COAL TO CARBON FIBER

François Giraud-Carrier & Evan Barlow Project Update for UDMC – December 10, 2021

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- Renee Bagwell & Briana Tom (Harper International)
- Cliff Eberle (IACMI)

For their invaluable contributions!

DoD Mandate

- "The use of coal as the source to manufacture carbon-fiber and the advanced manufacturing process (C2CF) will reduce the costs by at least half. The benefit to DoD is costs low enough for attributable aerial vehicles such as swarm drones. Under this task, grants and other research vehicles will be identified and pursued to further commercialization of C2CF for defense programs."
- Project timeframe: May 2021—April 2022

"I ordered a chicken and an egg from amazon. I wonder what'll come first."







Textile fibers

- Bio-ACN (from sugars and biomass)
- Decant oil
- Coal pitch
- Coal

Cost Reduction Strategies

- 1. Precursor is half of CF cost
- 2. Economies of scale
- 3. CF conversion line
- 4. CFRP manufacturing

Use coal pitch from EkoCoke process Large EkoCoke and CF plants Mat format Injection molding



Coal to Pitch: The EkoCoke Process

- The process efficiently separates coal into its solid, liquid and gaseous components. These components are collected as either high-value products themselves, or as feedstock material for the production of downstream high-value products.
- Essentially all coal types are candidate feed materials including waste coal which currently represents a significant environmental hazard.

Coal to Pitch: The EkoCoke Process



- Pyrolyzation of thermal coal and coke fines mix to produce clean coke
- Solid and gaseous byproducts are recycled in a closed system
- Mesophase pitch extraction and upgrade

Coal to Pitch: Plant Economics Assumptions

- Plant nameplate capacity: 250,000 tons-per-year
- Debt / Investment ratio: 75%
- Investment horizon: 7 years
- Cost of debt: 10% per year
- Hurdle rate (WACC):
- Buy-ins: Bought at retail price
- Byproducts: Sold at 50% of the retail price

9.30%

Corporate tax rate:

21% Federal + 4.95% Utah

Coal to Pitch: Plant Economics Raw Materials

Buy-In	Price	per lb	lbs/hr	\$/year
Rapeseed oil	\$	0.45	4	\$15,517.44
MDEA	\$	3.47	0.10	\$2,996.35
Sodium Hydroxide	\$	0.45	48	\$186,624.00
Thermal coal	\$	0.02	100,089	\$17,295,379.20
Phosphoric Acid (Anhydrous Ammonia)	\$	1.44	17	\$211,654.08
Caustic Soda (Anhydrous Ammonia)	\$	2.70	17	\$396,576.00
Citric Acid	\$	1.79	2	\$24,809.40
Total Cost per Year		1		\$18,133,556.47

\$40 per ton

Source: Combustion Resources

Coal to Pitch: Plant Economics

Byproducts

Byproducts-Sell	Price per lb	lbs/hr	\$/year
Benzene Toluene Xylene (BTX)	\$0.19	4116	\$ 6,579,014.40
Natural gas(*)	\$31.68	23	\$ 6,294,664.29
Coal Tar	\$0.20	2853	\$ 4,806,734.40
Sulfuric Acid 98%	\$0.34	2820	\$ 8,270,875.01
Coke	\$0.14	57841	\$ 68,715,108.00
Anhydrous Ammonia	\$0.98	984	\$ 8,331,724.80
Mesophase pitch	\$0.60	3068	\$ 15,904,512.00
Total Revenue per Year			\$ 118,902,632.90
	/	Coke	\$ 68,715,108.00
\$	275 per ton	Pitch	\$ 15,904,512.00

Others

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Source: Combustion Resources

34,283,012.90

Coal to Pitch: Plant Economics Cash Flows

Project Investment	\$ (141,780,000)
Revenues from coke	\$ 68,715,108
Revenues from pitch	\$ 15,904,512
Revenues from other byproducts	\$ 34,283,013
Total revenues	\$ 118,902,633
Operating costs	\$ (14,526,255)
Raw materials costs	\$ (18,133,556)
Depreciation, interests & taxes	\$ (44,884,222)
Earnings after tax	\$ 41,358,600

7-year NPV = \$104,094,750 7-year IRR = 27%

Coal to Pitch: Plant Economics

Product Costs & Margins

Byproducts-Sell	Co	ost / Ib	Price per lb
Benzene Toluene Xylene (BTX)	\$	0.05	\$0.19
Natural gas(*)	\$	8.70	\$31.68
Coal Tar	\$	0.05	\$0.20
Sulfuric Acid 98%	\$	0.09	\$0.34
Coke	\$	0.04	\$0.14
Anhydrous Ammonia	\$	0.27	\$0.98
Mesophase pitch	\$	0.16	\$0.60

Pitch to CF

- Nameplate capacity of CF conversion line
- Format
- Conversion line
- Pitch to CF yield
- With and without Ultra-High Temperature

3,850 tons Mat 3-meter wide 75%



Pitch to CF: Plant Economics

Pitch price = \$0.60

	N	/ithout UHT		With UHT	
CAPEX	\$	45,815,000	\$!	50,815,000	
Infrastructure	\$	45,815,000	\$!	50,815,000	
OPEX	\$	17,500,000	\$2	20,500,000	per year
Maintenance	\$	700,000	\$	1,000,000	per year
Precursor	\$	6,160,000	\$	6,160,000	per year

	Witho	out UHT	W	ith UHT	_
CAPEX	\$	0.85	\$	0.94	\$/Ib CF
Infrastructure	\$	0.85	\$	0.94	\$/Ib CF
OPEX	\$	2.27	\$	2.66	\$/Ib CF
Maintenance	\$	0.09	\$	0.13	\$/Ib CF
Precursor	\$	1.07	\$	1.07	\$/Ib CF
Total	\$	5.13	\$	5.74	\$/Ib CF

Excluding melt-spinning costs

UHT = Ultra high temperature (2,400 C)

Source: Harper International

Pitch to CF: Plant Economics

Pitch price = \$0.30

	N	/ithout UHT	With UHT	_
CAPEX	\$	45,815,000	\$50,815,000]
Infrastructure	\$	45,815,000	\$50,815,000	
OPEX	\$	17,500,000	\$20,500,000	per year
Maintenance	\$	700,000	\$ 1,000,000	per year
Precursor	\$	3,080,000	\$ 3,080,000	per year

	With	iout UHT	w	ith UHT	_
CAPEX	\$	0.85	\$	0.94	\$/Ib CF
Infrastructure	\$	0.85	\$	0.94	\$/Ib CF
OPEX	\$	2.27	\$	2.66	\$/Ib CF
Maintenance	\$	0.09	\$	0.13	\$/Ib CF
Precursor	\$	0.53	\$	0.53	\$/Ib CF
Total	\$	4.60	\$	5.21	\$/Ib CF

Excluding melt-spinning costs

UHT = Ultra high temperature (2,400 C)

Source: Harper International

C2CF Economics

Revised Cash Flows If Pitch Price = \$0.30

Project Investment	\$ (141,780,000)
Revenues from coke	\$ 68,715,108
Revenues from pitch	\$ 7,952,256
Revenues from other byproducts	\$ 34,283,013
Total revenues	\$ 110,950,377
Operating costs	\$ (14,526,255)
Raw materials costs	\$ (18,133,556)
Depreciation, interests & taxes	\$ (42,820,611)
Earnings after tax	\$ 35,469,954
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7-year NPV = \$72,315,381 7-year IRR = 22%

was \$104,094,750 was 27%

C2CF Economics

Revised Production Costs & Margins If Pitch Price = \$0.30

Pitch Price	\$0.60	\$0.30
Production cost	\$0.16	\$0.09
Contribution	\$0.44	\$0.21

"I ordered a chicken and an egg from amazon. I wonder what'll come first."





Thank you for your attention...

