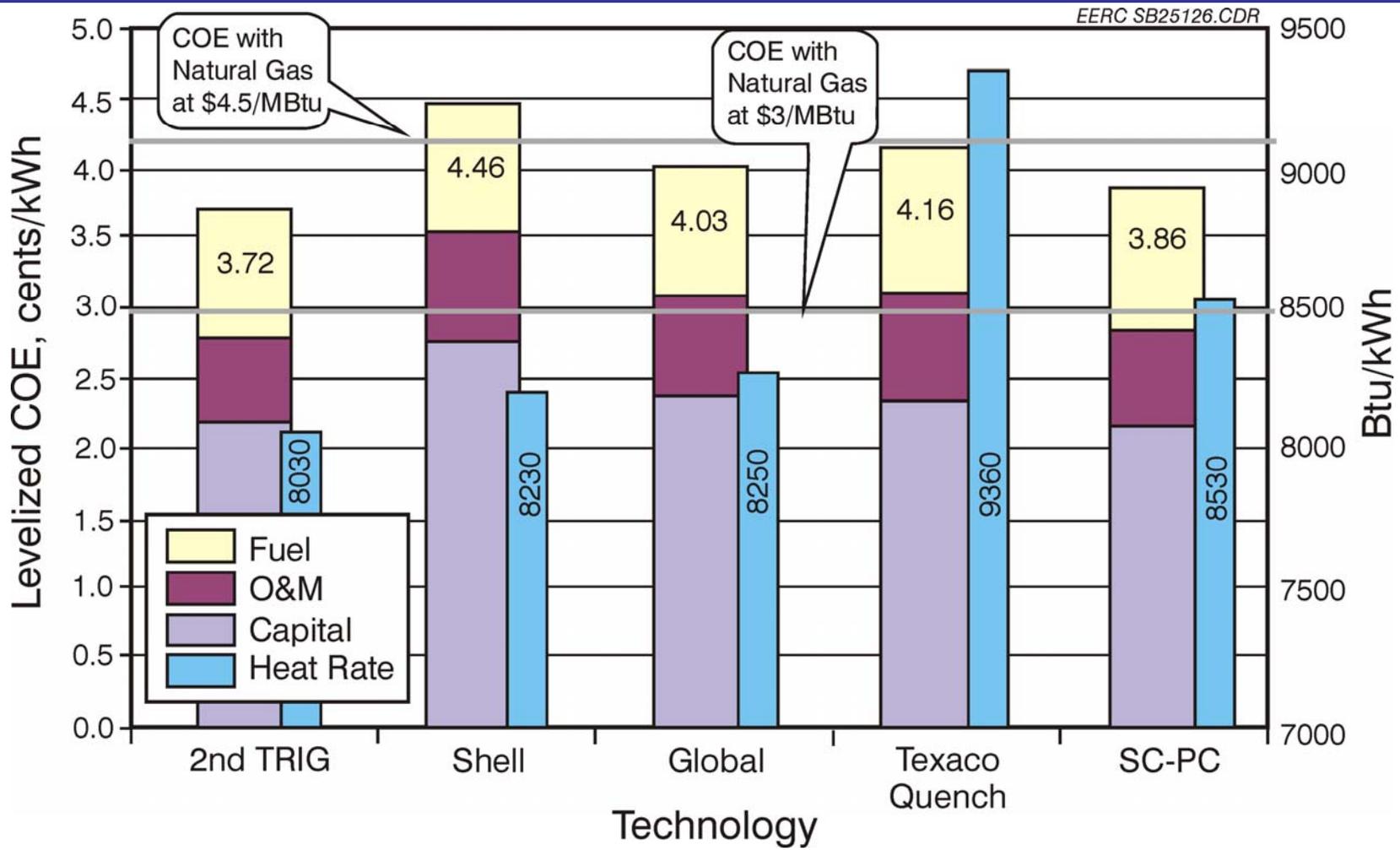
Entrained flow Slagging gasifier

Economic benefits of lignite development

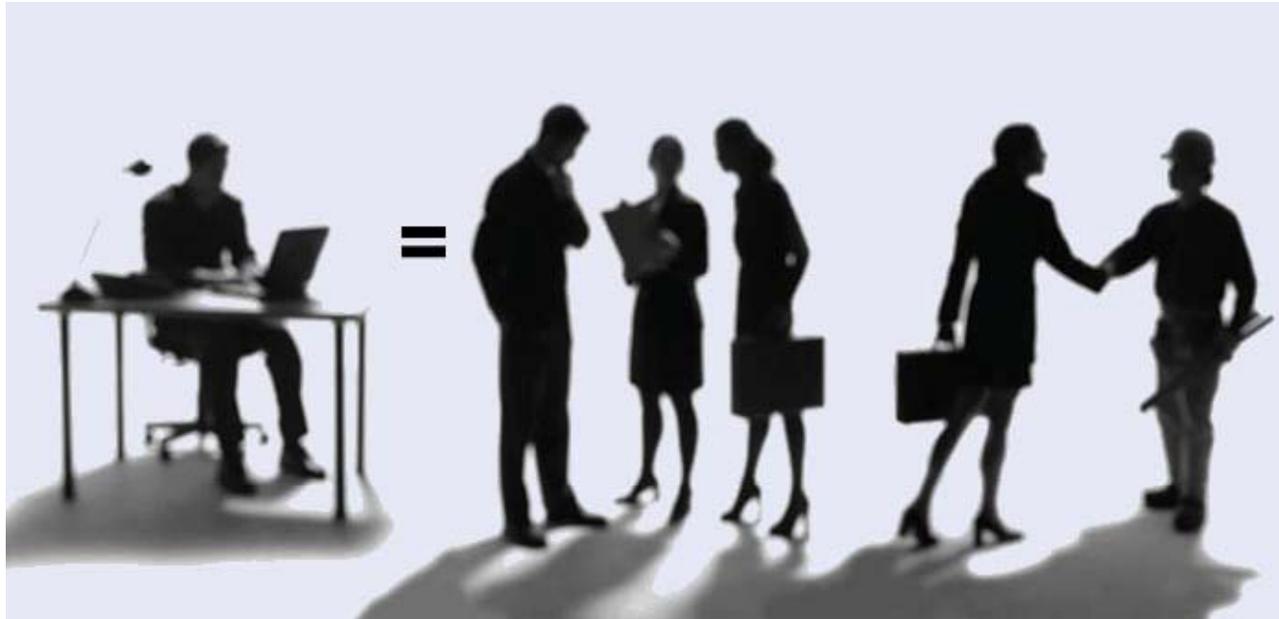
Current Uses for Lignite in the United States



Comparison of the Cost of Gasification Technologies (Leonard et al., 2005)

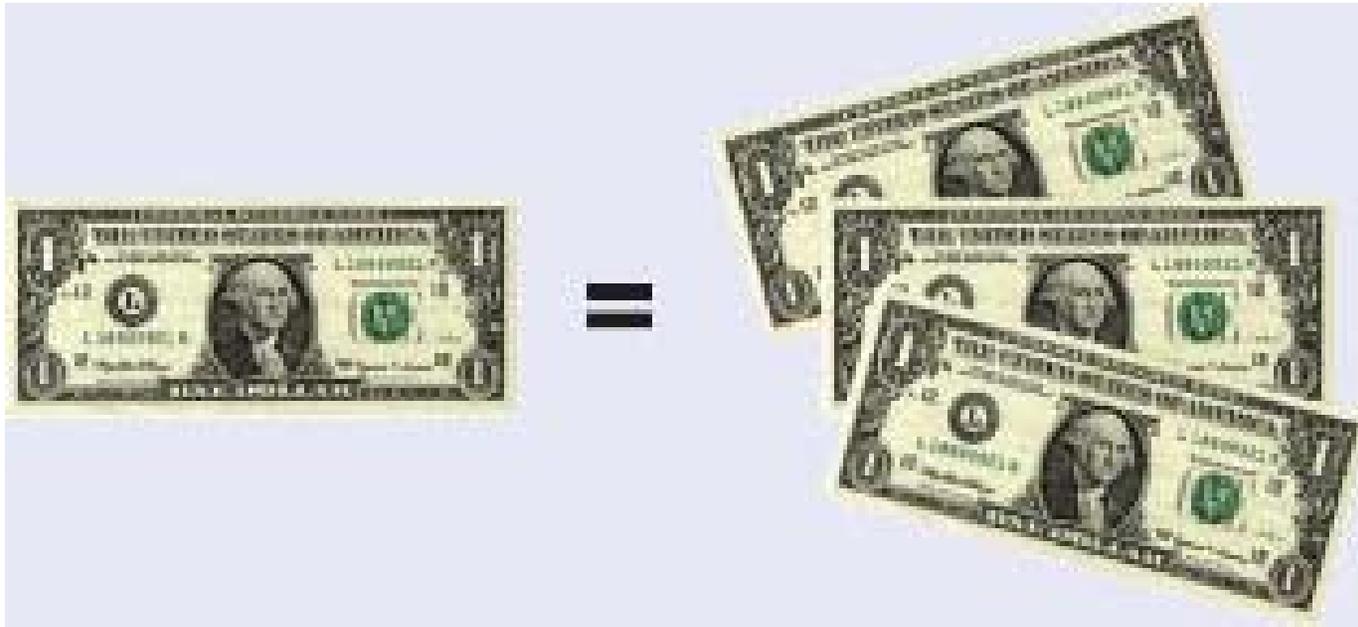


Lignite Industry Jobs in North Dakota



The lignite industry directly employs over 4000 people in North Dakota. For every direct job provided by the lignite industry, another approximately five jobs are needed to supply the industry with goods and services. Thus total employment is nearly 25,000.

Lignite Industry Business Activity in North Dakota



Lignite industry expenditures are \$734 million. Each dollar spent by the lignite industry circulates through the state's economy another three times. Thus total business activity is more than \$2.0 billion in North Dakota.

The lignite industry generates over \$83 million in state tax revenue.

Arkansas Opportunity

- ~9 Billion tons of lignite
- Largely undeveloped
- Access to CO₂ sequestration opportunities
- State government supportive of responsible development

Gasification

Industry Growth

Operating Plant Statistics 2004 vs. 2007

2004

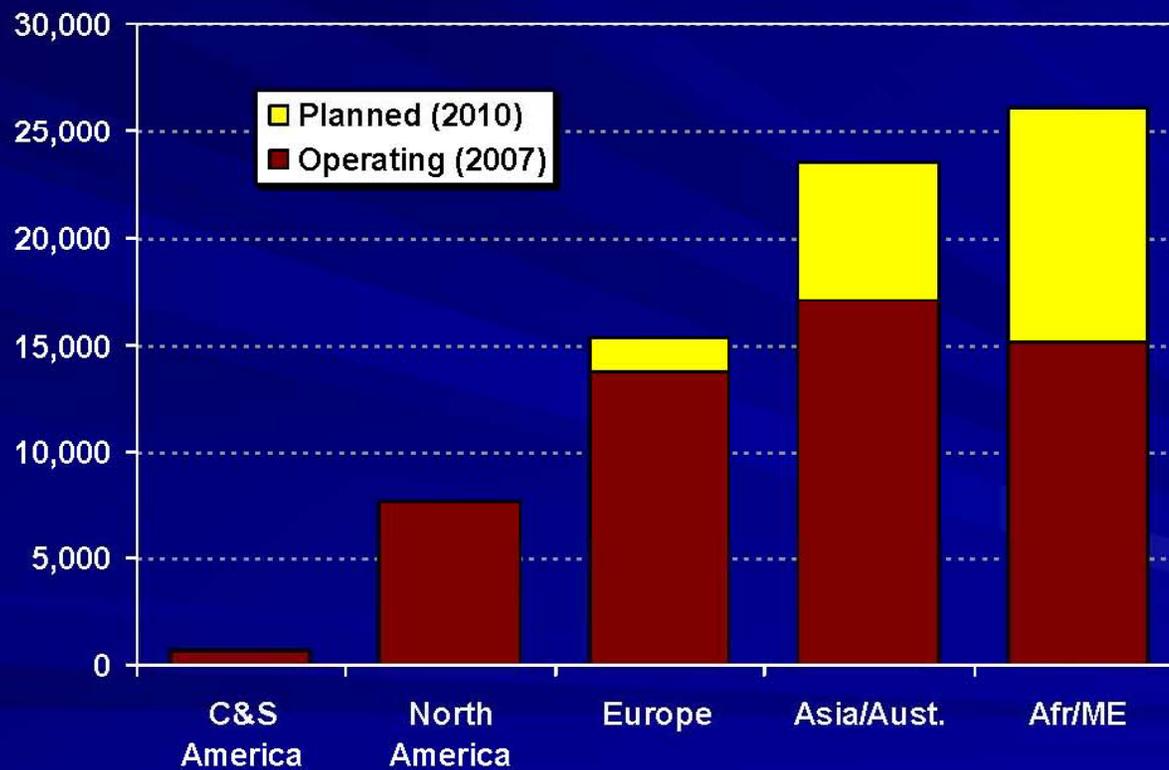
- **117** operating plants
- **385** gasifiers
- Capacity~**45,000** MWth
- Feeds
 - Coal **49%**, Pet. Resid. **36%**
- Products
 - Chemicals **37%**, F-T **36%**, Power **19%**

2007

- **142** Operating Plants
- **420** Gasifiers
- Capacity~**56,000** MWth
- Feeds
 - Coal **55%**, Pet. Resid. **32%**
- Products
 - Chemicals **44%**, F-T **30%**, Power **18%**

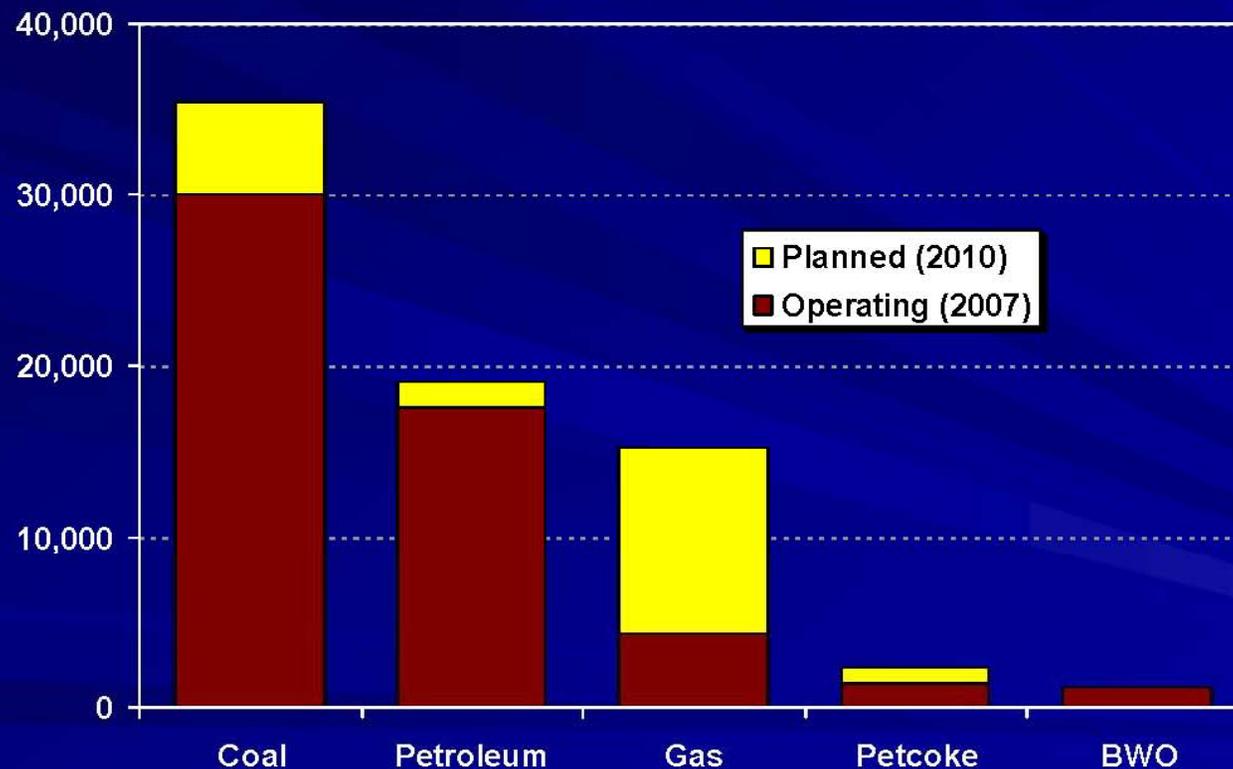
Geographical Distribution of World Gasification Capacity

(MW_{th} Equivalent)



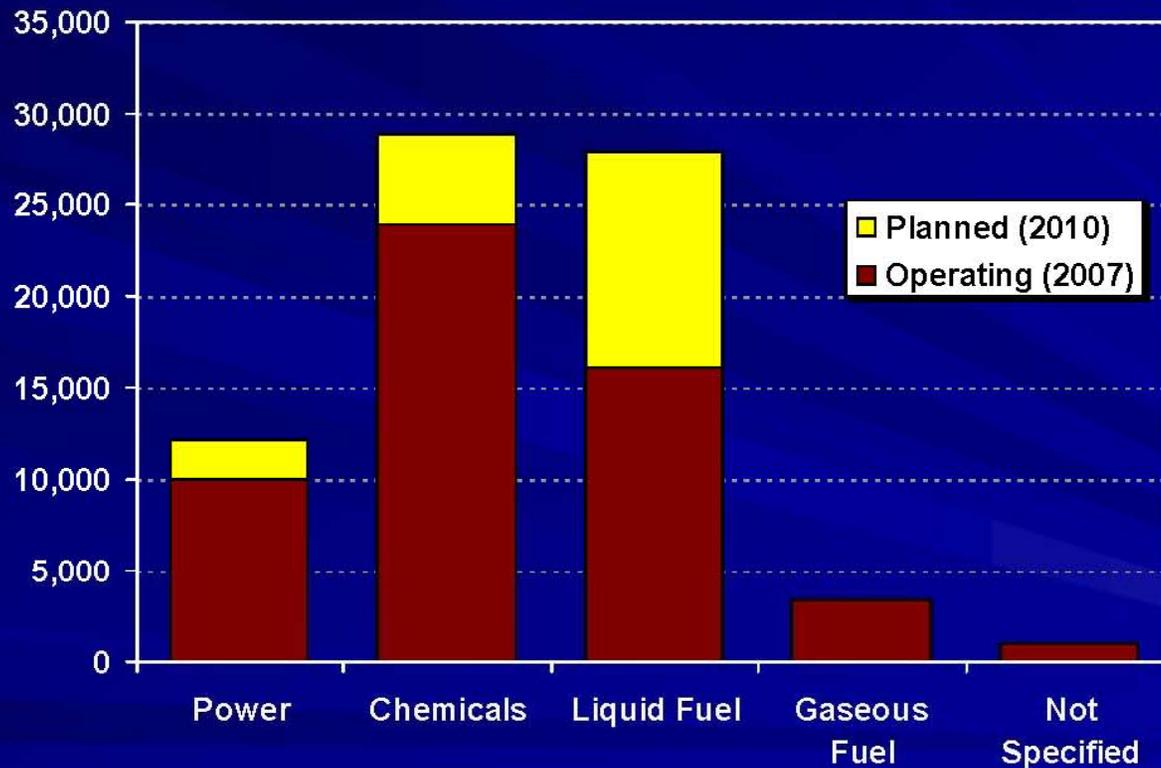
Feedstock Distribution of World Gasification Capacity

(MW_{th} Equivalent)



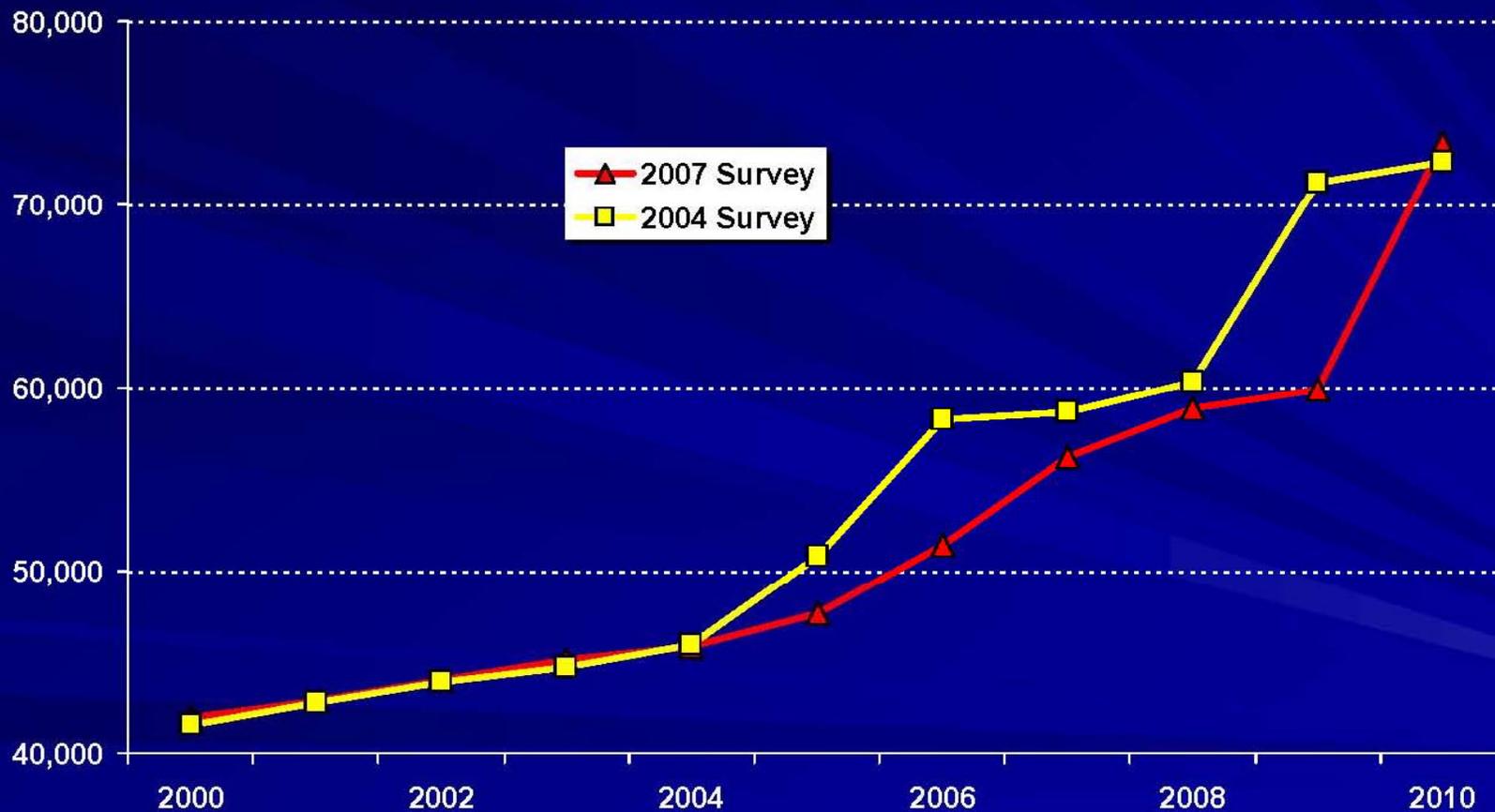
Product Distribution of World Gasification Capacity

(MW_{th} Equivalent)



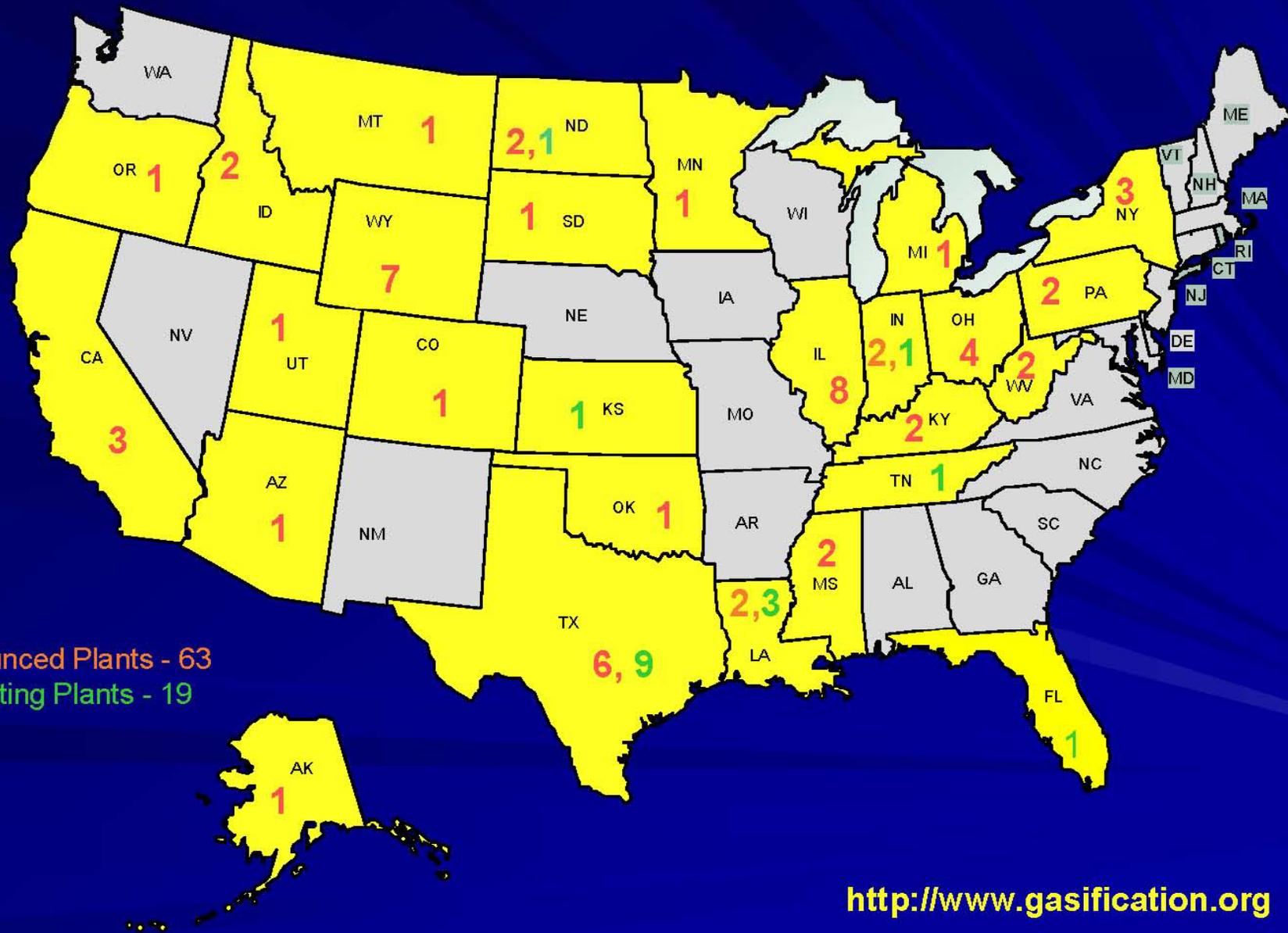
World Gasification Capacity Growth

(MWth Equivalent)



<http://www.gasification.org>

U.S. Gasification Activity



U.S. Gasification Direction

Growing demand for gasification
in face of rising NG prices:

- Chemicals, Fertilizers
- Refinery Polygen (H_2 + Power)
- Substitute Natural Gas

Carbon Capture & Compression Costs



Sources: MIT, Eastman Chemical

<http://www.gasification.org>

Lignite Gasification

Dakota Gasification Company Antelope Valley Station



Proposed Research activity

Three-Phase Activity

- Sampling and analysis of Arkansas lignite
- Use enhanced characterization and existing EERC models to rank feedstocks
- Use existing EERC facilities for proof-of-concept testing to produce Fischer–Tropsch (FT) liquids

Phase I -- Analysis

Conventional Analysis

- Proximate analysis
- Ultimate analysis
- Ash oxides

Advanced Analysis

- Computer-controlled scanning electron microscopy (CCSEM)
- Mercury and chlorine analysis
- Chemical fractionation

Phase II-- Modeling

Modeling of Gasifier Syngas and Coal to Liquids

- Model built using Aspen Plus™
 - Steady-state simulation
 - Mass and energy balances
 - Phase and chemical equilibrium
 - Reaction kinetics

Operational Challenges

- Entrained-flow gasifier (EFG)
- Fluid-bed gasifier
- Oxy-firing combustion

CABRE (Coal Ash Behavior in Reducing Environments) Predictions

- Ash formation (FactSage)
- Slag flow
- Deposition on various surfaces
- Plugging of hot-gas filters

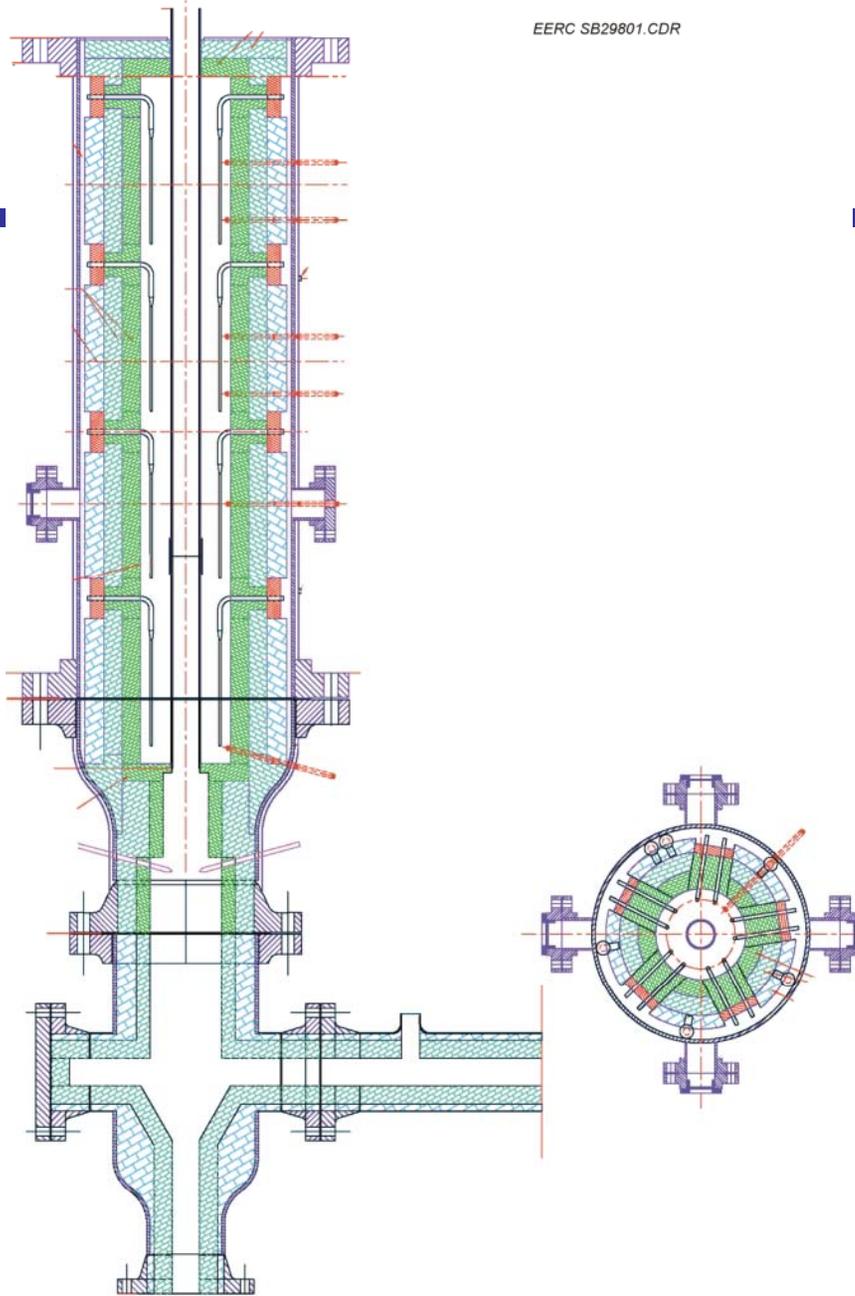
Phase III ---Proof of Concept

Bench-Scale Testing

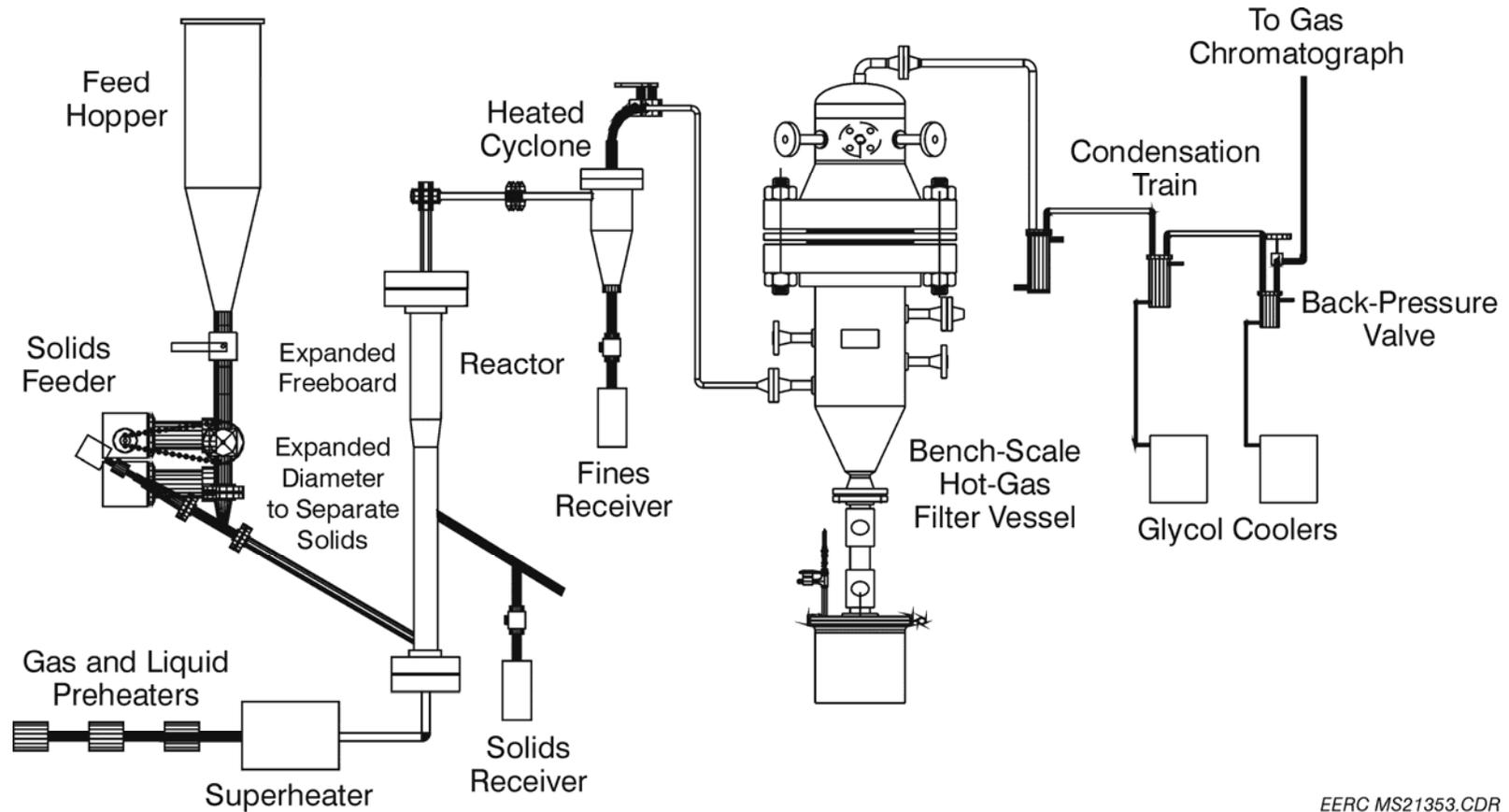
- Circulating fluidized-bed reactor (CFBR) testing
- EFG testing
- Gas cleanup and water–gas shift
- Hydrogen separation
- Liquid fuel production

EERC SB29801.CDR

Schematic of EFG

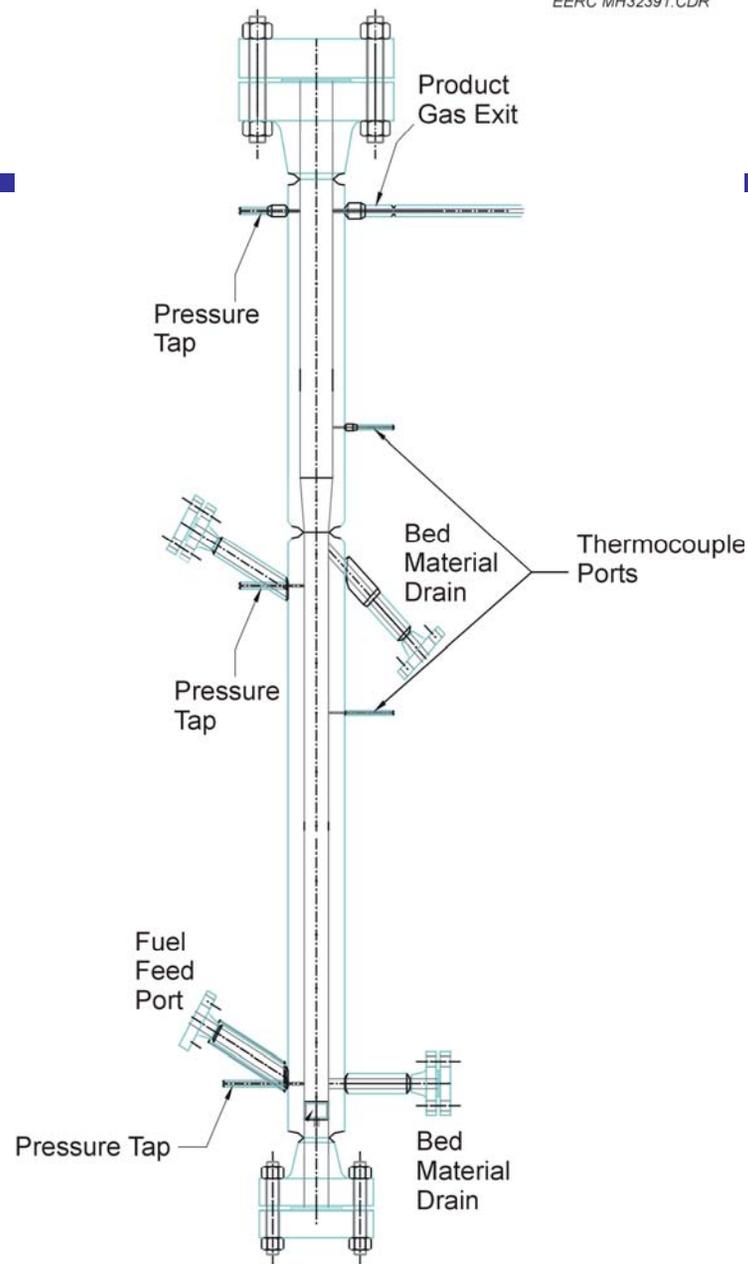


Schematic of CFBR



EERC MS21353.CDR

Design Drawing of the Pressurized Fluidized Gasification Reactor

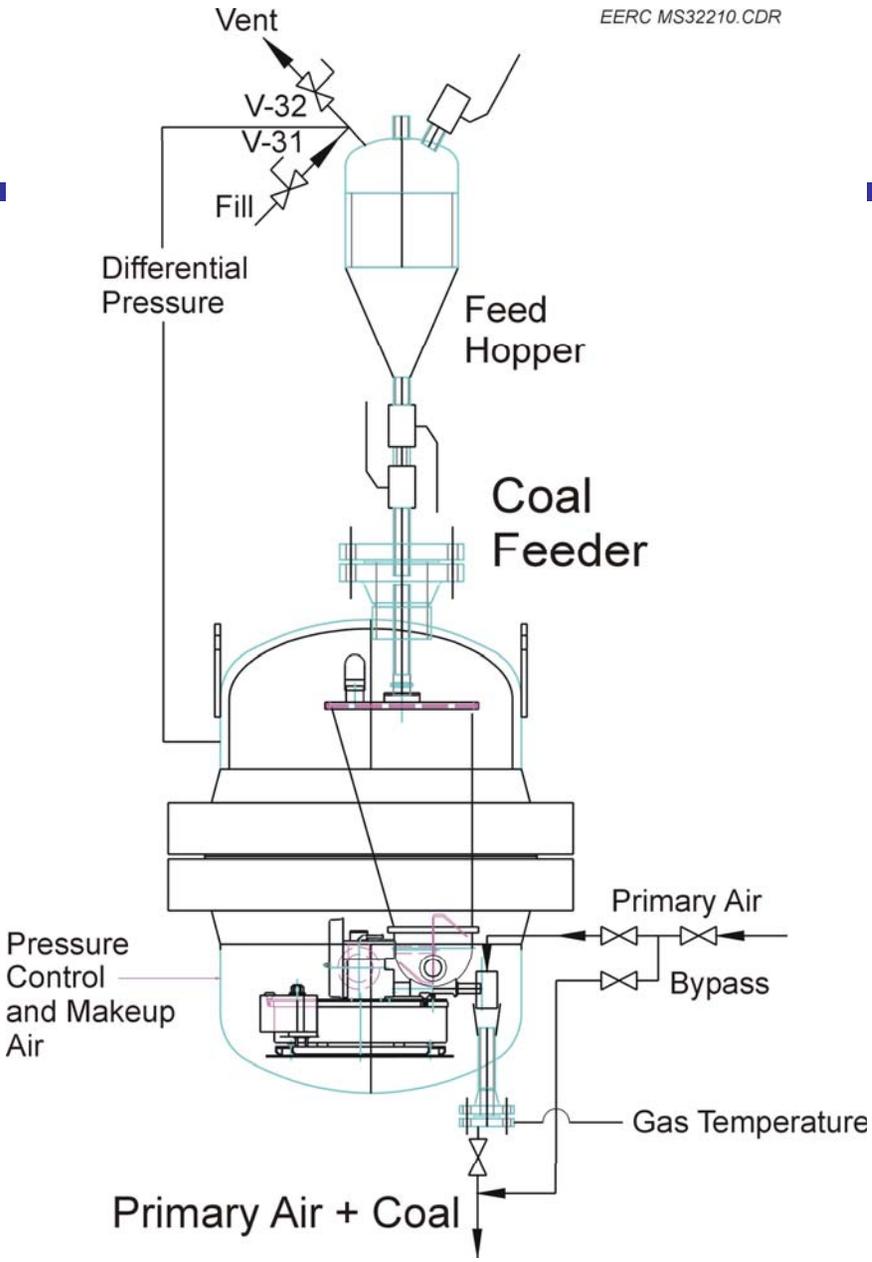


EERC Bench Scale FT Reactor

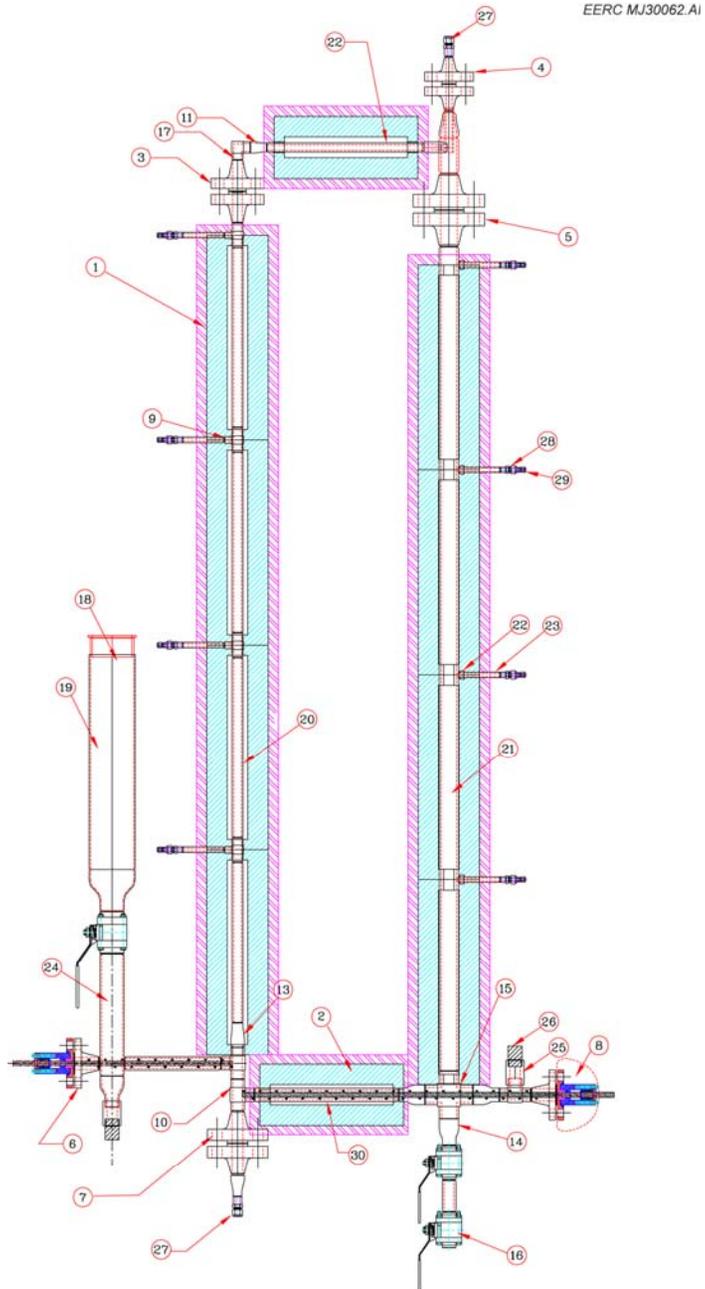
- Fixed bed reactor system
- Simulated syngas (.3 – 1 LPM)
- Supported iron catalyst pellets
 - Alumina, copper, potassium
- Hot/cold liquid traps
- Laser gas analysis



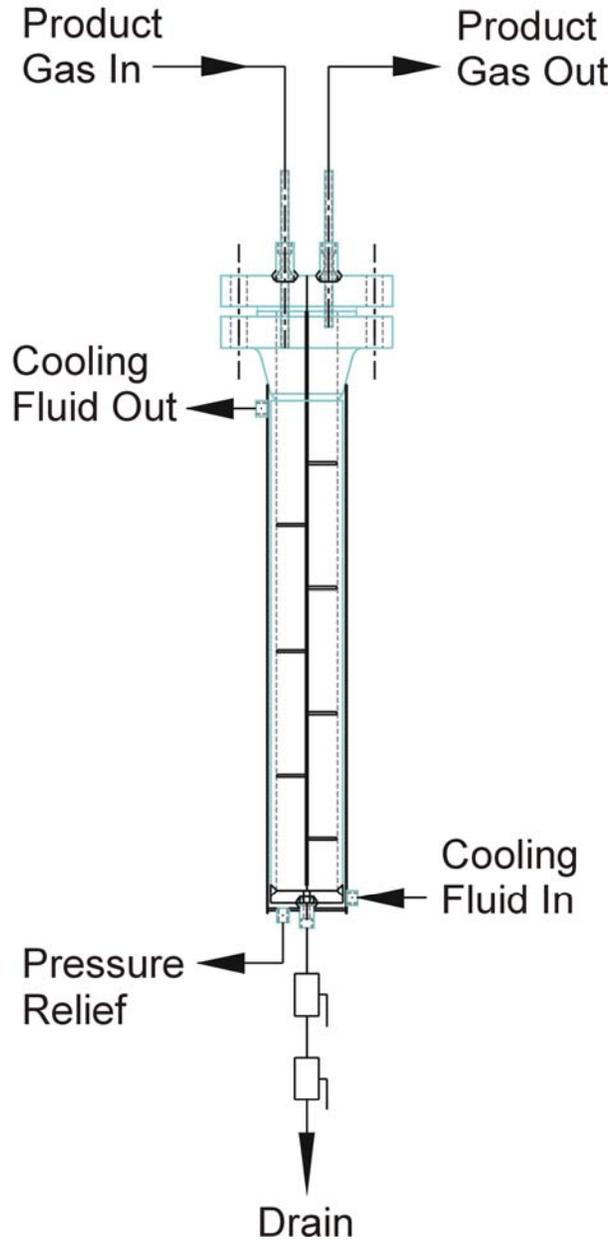
Cross-Sectional View of Fuel Feed System



Schematic of Sulfur Reactor

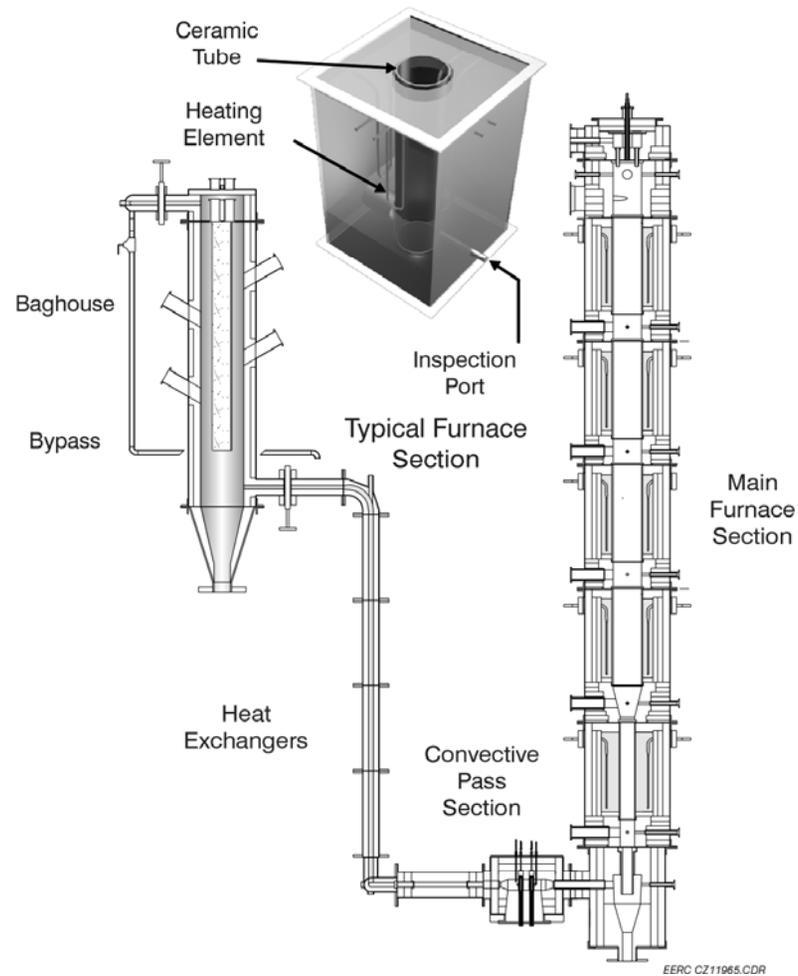


EERC MS32209.CDR



Cross-Sectional View of Quench Pot

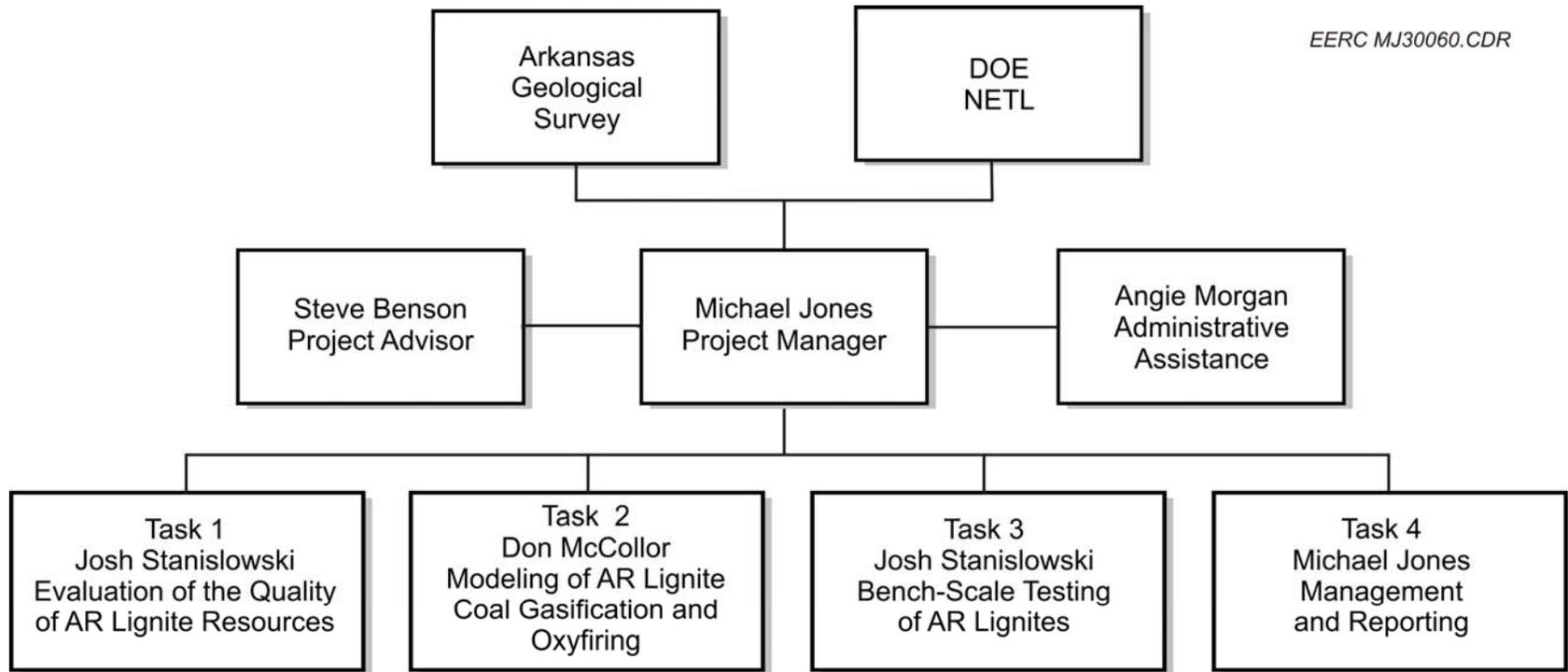
Conversion and Environmental Process Simulator



Deliverables

- Detailed analysis of Arkansas Lignite
- Identification of operational challenges using EERC models
- Proof of concept testing of Arkansas Lignite in existing EERC Gasification and combustion test units
- Samples of F-T liquids produced from the gasification of Arkansas Lignite
- Final Report

Proposed Management Structure



Contact Information

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