

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

NATIONAL COAL COUNCIL SPRING MEETING
APRIL 20, 2016
WASHINGTON, DC

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Acknowledgements & Special Thanks

Mark Northam, Director, School of Energy Resources (SER)

Richard Horner, Deputy Director of Emerging Projects & Technology, SER

Carl Bauer, former Director, Carbon Management Institute & consultant, SER

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)

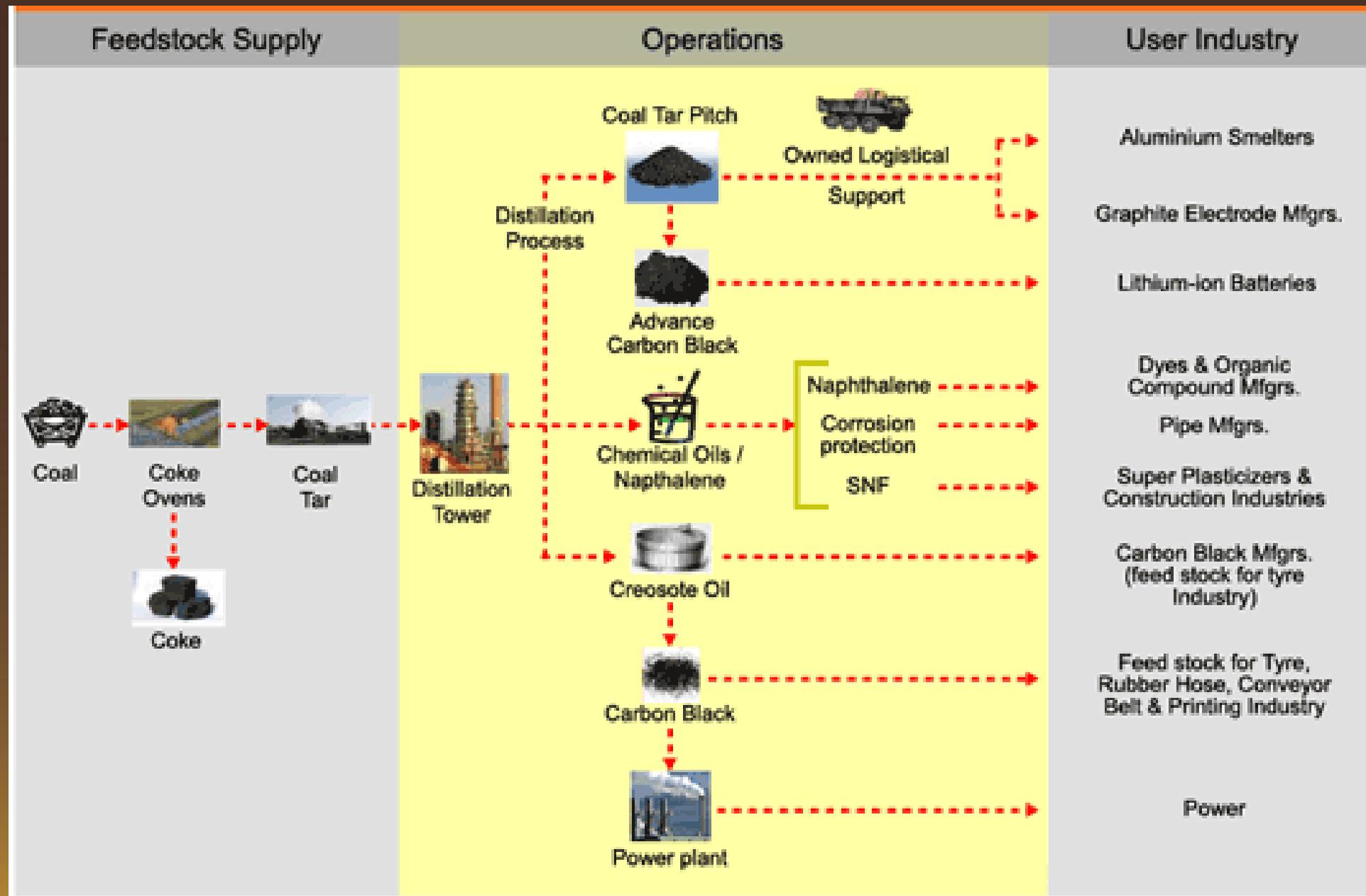
- **Present technologies not proven at scale, with the economics of retrofit constraining coal fired electricity generation & power industry profitability**
 - Focus on EOR plus saline research (Rock Springs Uplift)
 - Wyoming Integrated Carbon Capture Test Center

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

Coal – or “Carbon” – Refineries Were There at the Beginning

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

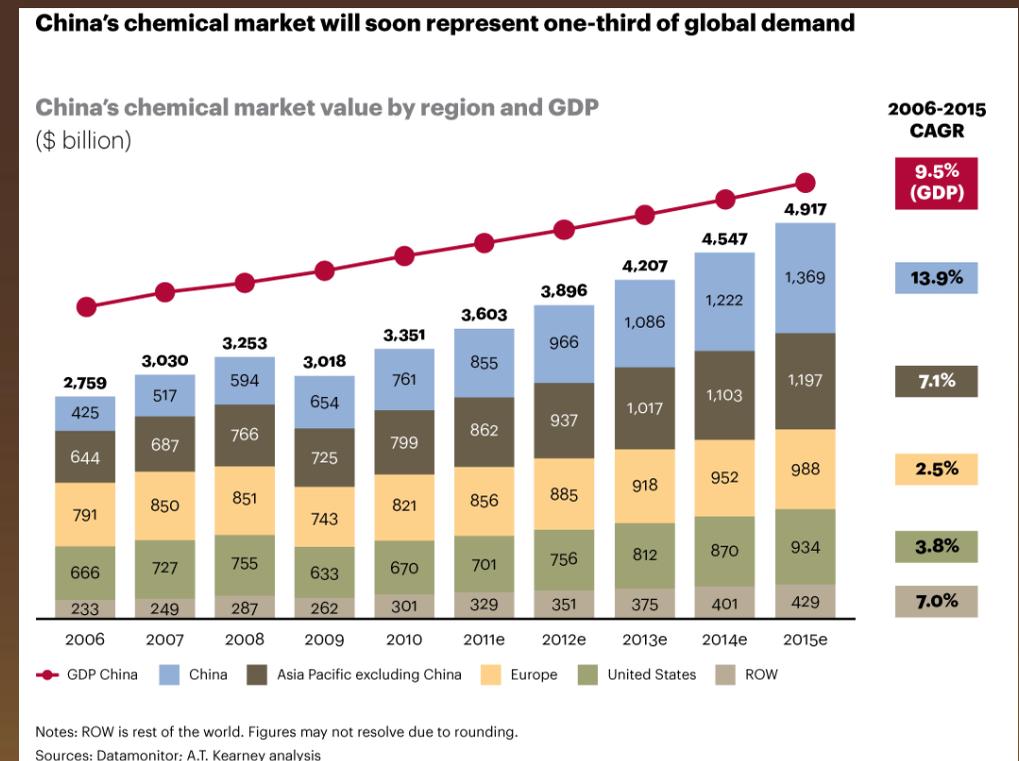
Turns CO₂ generated during conversion into products ... or does not make it in the first place

- 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



Petroleum Refinery
(Hydrogen Addition)



PRB Coal

Coal Refinery
(Carbon Rejection)

Common
Product
Families

*New
Carbon
Conversion
Solutions*

Current Product Slate

- Petrochemicals

- Olefins
- Acetyls
- Alcohols
- Aromatics
- Asphalt

- Gasoline
- Diesel
- Naptha
- Aromatics
- Base Oil & Lubes

- Coal chemicals

- Pitch
- Activated Carbon
- Carbon Composites
- Aerogels
- Graphene

*New Carbon
Product
Solutions*

**Potential
Product
Slate**

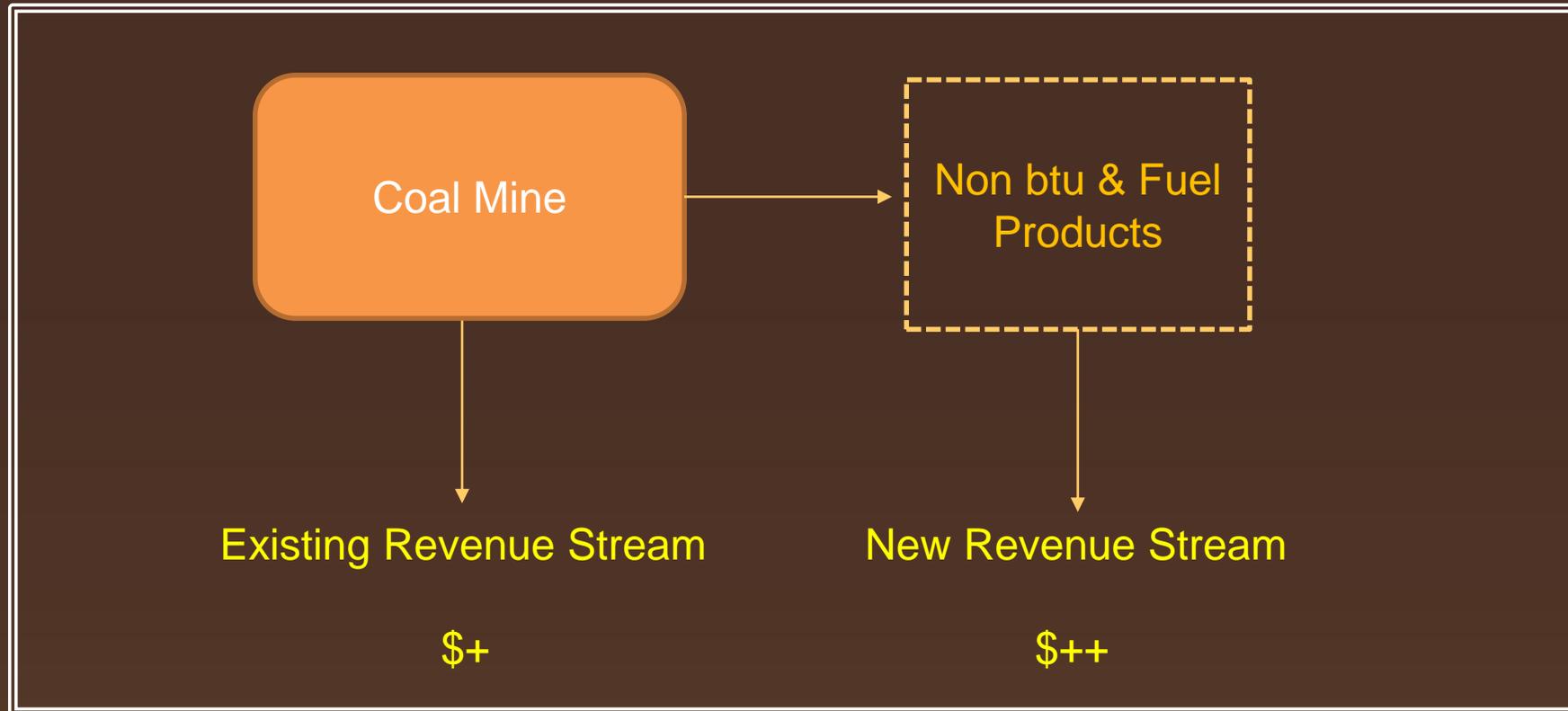
- Petrochemicals

- Acetyls
- Alcohols
- Aromatics
- Asphalt
- Carbon Fiber
- Carboxylates
- Needle Coke

Investment in Carbon Engineering

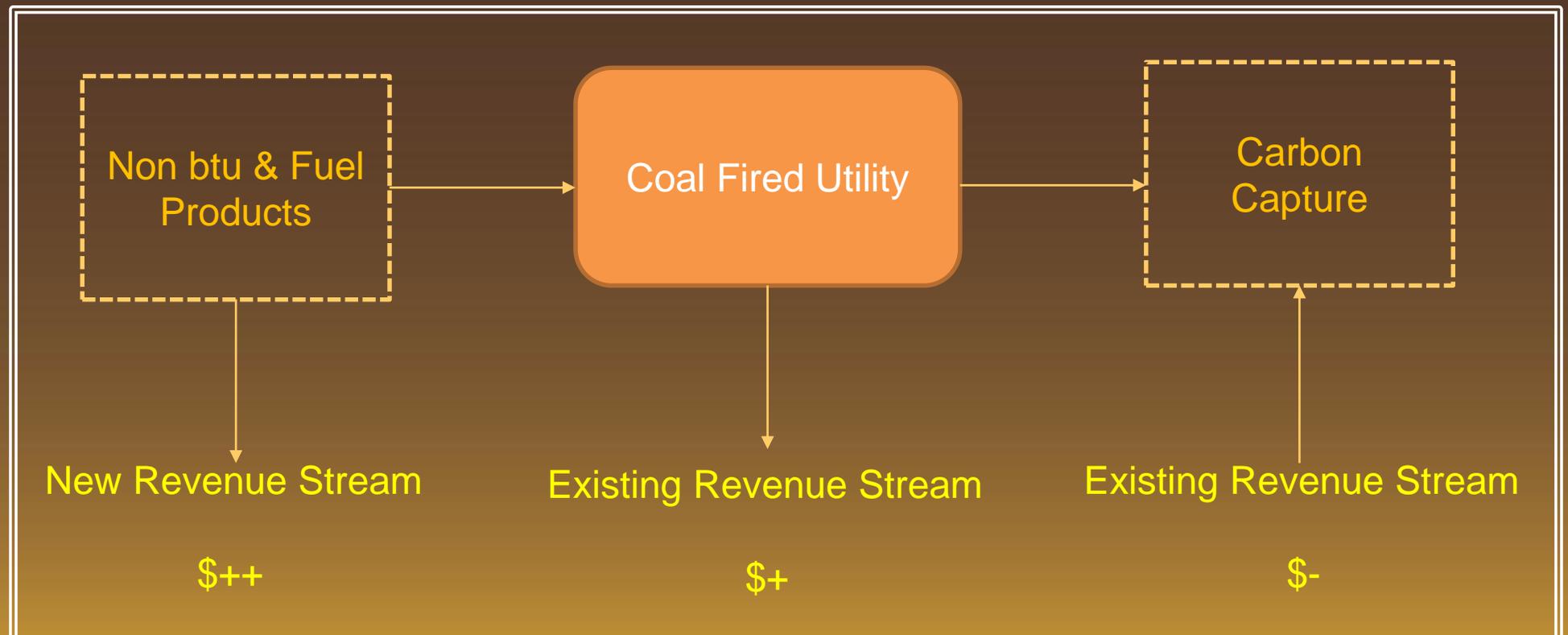


Coal Conversion to Non-Btu & Energy Products: At the Mine or Elsewhere



At the Mine

At the Coal Fired Utility Plant



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

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