Re-envisioning Coal
Coal Use in Non-conventional Markets

Janet Gellici, CEO, National Coal Council
Cosmos Club Science Group
May 6th, 2019 – Washington, DC
The National Coal Council provides advice and recommendations to the Secretary of Energy on general policy matters relating to coal and the coal industry.

Celebrating 35 years – 1984|2019

Members
Appointed by Secretary of Energy
Limited to 125-150 members representing a broad spectrum of coal interests
Reports
~ 35 reports prepared by NCC members at no cost to DOE
Extensive Range of Report Topics:

Carbon Management
Clean Coal Technologies
Coal & Coal Technology Exports
Coal Conversion
Utility Deregulation
Climate & Clean Air Regulations
Enhancing Coal’s Image
Building New Coal Plants

Industrial Coal Use
CCUS for EOR
Value of Existing Coal Fleet
Advancing CCS Technologies
Policy Parity for CCS
CO₂ Utilization
Advancing U.S. Coal Exports
Power Reset: Existing Coal Fleet
“A diamond is a chunk of coal that did well under pressure.”

~ Henry Kissinger
Coal in a New Carbon Age

The Secretary of Energy
Washington, DC 20585
August 31, 2018

Mr. Dock Slone
Chairman, The National Coal Council
1000 Independence Avenue SW, Room 4G-036
Washington, DC 20585

Dear Chairman Slone:

I am writing today to request the National Coal Council (NCC) develop a white paper assessing opportunities to enhance the use of U.S. coal beyond power markets.

The white paper should focus on new markets for “coal to products” including coal to conversion (coal to liquids, coal to gas, coal to chemicals); carbon engineered products (value-added non-Btu products); rare earth elements; coal combustion products, methanol; biotechnology approaches (agriculture, liquid fuels); and beneficiated coal for non-power uses, among others.

The key questions to be addressed include:

- What significant market-scale opportunities exist for new markets for coal?
- What are the economic, energy security, trade, and other issues the U.S. faces now that can be addressed with new markets for coal?
- Considering the current uses for coal overseas (syngas, chemicals, synthetic oil, transportation fuels, etc.), where and how are these markets operating today and what is the outlook for these markets going forward?
- What has been the domestic history of coal utilization and what can be learned from past successes/failures in coal utilization?
- How can domestic markets for utilization (other than for CO2) be developed similar to those underway in other countries?

The white paper should be managed under the auspices of the Executive Advisory Board within the NCC. I ask that the white paper be completed no later than April 12, 2019.

Upon receiving this request and establishing your internal working group, please advise me of your schedule for completing the white paper. The Department looks forward to working with you in this effort.

Sincerely,

Rick Perry

Rick Perry
Coal in a New Carbon Age

• The Value of Advancing New Markets for Coal
• International Activity
• U.S. Historical Efforts
• Trends & Outlook for Coal-Derived Products in the U.S.
• Recommendations
• + Technology Compendium Appendix
Coal-to-Products

BENEFICIATION

Indirect Coal Liquefaction (ICL)

GASIFICATION

Direct Coal Liquefaction (DCL)

HYDROGENATION

High Temperature COKING

Mild Temperature PYROLYSIS

ELECTRIC ARC

SYNGAS

METHANATION

METHANOL

MTO

MTA

MTG

FISCHER-TROPSCH SYNTHESIS

AROMATICS & LIGHT OIL

COAL TAR PITCH & COKE

CHAR

Upgraded Coal (size/sulfur/ash reduced)

Upgraded Coal (dried/heat treated)

Synthetic Natural Gas (SNG)

Polyolefins, polyethylene, polypropylene

Aromatics

Gasoline, naphtha

Diesel, naphtha, gasoline

Electrode materials, needle coke, binder

Synthetic graphite, battery materials

Carbon fibers, graphite foam

Activated Carbon

Carbide, acetylene
Coal Beneficiation

Physical coal preparation technologies

Dense media wet separation:
- dominant prep technology
- need to improve recovery of fines + reduce wastes

Dry separation:
- sorts coarse and small coal
- increasing use in drought regions
- attracting solutions such as x-ray sorting

Cost: 2 - 10 US$/t
Coal to Liquids
Coal to Chemicals

Gasification-Based Coal to Chemicals Process
Coal to Liquids
Coal to Fuels

Typical Direct Coal Liquefaction Process
Coal to Products

- Graphite
- Carbon Fibers
- Activated Carbon
- Graphene
- Carbon Nanotubes
- Carbon Foam
- Carbon Black

- Electrodes
- Seals & bearings
- Fishing rods
- Golf clubs
- Automotive materials
- Airplane fuselages
- Building materials
- Water purification
Activated Carbon
Carbon to Graphite & Electrodes
Graphene Application Field by Product

- Transistor
- Sensor
- Display
- Solar cell
- Touch Panel
- Flexible Display
- Semi
- Ink
- Conductive Ink
- EMI Screen Ink
- Bio, 3D Printing
- TCO
- Barrier
- Energy
- Super Capacitor
- Battery
- Composite
- Thermal
- Thermal Materials
- Paste, Paint
- Film
- Automobile
- Air Plane
- Components
Rare Earth Elements

The Rare Earth Value Chain

Raw Materials
- Bastnäsite
- Monazite
- Ionic Clays
- Other

Basic Rare Earth Materials
- Separated Rare Earth Oxides, Carbonates, Oxylates, Chlorides, & Nitrates
- Rare Earth Mixed Oxides
- Rare Earth Metals
- Other

Engineered Rare Earth Materials
- Rare Earth Alloys
- Magnets & Magnetic Powders
- Catalysts
- Metallurgical Additives
- Polishing Powders
- Phosphors
- Glass Additives
- Ceramics
- Water Purification Chemicals
- Other

Component & Systems
- Batteries
- Controls
- Drives
- Fabricated Metal Products
- Lasers
- Motors & Generators
- Sensors
- Transducers
- Other Systems & Components

End Market Products & Technologies
- Health Care Technologies
- Hybrid, Electric & PHEVs & Other Vehicles
- HVAC and Home Appliance Systems
- Consumer Electronics
- Energy Efficient Lighting
- Communications & Electronics
- Audio Equipment
- Defense Technologies
- Other Electronics
- Advanced Optics & Other Glass Products
- Oil Refining
- Electric Power
- Other
Life Sciences & Medical

- Drug Discovery
- Disease Detection
- Prosthetic Devices
- Water Quality Management
- Environmental Monitoring
- Soil Quality Monitoring
- Food Quality Monitoring
- Toxins of Defence Interest
- Biosensor
Soil Amendments – Humic Acid/Humate
Market Sectors
Nine Block Analysis

Market Attractiveness
- Market size
- Market Growth Rate
- Attributes

Competitive Strength
- Relative market share
- Ability to compete on price & quality
- Competitive strengths & weaknesses
Value of New Markets for Coal
## Global Coal Reserves

<table>
<thead>
<tr>
<th>Country</th>
<th>Million Tonnes</th>
<th>Share</th>
</tr>
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<tbody>
<tr>
<td>U.S</td>
<td>258,709</td>
<td>25.0%</td>
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<tr>
<td>Russia</td>
<td>160,364</td>
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<tr>
<td>Australia</td>
<td>144,918</td>
<td>14.0%</td>
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<tr>
<td>China</td>
<td>139,919</td>
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<tr>
<td>India</td>
<td>97,728</td>
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<tr>
<td>Germany</td>
<td>36,100</td>
<td>3.5%</td>
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<tr>
<td>Ukraine</td>
<td>34,375</td>
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<tr>
<td>Poland</td>
<td>25,811</td>
<td>2.5%</td>
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<tr>
<td>Kazakhstan</td>
<td>25,605</td>
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<tr>
<td>Indonesia</td>
<td>22,598</td>
<td>2.2%</td>
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<tr>
<td>Other</td>
<td>88,885</td>
<td>8.6%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,035,012</strong></td>
<td><strong>100.0%</strong></td>
</tr>
</tbody>
</table>

Source: BP Statistical Review of World Energy, June 2017
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