Monolith Background & H_2 GHG Impact

Lightning Talk: Anthony Spizuoco

Change your environmental story. monolith Carbon Black

Monolith Presenter

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Technology Background

Clean Hydrogen & Carbon Black from Electricity and Natural Gas

Renewable electricity

+

Natural gas (CH_4)
renewable or pipeline

Protected Methane Pyrolysis Technology

Olive Creek 1 (OC1)
Commercialization of technology complete

H_2

Hydrogen

+

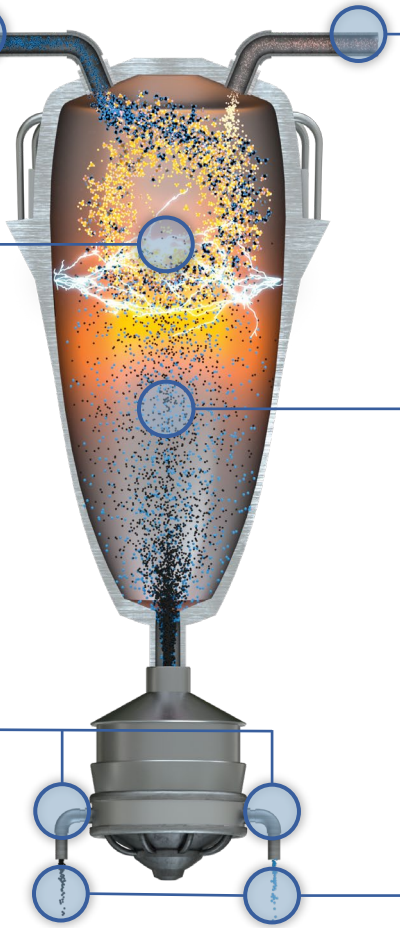
Carbon Black

Monolith's proprietary methane pyrolysis technology uses renewable electricity to split natural gas into hydrogen and highly valuable solid carbon materials without emitting CO_2.

Methane Pyrolysis Process

A natural gas feedstock enters here.

A process gas may be added to help heat the natural gas.



The natural gas is super-heated by electricity. This is combustion-free and does not release CO_2.

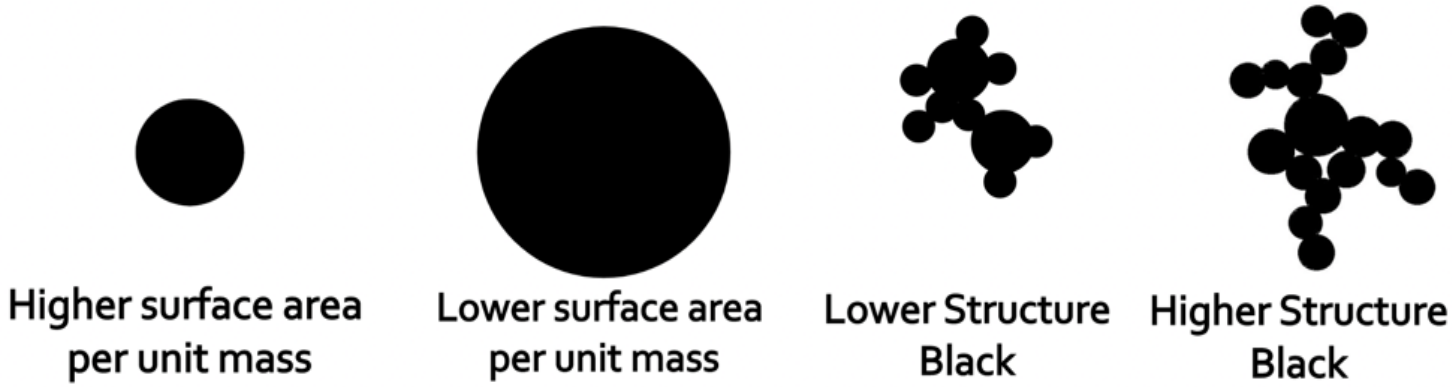
The heat breaks the bonds between the hydrogen and carbon in the natural gas molecule.

The pairs of hydrogen atoms and carbon atoms move through the chamber and exit separately.

The Clean hydrogen is directed to end users, including conversion to carbon-free ammonia. The carbon is further processed into Clean Carbon Black and other uses.

What is Carbon Black?

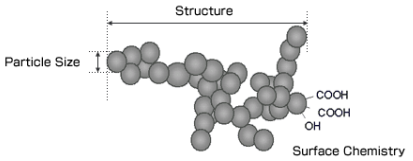
- A very fine, very black powder
- Has a molecular and crystalline structure similar to graphite, but with many curved and amorphous regions
- Consists of primary particles (typically 10-50 nm) welded together into aggregates (typically 50-250 nm)



Carbon Black Market and Applications

~$16 bn global market (growing 2-3% / year) with prevalent and diverse end-uses

- Among the top 50 industrial chemicals worldwide
  - 100-year-old commodity product with ubiquitous and diverse end-uses
- Output is 98.0 - 99.5% solid carbon
- Unique properties ideal for rubber and plastics applications
  - Structure and surface properties help reinforce and color rubbers and plastics
  - 1/3 of tire made of carbon black



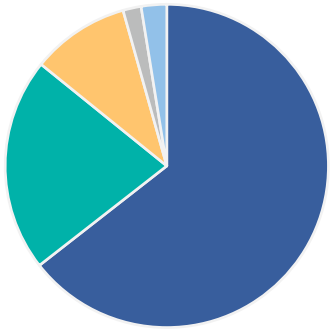
Monolith Carbon Black pellets

Market Breakdown by Application (% share volume)

Inks
2%

Plastics
10%

Industrial Rubber
21%



Specialty
3%

Tires
64%

Tire

~$11.3 bn / yr

MRG

~$3.6 bn / yr

Specialty

~$1.9 bn / yr

Change your environmental story. monolith Carbon Black

Successful Technology Scale-Up

CLEAN HYDROGEN PRODUCTION

0.3 kg/hr | 3 kg/hr | 30 kg/hr | 300 kg/hr | Commercialization completed

LAB 1
Laboratory Scale

up to 0.3 kg/hr
2016 – 2018

MINES ParisTech
Pilot Scale

0.3 – 2 kg/hr
2018 – Present

Seaport 1
Demonstration Scale

12 – 18 kg/hr
2014 – 2018

Olive Creek 1
Commercial Scale

540 – 620 kg/hr
2020 – Present

Olive Creek 2
Commercial Scale

6,390 – 7,440 kg/hr
2027

Replicate Rx 12 Times
No technology scaling required

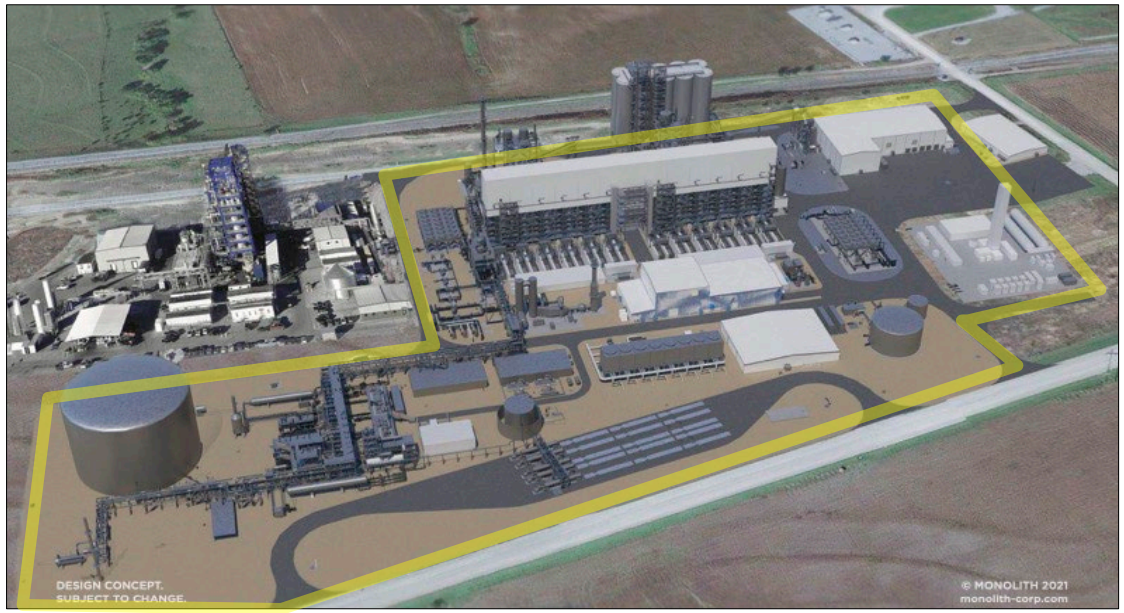
Demonstrated ability to scale-up *patent protected*, *commercially viable* technology

Note: Assumes 0.31kg of hydrogen is produced for every kg of carbon black

Monolith Expansion (Olive Creek 2)

Olive Creek I (OC1)	
Production Capacity	**Hydrogen:** ~5 ktpa **Valuable Carbon:** ~15 ktpa
Completion	June 2020
Location	Nebraska, United States
Technology	Full, commercial-scale reactor

Olive Creek II (OC2)	
Production Capacity	**Hydrogen:** ~60 ktpa **Valuable Carbon:** ~180 ktpa
Completion	2027 (target)
Location	Nebraska, United States
Technology	Two 6-reactor trains (same scale as OC1)



Hydrogen Life Cycle Assessment (LCA)

Hydrogen Production Technologies

	Steam Methane Reforming ("SMR")	Auto-Thermal Reforming ("ATR")	Electrolysis	Pyrolysis
	 Natural gas is passed through steam to split methane into hydrogen and CO_2; high carbon footprint but relatively cheap today.	 Natural gas is reacted with oxygen to split methane into hydrogen and CO_2;	 Electricity is used to split water into hydrogen and oxygen; greatly reduced carbon emissions, assuming a renewable energy source.	 Decomposition of natural gas into hydrogen and carbon; generates CO_2-free hydrogen with solid carbon as the only byproduct.
Select Players	Air Liquide, Air Products, Linde	Air Products, TOPSOE, Johnson Matthey	ITM Power, Hydrogenics, nel, Plug Power	C-Zero, EKONA, HazerGroup, monolith
H_2 Carbon Intensity [kg CO_2 / kg H_2]	⌈ ● ○ ⌉	⌈ ● ○ ⌉	○	○
Technical readiness level	W/O CCS / 11 / 9-10 / With CCS[2]	W/O CCS / 9-10 / 9-10 / With CCS[2]	8	8
Capital Intensity	⌊ ◔ ◕ ⌋	⌊ ◔ ◕ ⌋	●	◕
Water usage w Steam & Cooling	5.2 -13 gal / kg H_2	5.2 -13 gal / kg H_2	3- 4.7 gal / kg H_2	2.5 gal / kg H_2
Electricity usage	N/A	N/A	59 kWh / kg H_2	30 kWh / kg H_2
Natural gas usage	125 – 155 MMBTu / T H_2	115 – 145 MMBTu / T H_2	⊘	210 MMBTu / T H_2 No allocation to Carbon
Access to government incentives like 45Q/ 45V	No / Yes, @ \$3/kg H_2[3]	No / Yes, @ \$3/kg H_2[3]	Yes, @ \$3/kg H_2[3]	Yes, @ \$3/kg H_2[3]

Sources: Wolfe Research, BNEF and company documents; C-Zero, EKONA and HazerGroup are at Technical Readiness Level (TRL) 5 as reported in ChemBioEng Reviews; [1] Based on US hydrogen cost curve
[2] Carbon capture and storage (CCS) which comes with geographical restrictions. [3] Likely to need some level of RNG feedstock to get to 0.45.

The hydrogen to power a green world. monolith

LCA System Boundary (OC1 + OC2)

Monolith's LCA assesses the carbon intensity of its future products and process on a “Cradle-to-Gate” basis modeled with GREET1 2022

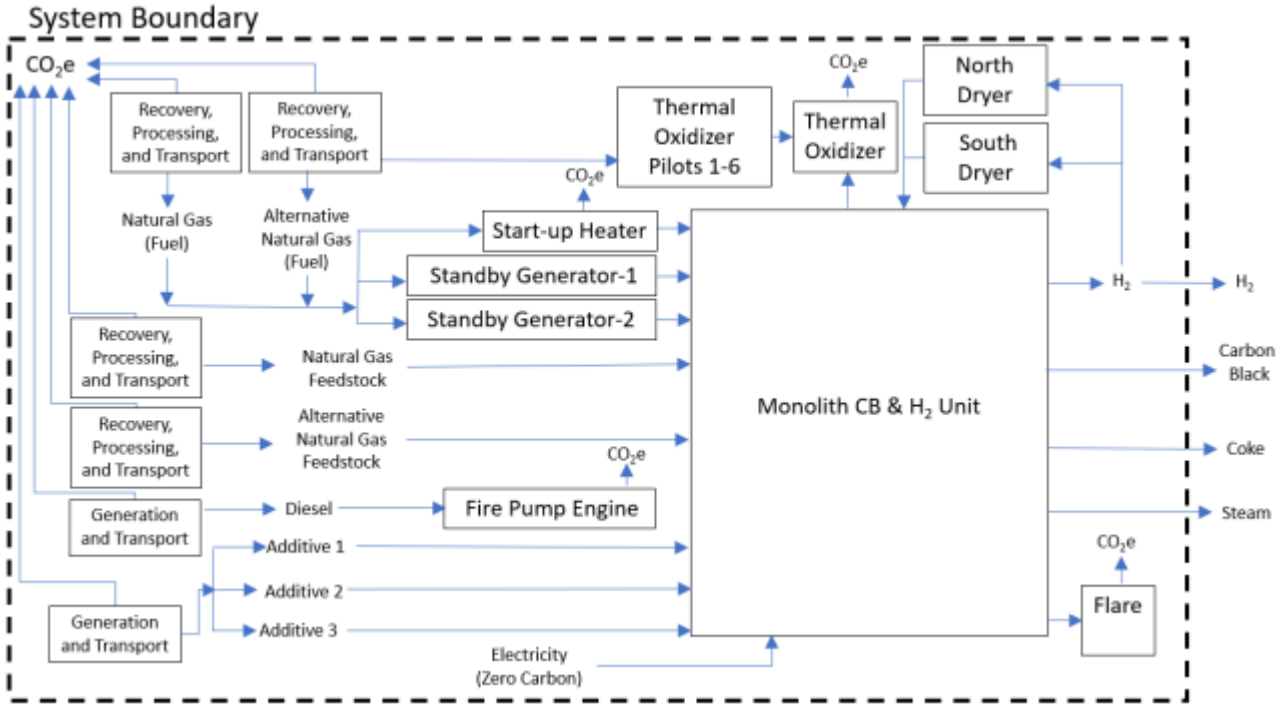
In Scope:

- Recovery, processing and transmission of natural gas (and alternatives) to the OC1+2 facility
- Production and transportation of process additives
- The production process

Out of Scope:

- Shipping
- End use
- Ultimate disposal after use stages

These steps are assumed to be like conventionally produced products in the market



"Cradle-to-Gate" means...

- Scope 1 Direct Emissions (our production process)
- Scope 2 Indirect Emissions (purchased electricity)
- Scope 3 Upstream Emissions (production & transportation of procured raw materials)

...for the manufacture of our products. Our accounting ends when our product is produced.

Comparison of SMR + CCS Hydrogen & Monolith GHG Footprint

Ongoing study – results presented based on information available so far

RNG is Swine Manure RNG as per GREET 2022

SMR+CCS is per GREET 2022

Monolith in the News

The hydrogen to power a green world.