

Innovation Showcase

Innovation & Entrepreneurship



CuB Fuels

*Renewable Octane.
Improved Gasoline.*

Josh Schaidle, Jesse
Hensley, and Dan Ruddy

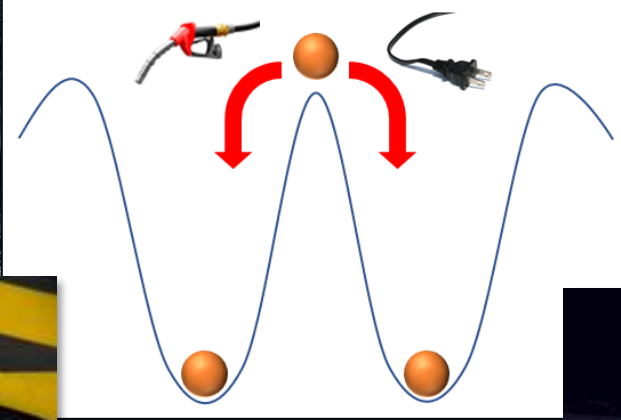
September 21st, 2018

Beaver Creek, CO

Gasoline is Living in the Past



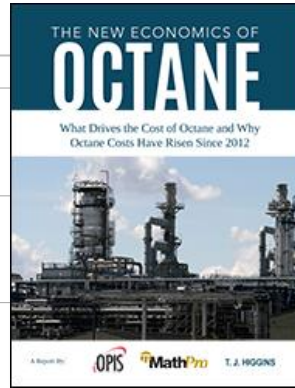
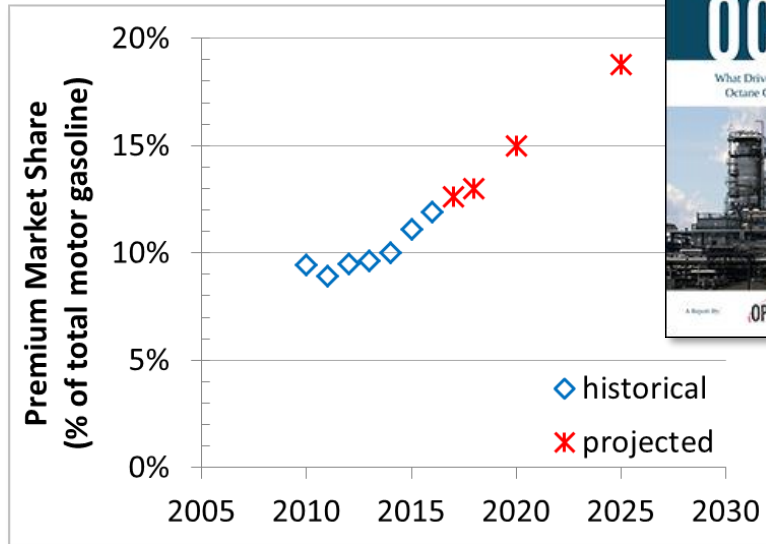
acturer



Need higher octane standard

Need charging infrastructure

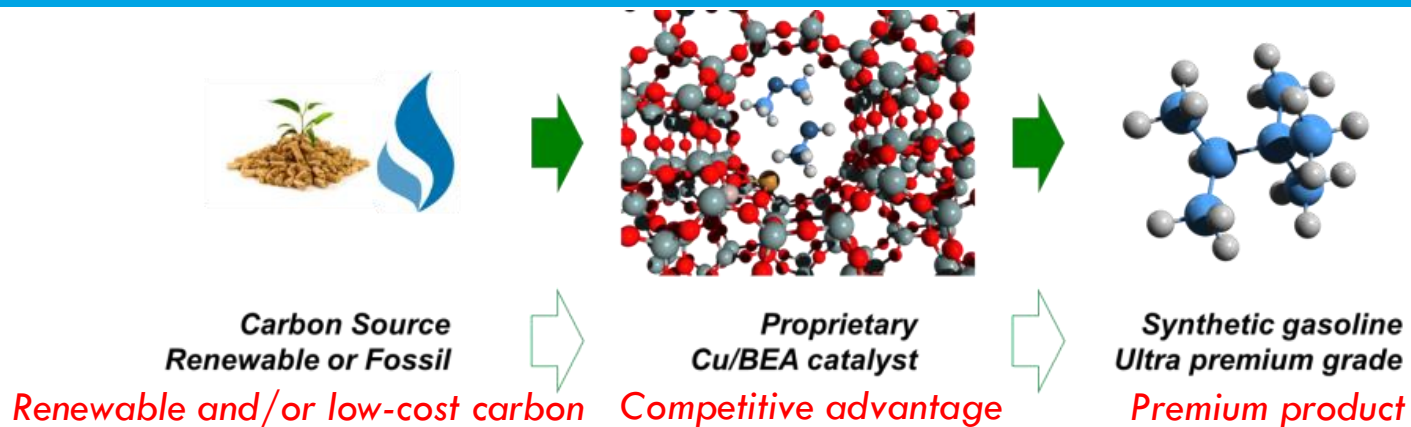
Market Pull for Green Octane



Low GHG Fuels



Synthetic Alkylate Meets the Need



Key advantages of our synthetic alkylate:

- ➔ Unlike grain Ethanol, provides octane boost while decreasing vapor pressure, does not consume food crops, and is *eligible for advanced RFS credits*
- ➔ Unlike refinery reformat, does not contribute to particulate pollution and *expands product volume*
- ➔ Unlike refinery alkylate, provides a *higher-octane alternative for an industry already operating at maximum capacity* and is naturally sulfur-free

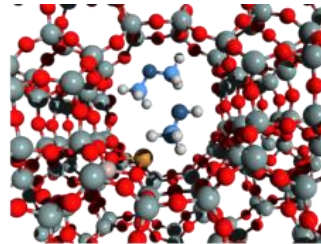
Value Proposition

Help mid-sized West Coast automotive fuel refiners to meet regulatory mandates (RFS, LCFS, CARB) while also increasing their gross profits by \$60 MM/y by providing a synthetic, bio-derived alkylate blendstock.



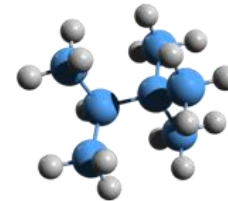
Carbon Source
Renewable or Fossil

Renewable and/or low-cost carbon



Proprietary
Cu/BEA catalyst

Competitive advantage

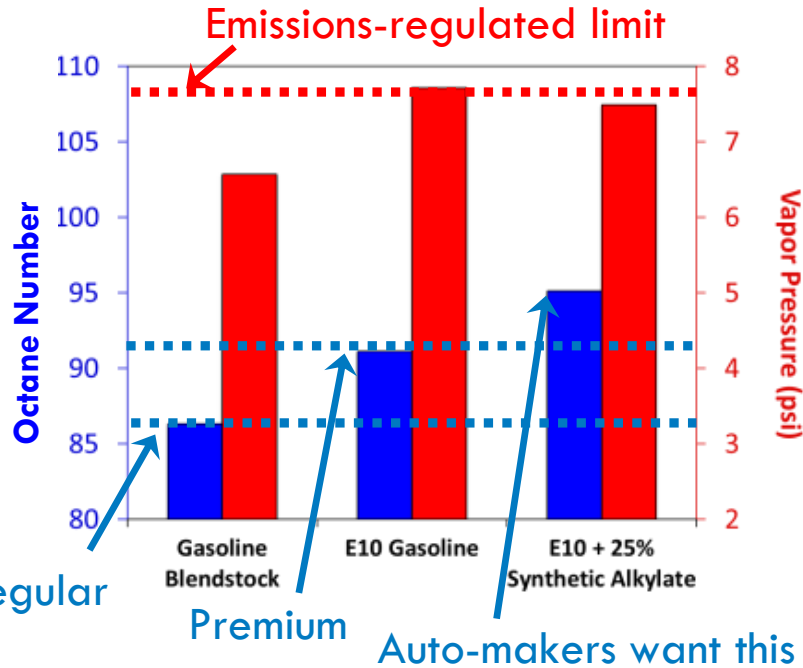


Synthetic gasoline
Ultra premium grade

Premium product

The Key Advantage and The Market

Fuel Properties



CuB's product is drop-in and pipeline ready

Market Assessment



- **Target Market (First Customer): \$103M/y**
10% of premium gasoline sold out of 1 refinery
- **Served Available Market (Highest Demand): \$617M/y**
10% of premium gasoline sold out of 50% PADD 5 refineries
- **Available Market: \$19B/y**
30% of premium gasoline sold in US + Europe

Revenue Streams

1st
Customer



West Coast
Market



Assumptions:

- Oil @ \$50/bbl
- \$0 RFS credit from license play
- 1st customer = 4 kbbbl/d production
- Catalyst sale price \$32/lb

License IP: 3% of catalyst sales \$83k/y \$500k/y

License IP: 1% of fuel sales \$1M/y \$6.2M/y

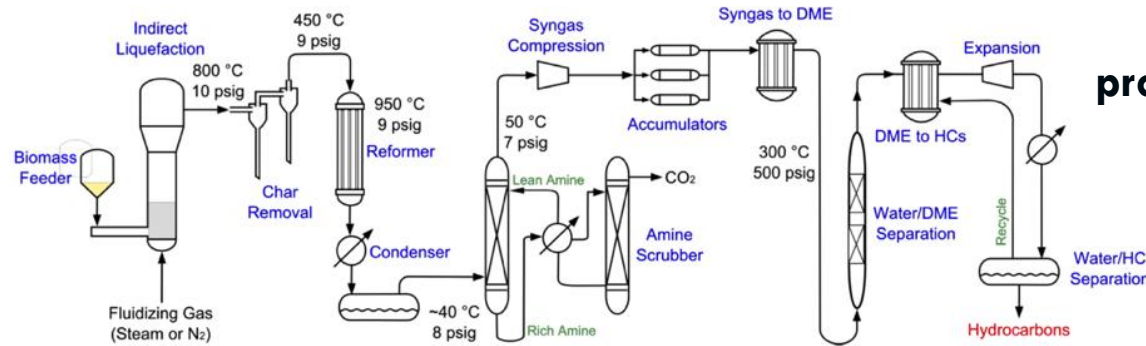
Produce from fossil NG \$103M/y \$617M/y

Produce from bio-NG \$243M/y \$1.5B/y

Strategic partners are a necessity for technology and product validation at scale

→ Royalties go back into the lab

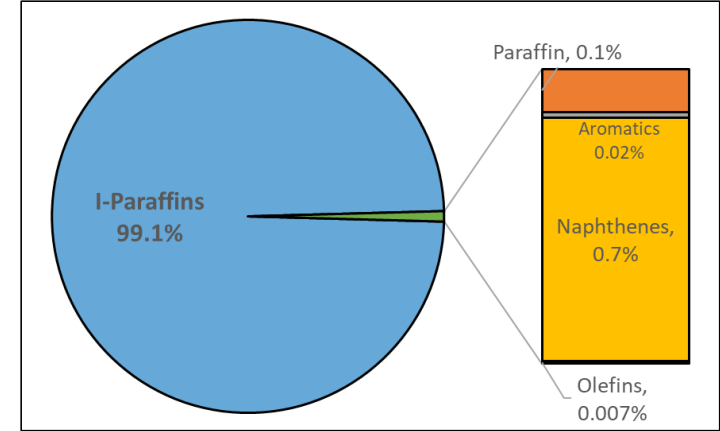
Current Development: Technology and Product Validation



**DOE grant with partner Enerkem:
produced gallons of product at pilot scale**



Octane Rating (R+M/2) = 102.4



Fuel currently undergoing testing by 1 major auto manufacturer and 2 major refiners

Next Steps

- **Milestone 1:** Demonstrate similar catalyst productivity at pilot scale as observed at bench scale

- *Driver:* Productivity significantly impacts process economics
- *Timeline:* 6 months
- *Funding Required:* \$500k



- **Milestone 2:** Generate at least 100 gallons of product from extended pilot scale operations

- *Driver:* Fuel volume requirements for external product validation
- *Timeline:* 1 year
- *Funding Required:* \$1.5M



Critical Need: We are seeking a strategic partner with established expertise in the development and scale-up of catalysts and technologies for hydrocarbon processing

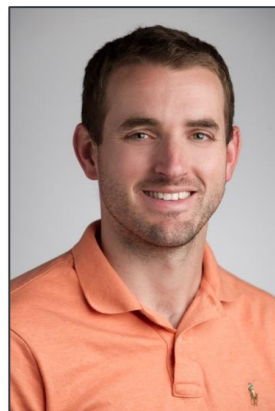
Thank You

Contact us to discuss how our technology can address your needs



CuB Fuels

*Renewable Octane.
Improved Gasoline.*



Josh Schaidle



Jesse Hensley

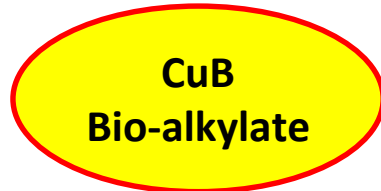


Dan Ruddy

303-384-6322, HighOctane@nrel.gov

The Gasoline Ecosystem in North America

Option CuB:
purchase octane
No regulatory
hurdle, no disruption



Ethanol

Option A:
change
regulations



RFS

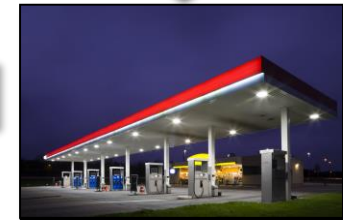


obligated party

Option B: reconfig
Capital project, disrupt
refinery balance

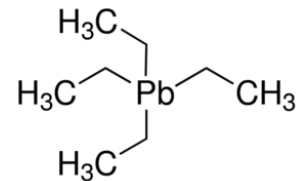


CAFE
Corporate Average Fuel Economy
obligated party

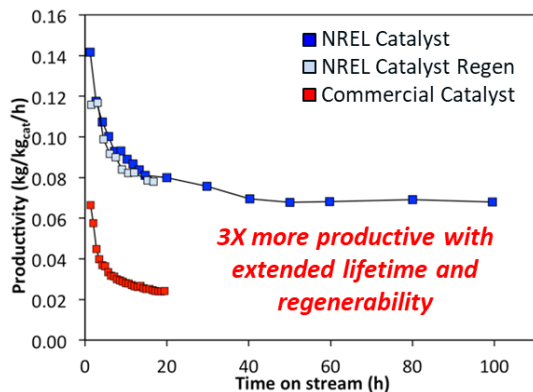


Alternative Market: Aviation Gasoline

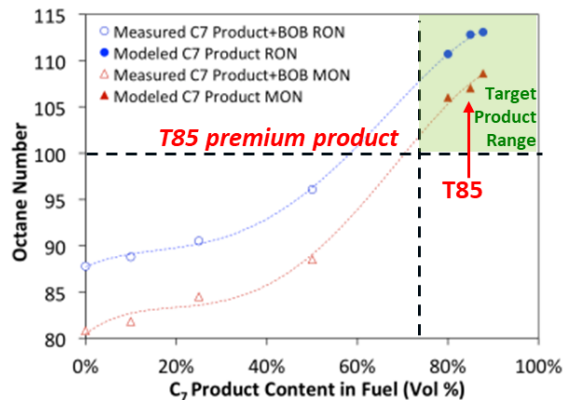
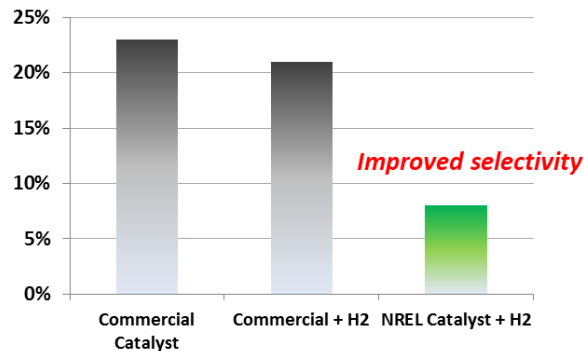
- Avgas is a specialized fuel used to power piston engine aircraft
 - ▣ 167,000 aircraft in US require avgas for safe operation
 - ▣ Market size: ~150M gallons per year
- These aircraft require high octane (~100 MON)
 - ▣ Tetraethyl lead is used to boost octane, but is toxic to humans
 - ▣ Primary avgas fuel is 100LL (100 MON, Low Lead)
- FAA is actively seeking to remove lead from avgas
 - ▣ Initiated the Piston Aviation Fuel Initiative to overcome technical and logistical challenges to developing and deploying a new, unleaded fuel, but...
 - ▣ ***A suitable, operationally-safe replacement has yet to be found***



Key Features of the Technology



Selectivity to Undesirable Aromatic Products

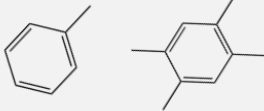
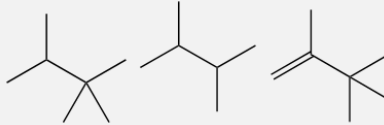


6 components make up majority of C₅₊ product

Products	Formula	Mol%
2-methylbutane	C ₅ H ₁₂	27.7
2-Methylpentane	C ₆ H ₁₄	7.9
2,3-Dimethylbutane	C ₆ H ₁₄	6.5
2,2,3-Trimethylbutane	C ₇ H ₁₆	28.7
2-Methylhexane	C ₇ H ₁₆	8.4
2,2,4-Trimethylpentane	C ₈ H ₁₈	20.7

Boiling point range 27-99 °C

How our Process Differs from Exxon-Mobil's "MTG"

Methanol to Gasoline (MTG) Pathway	High-Octane Gasoline (HOG) Pathway	Advantage of HOG Pathway
		<i>Branched HC product, minimal aromatics</i>
ZSM-5 catalyst	Beta-zeolite catalyst	
350 – 500 °C 20 atm	175 – 225 °C 1-10 atm	<i>Lower severity conditions, lower coking rate</i>
RON: 92 MON: 83	RON: 95+ MON: 90+	<i>High octane synthetic alkylate</i>
100 gal*	118 gal*	<i>Higher yield (18%)</i>

*relative yield from same carbon source