Southern States Energy Board and Virginia Coal and Energy Alliance

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21st Century Coal

The future of coal in the 21st Century depends on four pathways

• *Developing Coal FIRST Power Plants of the Future*

• *Advancing Carbon Capture, Utilization and Storage*

• *Expanding Coal’s Value Chain – Commercial Products, Advanced Materials, Rare Earth Elements, and Critical Minerals*

• *Coal Exports*
Outlook for Global Energy Consumption to 2050

Outlook for U.S. Coal-Fired Power Generation

Coal’s share of U.S. power generation declines over the next 30 years

Source: U.S. Energy Information Administration, Annual Energy Outlook 2020


Coal Plants Retiring

Coal plant retirements over the past decade have reduced coal-unit capacity by more than 78,000 MW

Data for 2019 are preliminary. Megawatts represent summer capacity of generating units.

Source: U.S. Energy Information Administration
Coal FIRST: The Future of Power Generation  
(Flexible, Innovative, Resilient, Small, Transformative)

- Provides a **zero or near zero CO₂ emissions**
- Provides **low cost power generation**; economically competitive
- Uses advanced materials and processes; **maximizes efficiency**
- Meets IEA solution for CO₂ emissions -- carbon capture
- Only zero or near zero CO₂ emissions power plant **R&D effort in the world**
- Potential to **revive the US coal industry**; provide a source of **high value exports**
- Provides stability and reliability to the grid of the future, and offer both **“firm and flexible” operations**

Per International Energy Agency (IEA), coal will be the largest source of electricity production in the world by 2040, and likely beyond.

- **Near-Zero Emissions**
  - Secure, Stable, Reliable Power
- **Flexible** coal plant operations to meet the needs of the grid
- **Innovative** and cutting-edge components; improved efficiency and near-zero emissions
- **Smaller** than conventional utility-scale coal plants
- **Resilient** power generation

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Coal FIRST Adapts to the Needs of Tomorrow

Coal FIRST will deliver advanced technologies that serve as building blocks to meet the variety of evolving energy needs across the globe.
Accomplishments & Next Steps

- **September 2019** – 13 Conceptual FEED Study designs completed
- **April 2020** – 7 Pre-FEED Studies to be completed
- **September 2020** – Two technology Front End Engineering and Design (FEED) Study awards
- **September 2020** – Critical components awards to advance other Coal FIRST designs.
- **Anticipated September 2023** – FEED Study designs and critical components study completed
Total U.S. Greenhouse Gas Emissions by Economic Sector in 2017

Total Emissions in 2017 = 6,673 million metric tons (MMT) of CO₂ equivalent.

- Transportation (29%)
- Electricity (28%)
- Industry (22%)
- Commercial and Residential (12%)
- Agriculture (9%)

Source: International Energy Agency
Total GHG Emissions from Power Generation by Source (2018)

U.S. CO₂ Emissions from Power Generation by Fuel Type (1,763 MMT)

- Coal: 1,150 (65%)
- Natural Gas: 581 (33%)
- Petroleum: 21 (1%)
- Other: 11 (>1%)

Source: EIA
Carbon Capture, Utilization, and Storage

Source: IEA
CCUS Provides a Third of CO₂ Reductions in B2D Scenario

Source: IEA
CCUS R&D Program Goals and Challenges

Reduce the cost of capture by 50%
- Capital cost
- Energy penalty
- Integration or process intensification

Develop viable carbon utilization alternatives ($1T opportunity)
- Reduce Capital cost
- Reduce energy requirements
- Lifecycle assessment better than existing products

Reduce the risk of geologic storage – improve monitoring and simulation
- Higher resolution and quantification (e.g., accurate characterization of faults and fractures)
- Geomechanics (pressure and state of stress)
- Costs/uncertainty/enabling real-time decision making


2012: $80/tonne
2016: $60
2020: $40
2030: $30
**Getting Additional Value from CO₂**

**Carbon Utilization R&D Program**

- **Algae Conversion (7.5 projects*)**
- **Synthesis of Fuels and Organic Chemicals (30 projects)**
- **Production of Inorganic Materials (9.5 projects*)**

*Some projects incorporate multiple conversion pathways

**Mission:** Develop technologies to recycle CO₂ into economy by transforming carbon waste streams into value-added products. Areas of research include, but are not limited to, catalytic conversion to chemicals and polymers; mineralization to building products; generation of solid carbon products; and algal conversion platforms designed to integrate into large CO₂ point sources.
Hydrogen enables a number of clean energy and transportation platforms using hydrogen from fossil energy, including oil and gas – AND coal.

Steam methane reforming primary source of H2 (~ 95% of global production).

Hydrogen production from gas and coal with CCUS can reduce emissions to near zero at lowest cost.

Market opportunities:
• Transportation vehicles
• Clean energy
• Energy storage
• Clean products

R&D Opportunities:
• Materials embrittlement
• Autothermal and gasification
• Electrolysis, turbines, SOFC
• Hydrogen storage
• Conversion technologies
• Hybrid Systems
Cost of Hydrogen from Fossil Energy Sources

Fossil Energy is the lowest cost source of hydrogen, even with CCUS

H₂ Production Cost by Technology ($/kg)

Source: Solar Hydrogen Production, Chapter 3 – Hydrogen Production
Expanding the Coal Value Chain

Coal Beneficiation Program
- New processes to maximize coal’s value as a feedstock
- New technologies for value-added products from coal
Inherent carbon content of coal means it can be used as a feedstock to manufacture a wide range of products and materials.

Current global market for coal-to-products is estimated to consume 300-400 million tons/year of coal.

That market has the potential to consume another 300 million tons/year of coal.

National Coal Council *Coal in a New Carbon Age*
Opportunity – A Paradigm Sift in the Construction Market

Composites Require Holistic Rethink of Manufacture

Carbon Buildings + Cloud-Delivered CAD-CAM for Everyone

Materially-Driven Environmental Agendas – Not Code Driven

More Upstream Jobs (Materials, CAD-CAM), Less Site Labor

Global Building – 1 Million People Per Week Joining Urban Communities to 2050

Vast Potential Export Market
Rare Earth Elements from Coal and Coal Byproducts

Opportunities for REE Recovery Span the Coal Value Chain
Eliminate materials criticality as an impediment to the commercialization of clean energy technologies for today and tomorrow.

Development of an economically competitive and sustainable domestic supply of rare earth elements (REEs) and critical materials (CMs) to assist in maintaining our Nation’s economic growth and National Security.
Global Coal Imports

Total coal imports by major importers, 1971-2018

Mt

- Germany
- China
- India
- Japan
- Korea
- Chinese Taipei

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Exports – Increasing Share of U.S. Coal Disposition

Source: U.S. Energy Information Administration, Annual Coal Report, and the U.S. Department of Commerce, Census Bureau
Coal Exports – 116 MST in 2018

U.S. Energy Information Administration, Annual Coal Report, and the U.S. Department of Commerce, Census Bureau
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