“Coal to Cars”
and a Few Other Things
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An Optimistic But Disruptive Approach to Coal

Fact One: Currently, 95% of all coal produced worldwide is burned for power generation. Only 5% is used to make higher value products. That coal is sold for a higher price. Think met coal for steel at 10x PRB prices.

Fact Two: Long term, the safest bet is that coal may not prevail in the “race to the bottom” as the cheapest base load fuel for power generation.

So… How Do We Diversify Coal’s Future?

The Answer: Create a more intelligent use for coal, with a higher value end use, which will lead to a higher price paid for the coal and ultimately far greater use.
The Plot...Don’t Mine to Coal to Burn it
Develop a Higher Value Use...Sell Coal at a Higher Price

- Ramaco’s experience in metallurgical coal has taught us that “all coal is not created equal”. It is surely is not priced the same.

- So if the ultimate use of your coal is for a higher value product, then you can sell the coal for more money.

- Ramaco’s approach, however, may not be everyone’s role model.

- Ramaco owns all of its mineral in the ground (no 12% royalties). We also enjoy a fundamentally low cost of ownership. This allows Ramaco more financial flexibility and time to innovate.
Why and What are we up to?

- Thermal coal (especially in Wyoming) has some “material” quality advantages, such as higher carbon, coal tars and fewer contaminants.

- There have also been recent extraordinary advances in both: 1) Material Science and 2) Advanced Manufacturing techniques. We believe these will allow coal to be used in new ways.

- So, Ramaco proposes to borrow from other parts of the mining industry and “refine” coal down to its essential element… carbon. As carbon it is more suitable for higher value products.

The Approach Step by Step:

1) The Brook Mine. A coal mine
2) The iCAM. A carbon based research campus
3) The Wyoming iPark. A mine-mouth coal to carbon products industrial park

Together, these three components will provide carbon-based manufacturers the world’s only fully integrated carbon resource, research & development and production facility. All…here in Sheridan.
Who is Ramaco?

- Founded in 2011 as a coal reserve acquisition and development company. It stands for “Randy & Mike Acquisition Company”…

- Partnered with institutional capital from two successful energy private equity groups: Yorktown Energy Partners and Energy Capital Partners.

- First acquisition: the Brook Mine property in Sheridan.

- Ramaco has now grown to comprise three separate operations, which operate under a common umbrella we call Ramaco Coal:

  1) **Ramaco Resources, Inc. (NASDAQ – METC)**: The US first new coal IPO in ten years launched February 2017. Resources is a pure play metallurgical coal operating company in the East. We produce “Coal for Steel”, with projected full production of approximately 5 million tons of high quality, low cost met coal, with a stock market value of approximately $200+ million and no debt.

  2) **Ramaco Royalty, LLC**: a company which owns approximately 300 million tons of high quality metallurgical coal reserves and related infrastructure assets in the East.

  3) **Ramaco Carbon, LLC**: Our Wyoming based company focused on the “Coal to Products”. Carbon owns both our 1.1 billion ton mineral reserve in Wyoming and the Brook Mine.
Ramaco Carbon’s Operations

RAMACO CARBON has three components:

**COAL MINE:** The Brook Mine, with 1.1 billion tons of coal resource on a 15,000 acre site six miles north of Sheridan, WY, now under permit review.

**RESEARCH PARK:** The iCAM (or iCarbon Advanced Materials Center) will house national laboratories, university and private research groups and strategic manufacturing partners, conducting applied research and development on turning carbon into products.

**INDUSTRIAL PARK:** the Wyoming iPark (“iPark”), will be a unique mine-mouth zero emissions “coal to products” industrial park. It will utilize coal from the Brook Mine to ultimately create high-value carbon products – think: carbon fiber, carbon based building products, activated carbon and industrial gases.
Ramaco Carbon Org Chart

- RAMACO Carbon
  - BROOK MINE
    - WYOMING iPARK
    - iCAM
Ramaco Carbon’s Wyoming Operations
“In Case You’re Lost”
The iCAM

- The **iCAM** is a research park expected to begin permitting this year and open in 2018. It will be the first component of the **Wyoming iPark**.

- The **iCAM** Center will provide office, research and lab space to incubate carbon related projects from bench scale to pilot stage. Successful projects will then move to full-scale commercial operations at the **iPark**.

- The **Western Research Institute** of Laramie has been a partner from the beginning and will move their coal technology research to the **iCAM**.

- Judge us by the company we keep:
  
  **The Fluor Corporation- Project Innovation and Engineering Management**

- Research partners include:
  - **Oak Ridge** National Laboratory Carbon Fiber Center
  - **MIT**’s Grossman Advanced Carbon Materials Group
  - **Duke** University Nichols School of the Environment
  - **Southern Research Institute**

- The **iCAM** is also working with **Sheridan College** to create a vocational center for both local students and current workers, to offer the training in new carbon manufacturing operations.
iCAM
Initial Conceptual Design

The **iPark** and **iCAM** designs are being developed to compliment the land, and provide a unique architectural research and vocational campus. Permitting to begin this summer. Construction in 2018.
The Wyoming iPark  
Home for Advanced Manufacturing

- The **iPark** will house a number of advanced carbon industrial plants. The “**Brook Mine coal to Plant**” logistics eliminate transportation costs.

- The plants will take coal from the **Brook Mine** as feed-stock for high “value added” carbon products.

- The list of materials we hope to manufacture include:
  - Carbon Fiber and Carbon Fiber Reinforced Plastics
  - Resins
  - Graphite & Graphene,
  - Carbon Nanotubes and other new forms of composite materials
  - Host of Others…
Why are we trying this?
One Answer: Coal has some “Material” Advantages

- **The challenge and the opportunity:** There is a lot of very valuable material in a seam of coal, but it is mixed with a lot of “other stuff.”

- A typical seam of coal has more than 37 minerals and ores.

- To take advantage of the “opportunity,” one has to extract the “less valuable stuff” and deal with coal’s unique chemical component parts, rather than lump everything together and simply burn it.

- Basically, we need to **refine** coal to get the benefits of the good stuff…(not unlike gold and other minerals which are refined)
Another Answer: New Mining Techniques

- Large scale open pit mining for coal used in SPRB started in the 1970s.

- It is ideal for bulk extraction of coal for the power. It is less optimal for focusing on individual seams of coal, with particular mineral attributes.

- We will implement a low cost “High Wall” mining system to precisely extract those seams.
High Wall Miner
Why Now?
One Answer: New Advances in Material Science

• Coal is the cheapest and most abundant source of carbon on earth.

• Over the last 30 years there has been a revolution in carbon based material science. This has accelerated in the last few years.

• At the iPark, we will principally focus on two carbon uses:
  Carbon Fiber and Carbon based Building Products
  These Uses:
  1) Require the largest amounts of coal and,
  2) Could become the most “disruptive” new carbon technologies.

• Over Time…both of these broad uses could each require over 100 million tons of coal annually. In 2016 the US produced roughly 700 million tons. This demand explosion is a potential “Game Changer” for the coal industry.
Another Answer: Revolution in Advanced Manufacturing

• A new company **Carbon3D**, has revolutionized 3D printing. It’s Continuous Liquid Interface Process uses ultraviolet light, oxygen and carbon resins to print solid materials.

• Ford, BMW and Adidas are already working with Carbon3D. You will be able to buy new sneakers produced by their printers by this December.

• Carbon 3D resins can be made from **Brook Mine** coal and it will be partnering with the **iPark** on advanced 3D printing of products.

• This is not “smoke stack” manufacturing....
Coming to the iPark
Carbon 3D Printing “Farms”
Think…”The Transformers” Movie Meets Coal
The Products: Carbon Fiber (CF)… The Basics

**CARBON FIBER** is:

- 4x lighter than steel… but 2x as strong
- 2x lighter than aluminum… but 4x as strong
- CF is used today with reinforced plastics (CFRP) to displace steel and aluminum *everywhere* “light weighting” *is* important, and price *is not*:
  - Fishing rods, bikes, golf shafts, tennis racquets
  - 40% of commercial airliners, 31% of fighter jets

**THE PROBLEM:**

Today, CF is 8x more expensive than steel and 2x more expensive than aluminum.

**WHY:**

Because CF precursor material today comes from *petroleum* and now costs about $15 per pound.

*Ramaco’s* technology challenge, with its partners, *is* to drop the price of CF made *from coal* below $5 per pound. *At this level CF is completely disruptive.* Game Over.

Given Time… CF Will Displace Steel, Aluminum and Other Basic Materials. What about Coal to Cars??
Try Parking This Baby in Front of the Mint Bar

McLaren Carbon Series LT “Special Edition”
Coal to Cars

• Of roughly 100 million autos made each year, CF is currently used in less than 100,000 vehicles. The barrier is the high cost of CF made from a petroleum precursor.

• If only 14% of the weight of only US autos (body and parts) were made from CF derived from coal, we estimate as much as 100 million tons of coal could be required annually to make the CF precursor.

• The “Key” will be driving the price of coal based CF beneath the $5 per pound tipping point.

• At that point CF in cars moves from a niche market to Mass Market.
Coal to Cars…The Evolution

FIRST
High End & Niche
High End Low Volume Hand Layup

NOW
Low Volume Production of Affordable Car
Low Volume Production

NEXT
Mass Market Appeal
High Volume Production
Coal to Building Products

• The other “huge” market for coal is loosely defined as “Building Products”

• Building Products have the potential to use more coal than even “Coal to Cars”.

• Example: Coal Based Asphalt Roof Shingles
  If “coal based” asphalt was used in just 10% of Roof Shingles... Only 10% of the roof market would require over 100 million tons of coal a year.

• The range of product uses is practically endless. Two others:
  ➢ Rebar
    • CF Rebar can provide flexibility to concrete structures, is lighter and does not rust
  ➢ Repair Aging Infrastructure (think Bridge Renovation)
    • Can be molded around existing older infrastructure to provide structural strength and preventing further decay
    • The life span of infrastructure can be increased by 2-3x

The Possibilities Are Huge.....
Coal to Product Tree

- High Wall Coal Mining
- Chemistry Refinement
- Coal Separation
  - As
  - Hg
  - Water
- Chemicals
- Activated Carbon
- Water Filtering
- Rare Earth Elements
- Mesoporous Carbon
- Nuclear Graphite
- Graphene
- Thermal Insulation
- Building and Construction Materials
- Carbon Fibers
- Electrodes for Lithium-Ion Batteries/Supercapacitors and Casings
- Electrical and Thermal Conduction

RAMACO Carbon
In the End…It all Starts With a Lump of Coal…

• The past few years have been very difficult for coal industry. We need to think outside the box..

• **Ramaco** is investing to try and make the future brighter. We hope the **Brook Mine**, the **iCAM** and the **Wyoming iPark**… will be the first to break through some of the technology barriers.

• It starts with a lump of coal… but it requires new science and new forms of processing… all based on carbon.

• We have just touched the surface today on potential uses. As Buzz Lightyear said, ….“To Infinity…and Beyond.”

• **Ramaco** will try and make it all happen…**Right here in Sheridan.**

*If we get lucky… it could change the future of Sheridan and the Coal Industry… we hope in a very positive way.*