UW’s Carbon Engineering Initiative: Converting Coal to High-Value Carbon Products and Chemicals

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KIPP CODDINGTON
DIRECTOR, CARBON MANAGEMENT INSTITUTE
SCHOOL OF ENERGY RESOURCES
UNIVERSITY OF WYOMING (UW)
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OUTLINE

• One View from Wyoming

• Non-energy & Fuel Market Opportunities

• Transformation of Coal to High Value Chemicals & Materials

• University of Wyoming Carbon Engineering Initiative
One View From Wyoming (And There Are Other Perspectives)

Caveat: We are talking about new markets for coal; low-carbon technologies for Btu value (high efficiency, CCUS) all remain in the mix, and we are working on many of those, too.

Near Term (<10yrs): Grow Exports Overseas

- Beholden to neighboring states cooperating
- Environmental opposition - International carbon regulation/commitments and actions
- Volatile coal prices in Asia
- New Asian import tariffs/local free trade agreements
- Financial sentiment for funding projects

Medium Term (>10yrs): Develop CO₂ Capture & Utilization Solutions (CCUS)

- Present technologies not proven at scale, with the economics of retrofit constraining coal fired electricity generation & power industry profitability
  - Focus on EOR plus saline research (Rock Springs Uplift)
  - Wyoming Integrated Carbon Capture Test Center

Long Term (15 yrs +): Convert Coal into High Value Carbon-Based Products & Chemicals

- New research required to develop the technologies that meets the demands for and the constraints on the full utilization of coal in a carbon-constrained world
  - Creates new jobs and investment in the State
  - Significant investment in research and technology required – University of Wyoming leading pursuit of Carbon Engineering
  - Attracting industry interest and investment are key
Back to the Future: Non-Energy & Fuel Market Opportunities for Coal

Reference: US Geological Survey
The first oil refining process was invented to upgrade “coal oil” more than 150 years ago … and before Edwin L. Drake touched off a boom with his discovery of oil in Pennsylvania.
UW Is Looking at New Markets for Coal

• Use coal as source for manufacturing non-metals and chemicals
  Captures value beyond coal’s btu value
  Turns CO₂ generated during conversion into products … or does not make it in the first place

• Coal-to-chemicals plants are being built or planned in:
  China, Germany & India

• Demand for carbon-based materials is rising
  • Light-weighting
  • Substitution for metals (Existing Markets)
  • New Markets for (carbon) material classes
  • Superior functional performance of carbon materials over metals
  • Rising growth in non-metallic materials & industrial chemicals > GDP Growth Projections
UW’s Carbon Engineering Approach
Coal Fed Refinery: Design Requirements

• Maximize Yield of carbon-based intermediates & finished products
• Product slate value > coal Btu value
• Full conversion of primary (PRB) coal feed
  – Include other feeds (gas/LNG/shale oil/biomass) only to support this prerequisite
• Deliberate H₂ recovery & reuse from coal
• Extraction & complete process use of water extracted from coal
• Zero or minimal pure-stream CO₂ emissions
• Optimal energy consumption
  – exothermic rather than endothermic processing
• Zero effluent discharge & water consumption neutrality
The Coal Refinery – Adding Premium Value Beyond BTUs

Current Product Slate
- Petrochemicals
  - Olefins
  - Acetyls
  - Alcohols
  - Aromatics
  - Asphalt
- Gasoline
- Diesel
- Naptha
- Aromatics
- Base Oil & Lubes

New Carbon Product Solutions
- Petrochemicals
  - Acetyls
  - Alcohols
  - Aromatics
  - Asphalt
  - Carbon Fiber
  - Carboxylates
  - Needle Coke

Potential Product Slate
- Coal chemicals
  - Pitch
  - Activated Carbon
  - Carbon Composites
  - Aerogels
  - Graphene

Common Product Families
- Petrochemicals
- Gasoline
- Diesel
- Naptha
- Aromatics
- Base Oil & Lubes

Investment in Carbon Engineering

Coal Refinery (Carbon Rejection)

Petroleum Refinery (Hydrogen Addition)
Coal Conversion to Non-Btu & Energy Products: At the Mine or Elsewhere

At the Mine

Coal Mine

Non btu & Fuel Products

Existing Revenue Stream

New Revenue Stream

$+

$++

At the Coal Fired Utility Plant

Non btu & Fuel Products

Coal Fired Utility

Carbon Capture

New Revenue Stream

Existing Revenue Stream

Existing Revenue Stream

$++

$+

$-$

New Revenue Stream

Existing Revenue Stream

Existing Revenue Stream

$++

$+

$-$
Scale and Magnitude of a Coal Refinery: Value versus Volume

• On average 1 ton of coal contains about 21 gigajoules of energy

• Assuming full-conversion, 1 ton of coal could make 159 gallons of gasoline

• A 100,000 crude oil bbl/day full conversion integrated (fuel & chemicals) refinery manufactures 586,200 Giga-joules of product

• On an equivalent basis this equates to 28,000 tons of coal/day or about 4% of Wyoming daily coal production
Aspirational Outcomes

Develop a sustainable stream of valuable carbon-based products, leveraging WY’s competitive coal advantages of coal

University of Wyoming 2 Year Plan (Appraisal & Evaluation)

In Progress

• Stoichiometric determination of the slate of possible products that might be manufactured from Wyoming Powder River Basin coal - assuming full conversion
• Outputs will be used to develop econometric coal refinery model
• Understand (carbon) product markets suited to coal conversion

To-Do – Coming Year

• Establish techno-economic viability of coal refinery
• Research the decomposition properties of Wyoming coal, leveraging its competitive advantage
• Scope coal conversion and carbon materials from coal research projects
• Determine the compelling business case (facility scale and scope) that will attract investors to want to make the coal refinery happen in Wyoming
Thank you

Kipp Coddington
Director, Carbon Management Institute
School of Energy Resources
University of Wyoming
1020 E. Lewis Street
Energy Innovation Center
Laramie, WY 82071
Ph: (307) 766-6731
kcodding@uwyo.edu