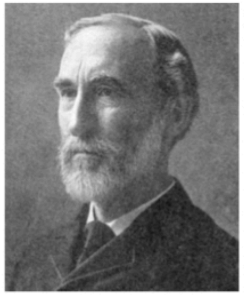
Use heat to make chemical bonds.

Patrick Grimes

William Grove

Robert Stirling



J Willard Gibbs

California Bioresources Alliance Symposium

19 NOVEMBER 2021

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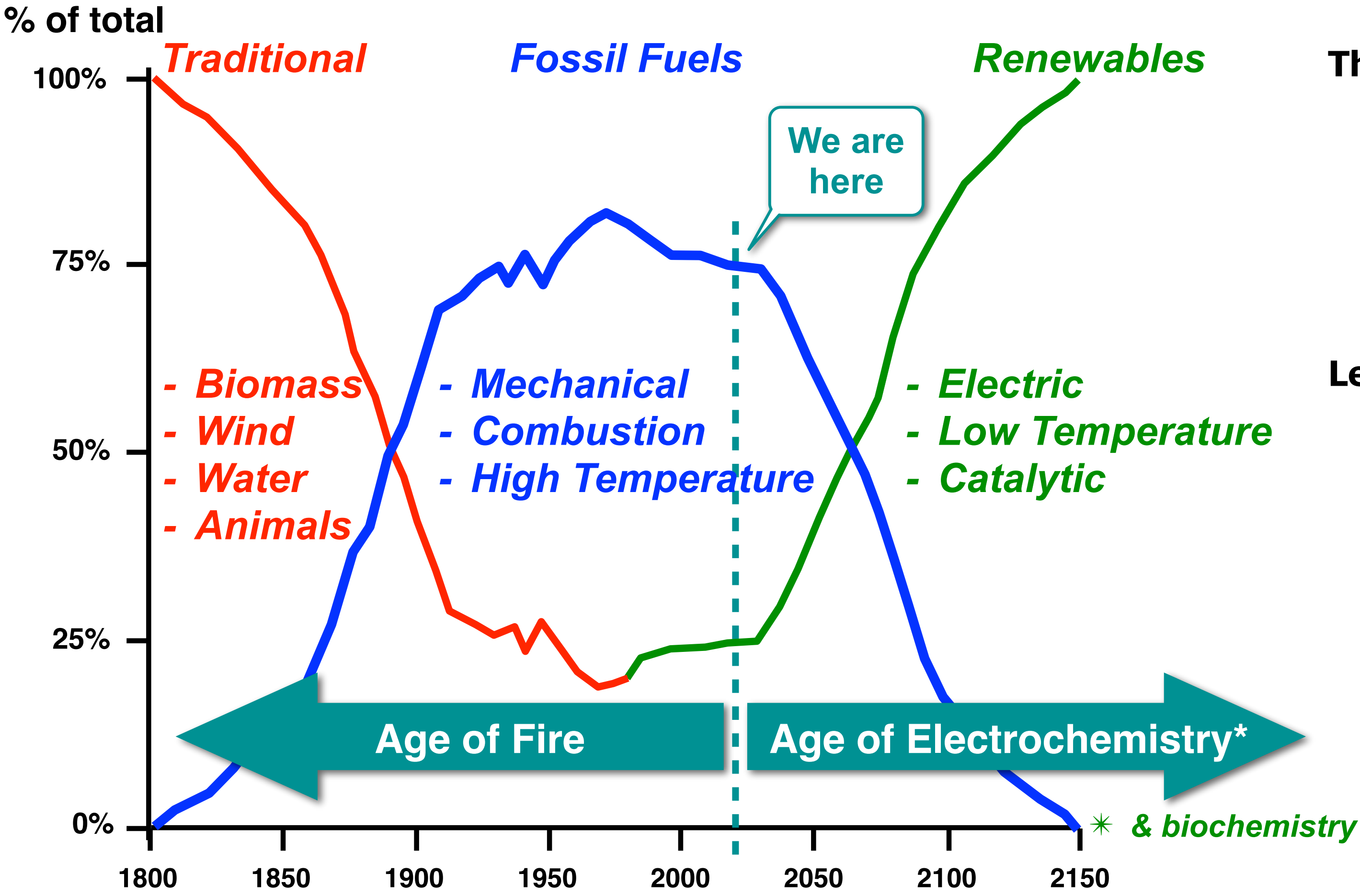
The History & Future of Energy - according to Shell



Source: Ewald Breunesse, Shell Netherlands, 14th IAMA Conference, Montreux, 14 June 2004

The World is at a Transition

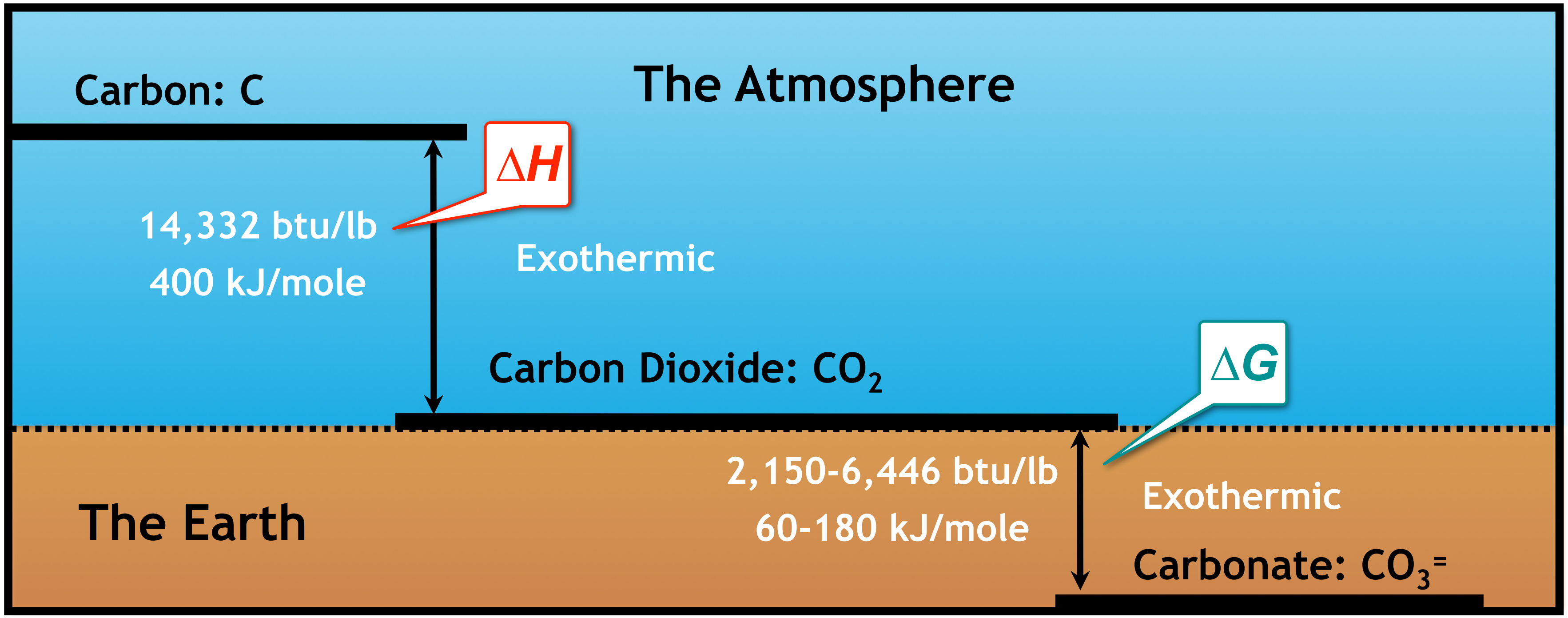
- Energy demand is growing worldwide.
- The negative effects of climate change have become unacceptable.
- No coherent plans to manage the transition of the current energy industry are in place.

Leadership is Needed

- After building the first fuel cell vehicle, ever, in 1957, in 1961 Dr Patrick Grimes wrote his original Energy Depot report for the Department of the Army outlining his method for synthesizing fuels from atmospheric CO_2.
- Although his ideas were never commercially adopted while he lived, until his death in 2007, he kept investigating and experimenting to determine a practical path toward his goal of a properly managed carbon energy economy.
- Like Galileo, he was ahead of his time. However, he lived long enough to see his work validated in the lab, initial patents secured and left others to continue the pursuit of his vision.

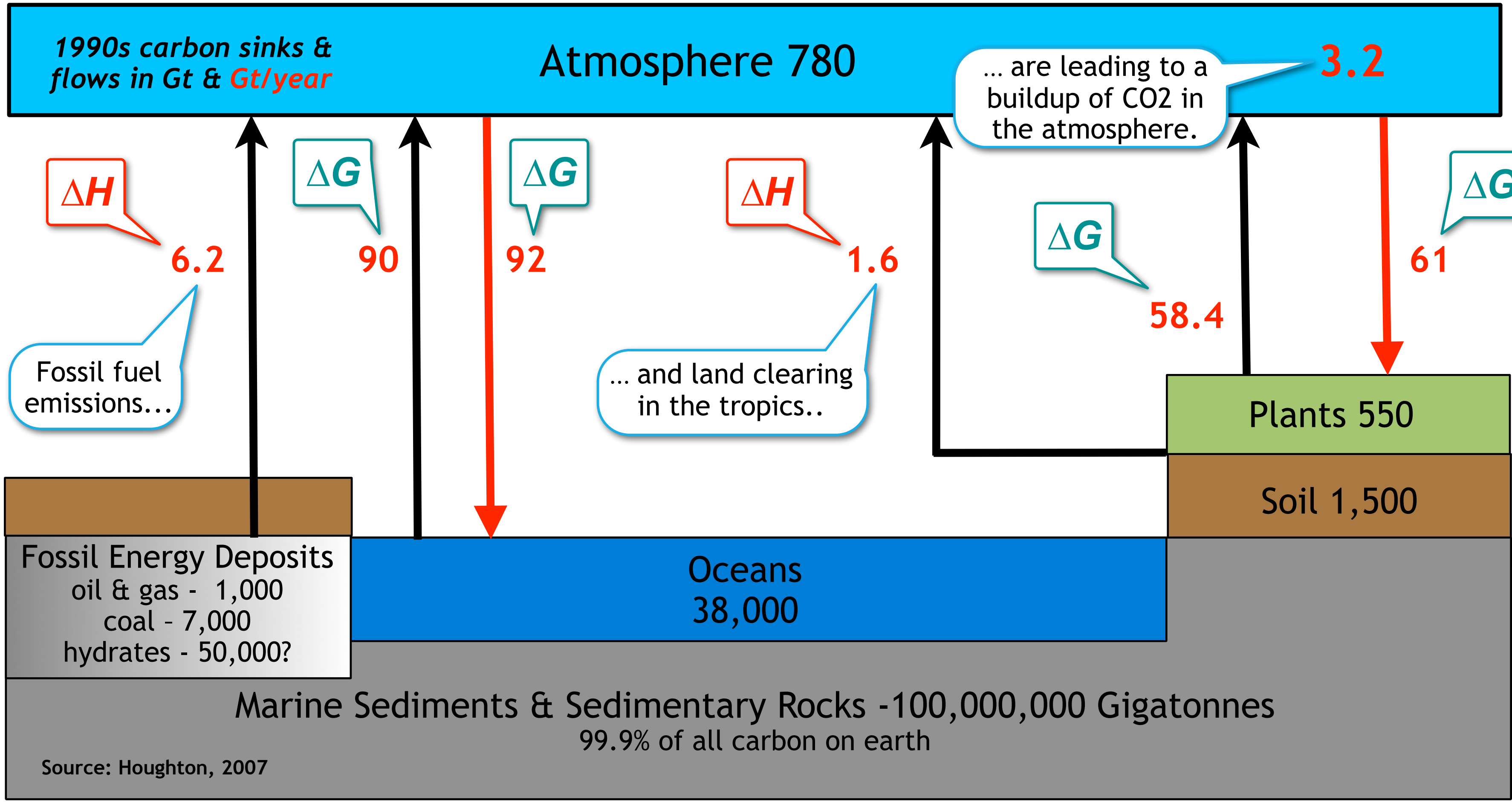
Pat Grimes observed that…

… the ground state of carbon is a mineral carbonate…



…and Carnot is leaving a lot of energy on the table.

Carbon Fluxes and Driving Forces



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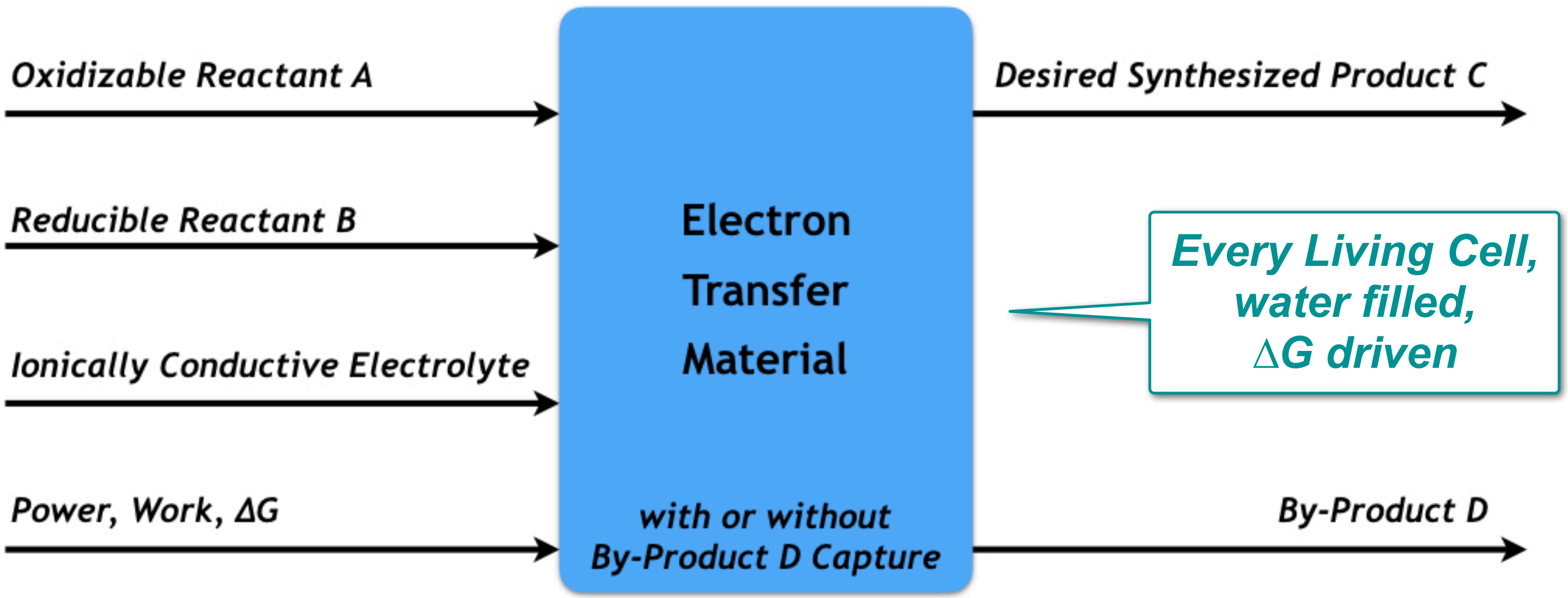
All Natural Processes Follow These Rules

Free Energy Driven Process

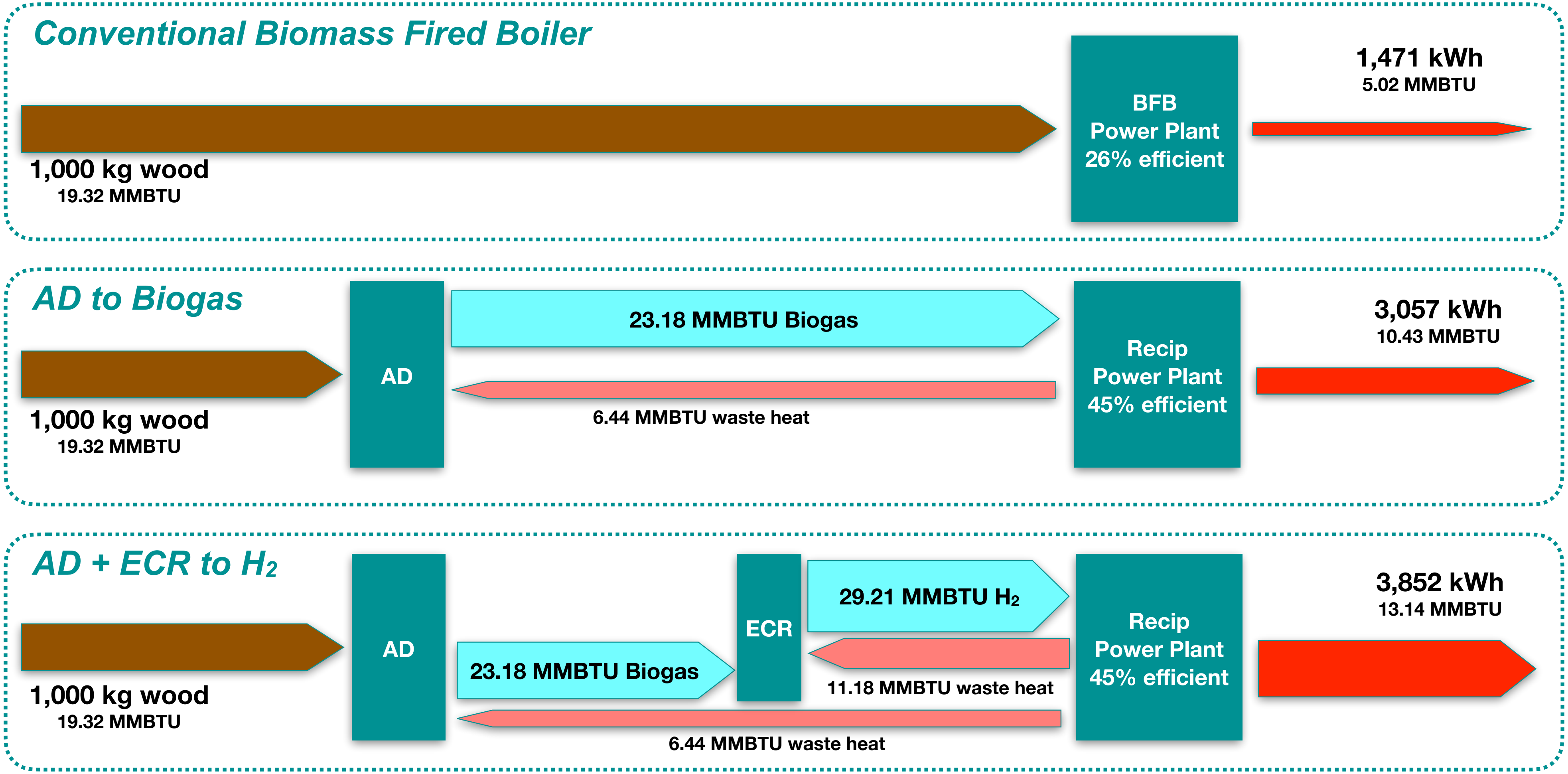
Occurs in Acidic, Buffer, Neutral & Basic Systems

Reactant A + Reactant B + Energy, Power, ΔG => Desired Product C + By-Product D

Redox Reactor



Example of Increasing Chemical Potential of a Fuel



Option 1: Biomass to Fischer-Tropsch Diesel

Hydrothermal Pretreatment

35,000 BDT woody biomass

Sawmill

230,000 tons slurry

Anaerobic Digestion

20.22 Mm^3 biogas

Integral to System

Water Cleanup
112.7 M tons

Biochar/Fertilizer
21,487 tons

FT waste heat drives HTC

Fischer-Tropsch Synthesis

7,829 tons
FT-Diesel

2.6 million gallons
167 BOED

CI# = 0

Optional

Indoor Produce Grow Houses

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Option 2: Biomass to Conventional Green H_2

Hydrothermal Pretreatment

35,000 BDT woody biomass

Sawmill

230,000 tons slurry

Anaerobic Digestion

20.22 Mm^3 biogas

Integral to System

Water Cleanup
112.7 M tons

Biochar/Fertilizer
21,487 tons

reformer waste heat drives HTC

Optional

Indoor Produce Grow Houses

Biogas Reformer

1,555 tons
Green Hydrogen

209,214 MMBTU
103 BOED

CI# = 0

Option 3: Biomass to ECR Green H_2

Hydrothermal Pretreatment

35,000 BDT woody biomass

Sawmill

230,000 tons slurry

Anaerobic Digestion

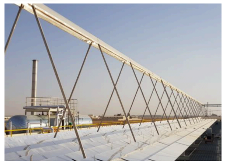
20.22 Mm^3 biogas

Integral to System

Water Cleanup
112.7 M tons

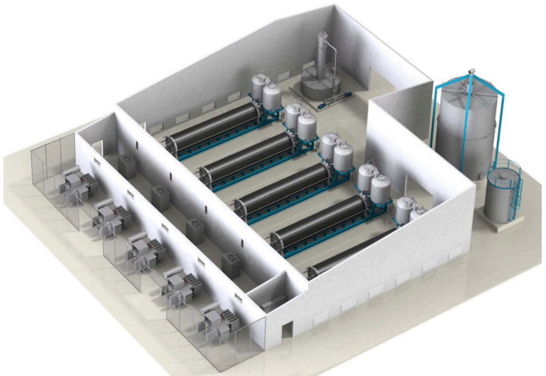
Biochar/Fertilizer
21,487 tons

Concentrated solar drives HTC & ECR



Optional

Indoor Produce Grow Houses



Electrochemical Reformer

4,044 tons
Green Hydrogen

544,090 MMBTU
268 BOED

CI# = 0

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Option 4: Biomass to ECR Green H_2 + Syngas

Hydrothermal Pretreatment

35,000 BDT woody biomass

Sawmill

230,000 tons slurry

Anaerobic Digestion

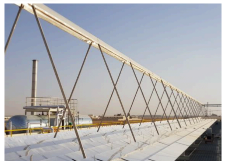
20.22 Mm^3 biogas

Integral to System

Water Cleanup
112.7 M tons

Biochar/Fertilizer
21,487 tons

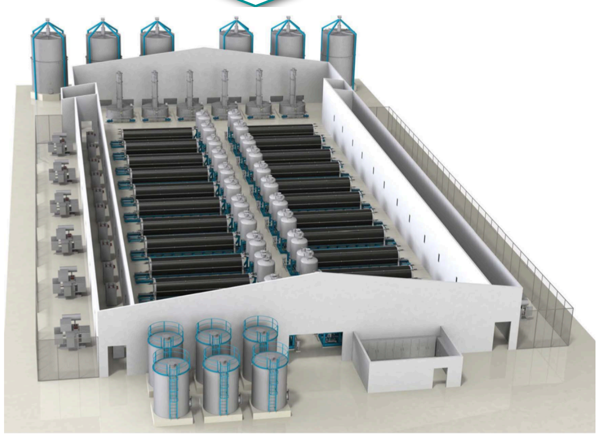
Concentrated solar drives HTC & ECR



Optional

Indoor Produce Grow Houses

PV drives ECR



Integrated ECR/CCR

4,044 tons
Green Hydrogen

544,090 MMBTU
268 BOED
CI# = 0

29,103 tons
Green Syngas

446,641 MMBTU
220 BOED
CI# = -67

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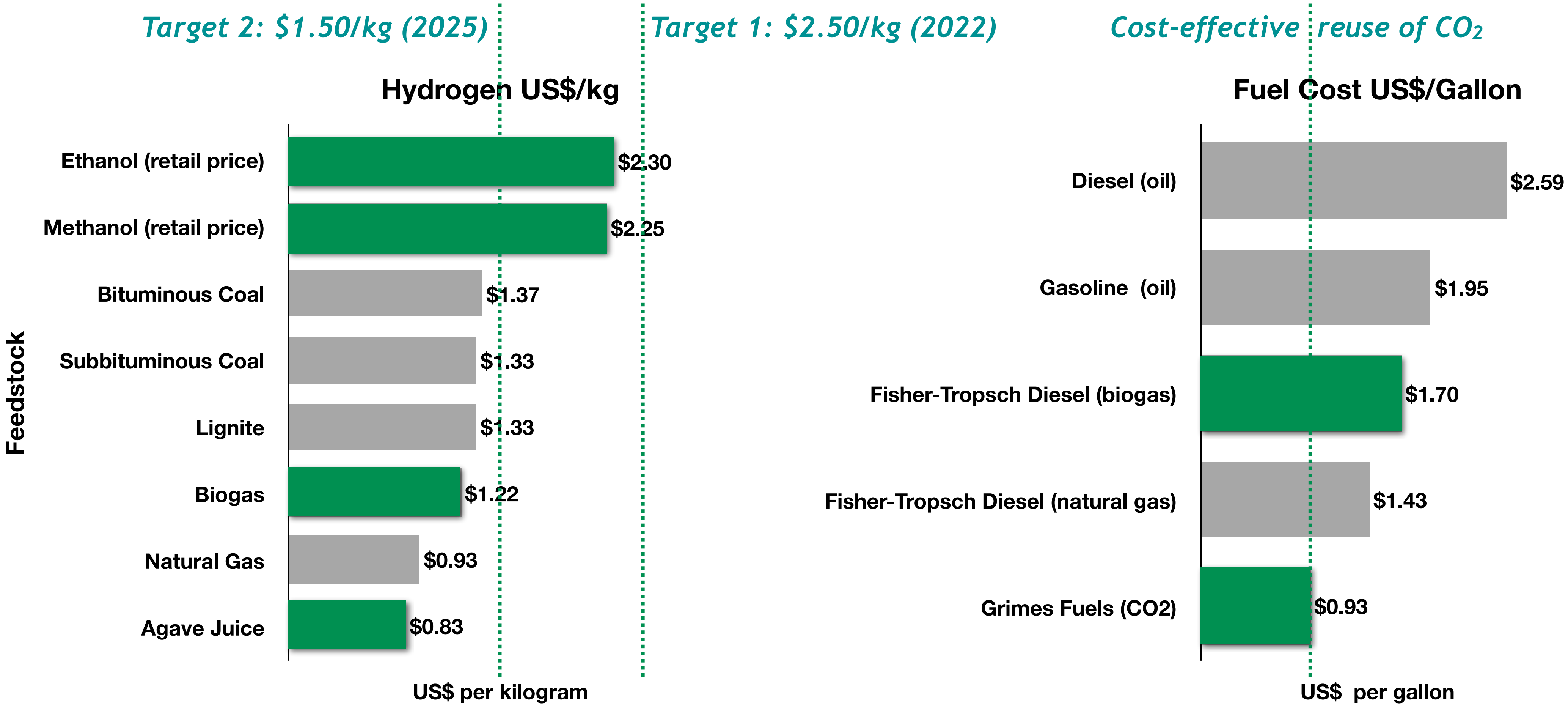
H_2 & Liquid Fuel Cost Comparison (as of April 8, 2020 - USDOE costs)



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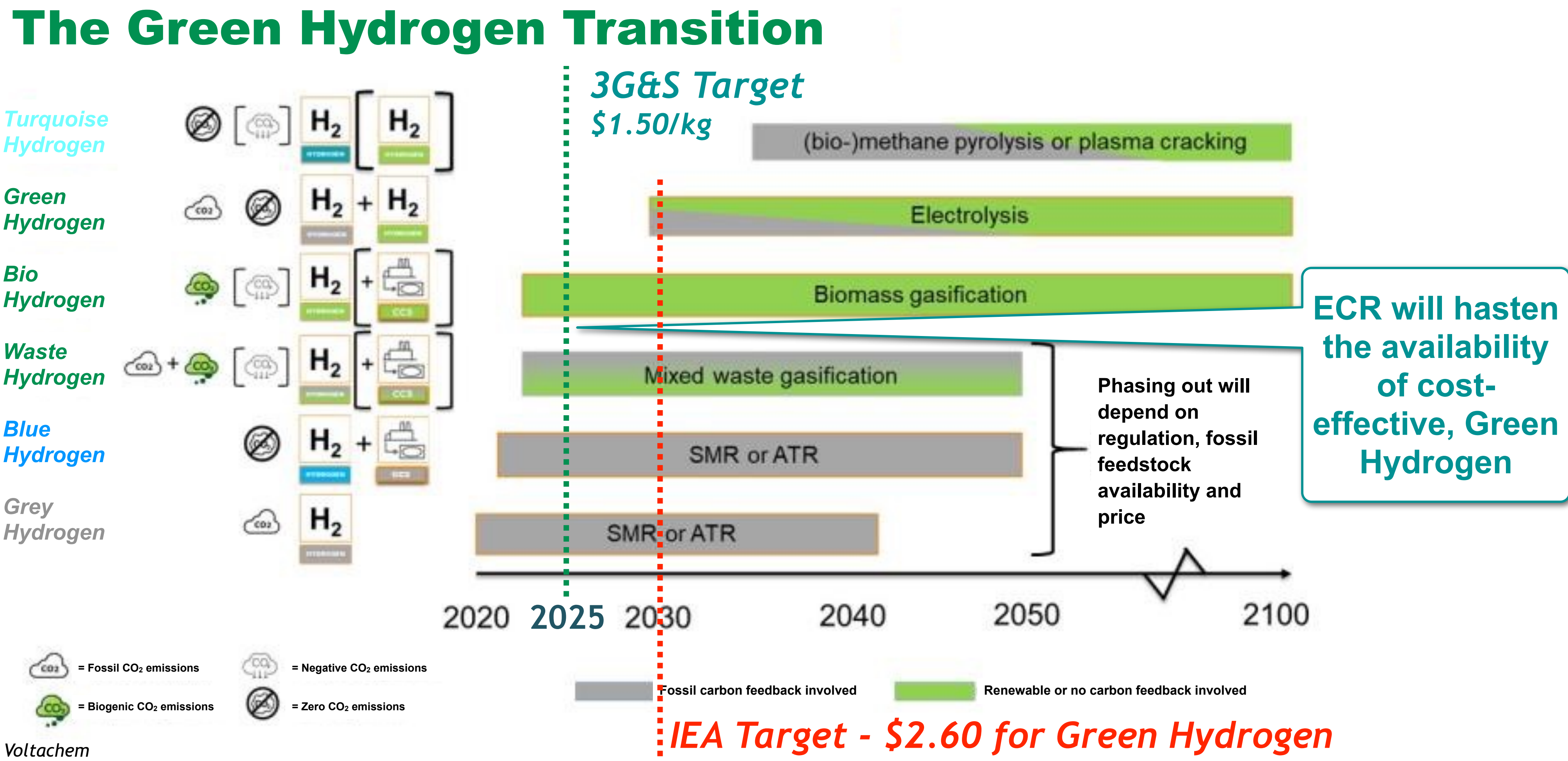
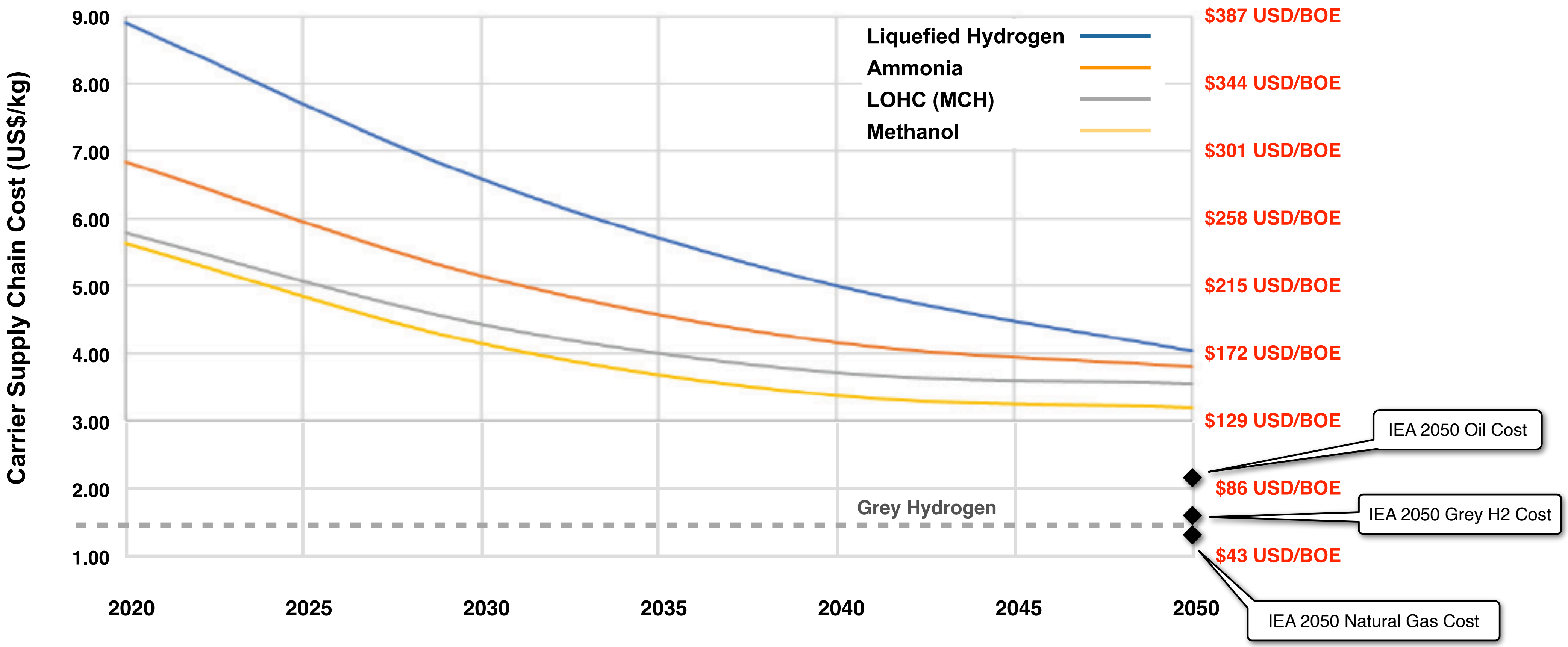
ECR v existing hydrogen solutions



Graphic Source: Voltachem

Conventional Wisdom on H_2 Cost in Singapore

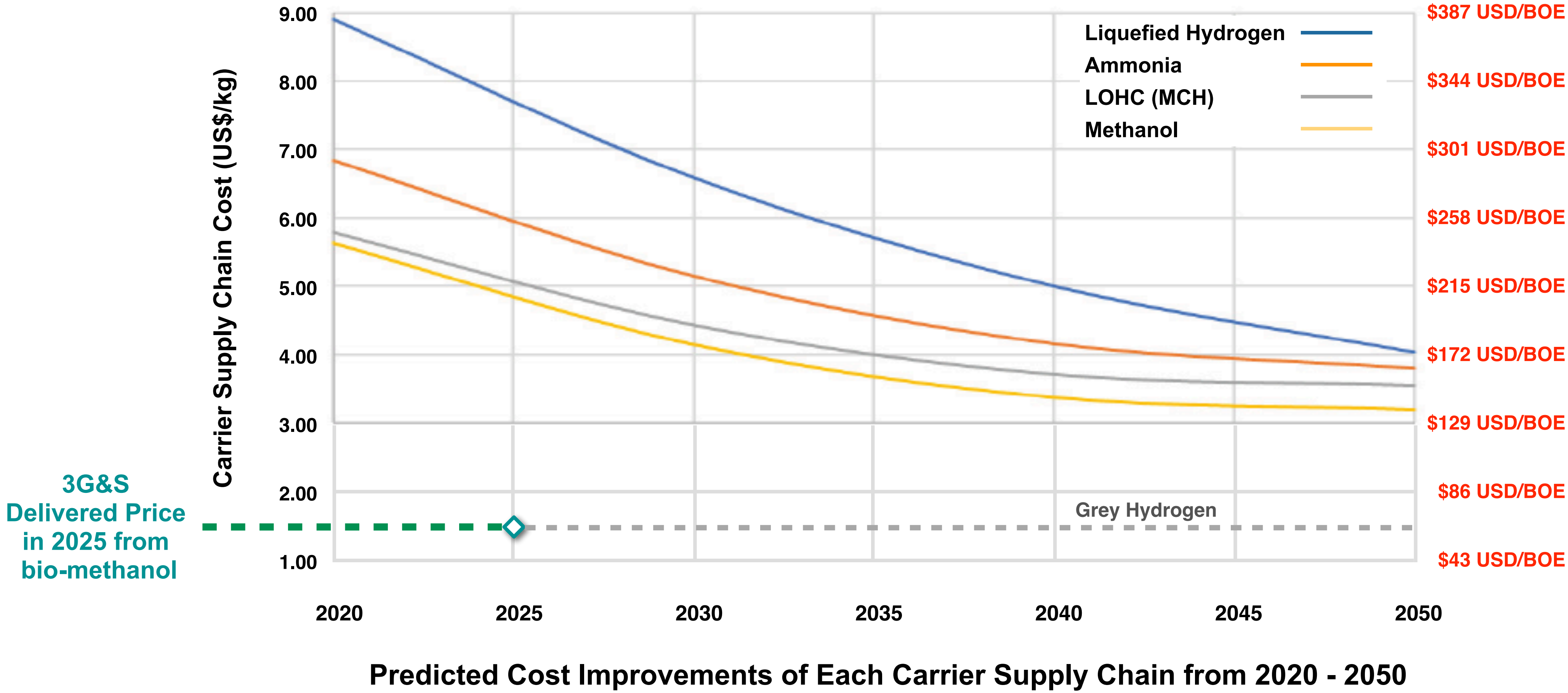
Comparison of LCOH to Fossil Fuels



Predicted Cost Improvements of Each Carrier Supply Chain from 2020 - 2050

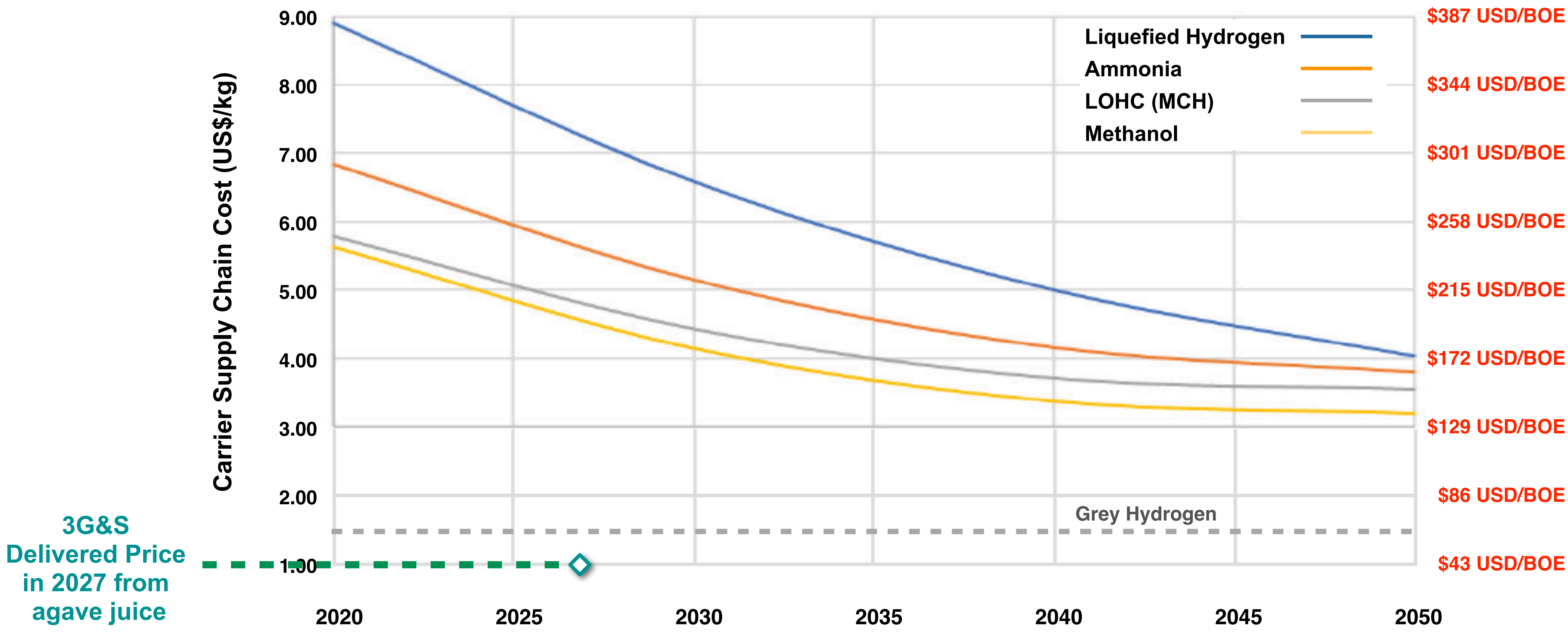
Source: Study of Hydrogen Imports & Downstream Applications for Singapore, Figure 5.14 - KBR - 2020

Comparison of projected hydrogen costs v bio-methanol *(no subsidies)*



Source: Study of Hydrogen Imports & Downstream Applications for Singapore, Figure 5.14 - KBR - 2020

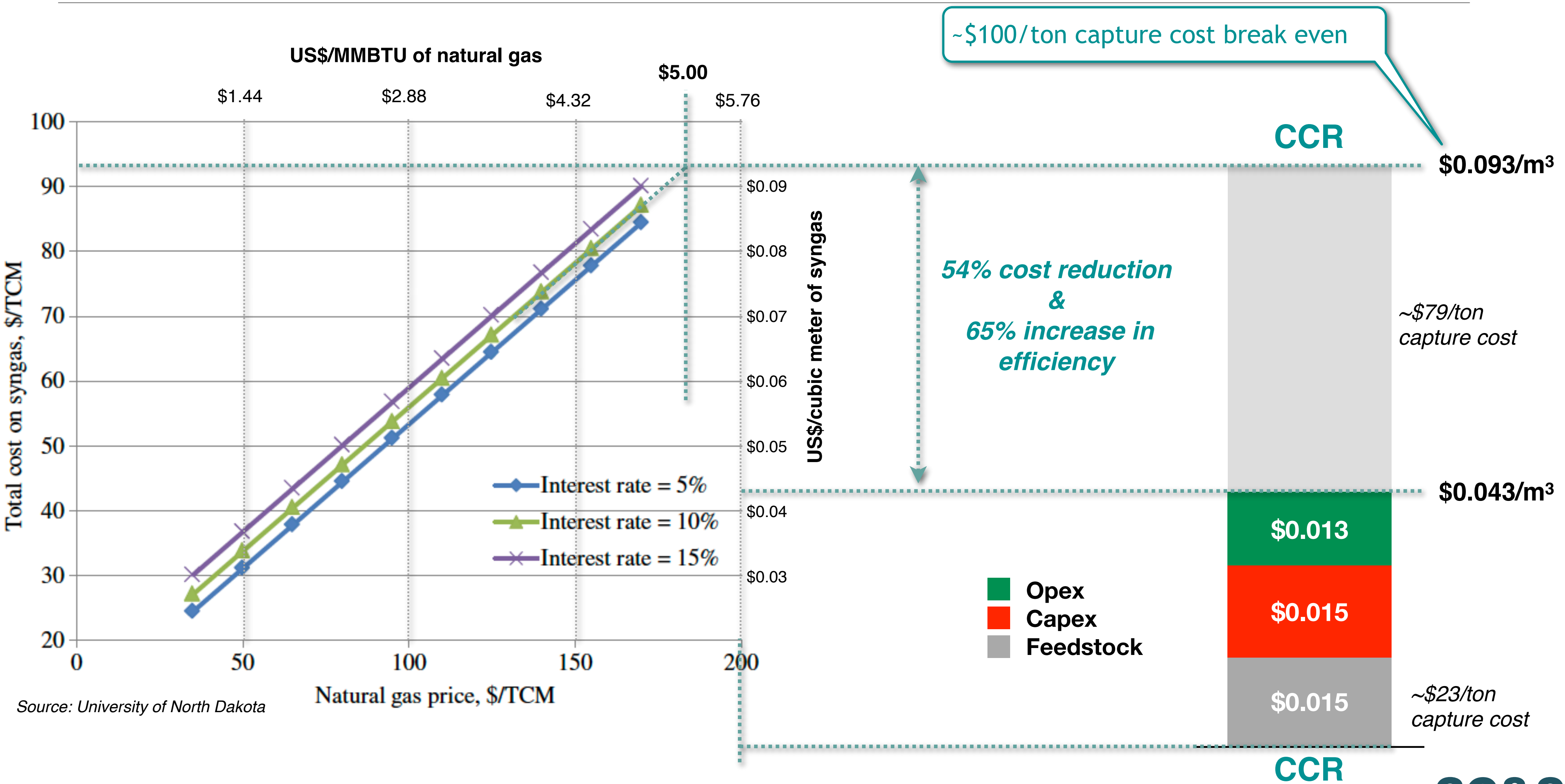
Comparison of projected hydrogen costs v agave juice *(no subsidies)*



Predicted Cost Improvements of Each Carrier Supply Chain from 2020 - 2050

Source: Study of Hydrogen Imports & Downstream Applications for Singapore, Figure 5.14 - KBR - 2020

Syngas Costs (US$/m³) - Natural Gas SMR



Source: University of North Dakota

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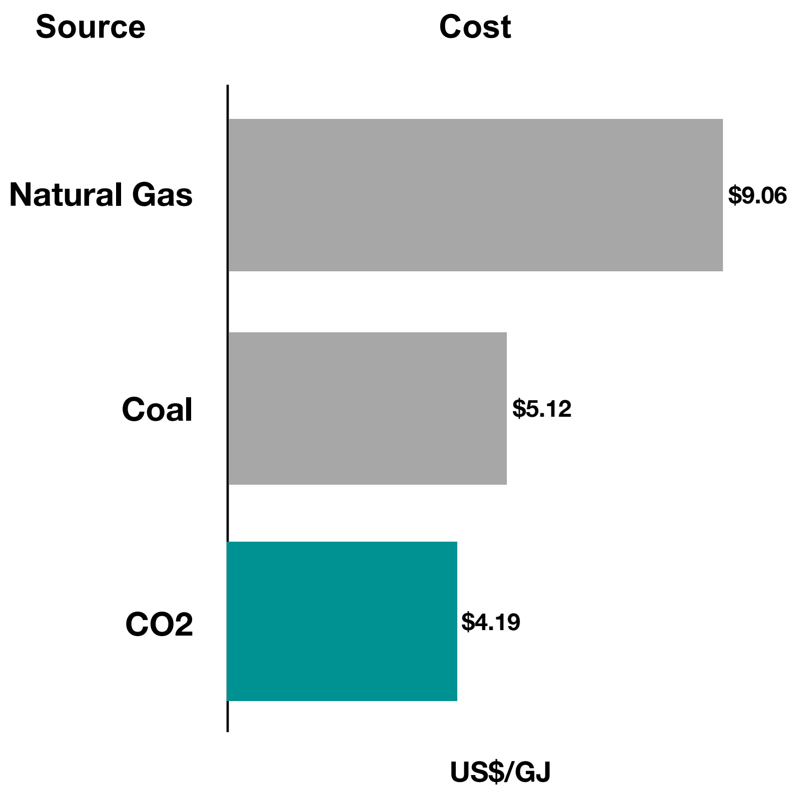
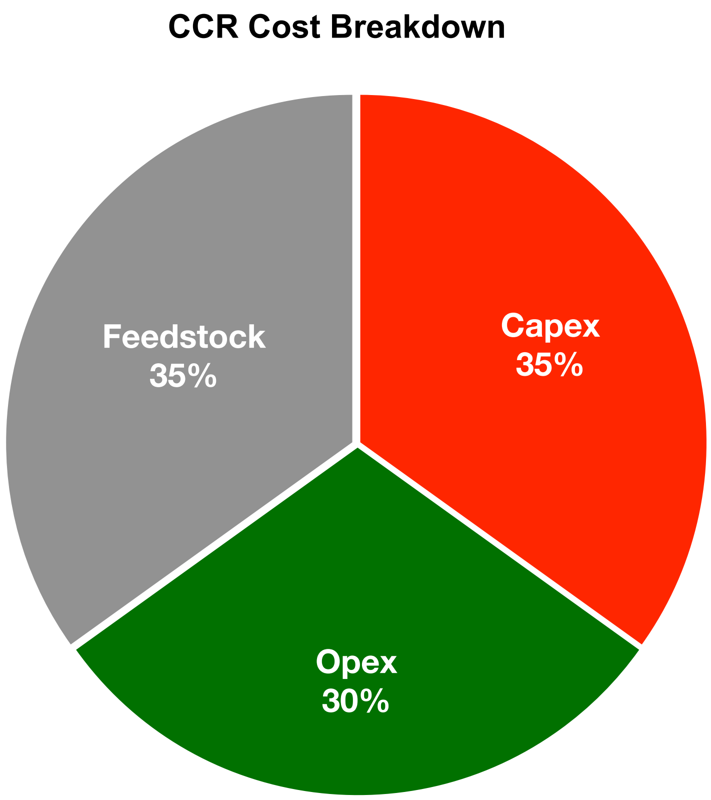
Syngas Cost Comparison





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Thank You - Contact Information

contact: Joe Maceda
+1.917.932.7583
maceda@3gands.com

Background

Requirements for All Financeable Projects

1. Feedstock
2. Site
3. Permits
4. Offtakes

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Definitions

Electrochemistry is the study of chemical processes that cause electrons to move.

Biochemistry is the branch of science that explores the chemical processes within and related to living organisms.

A **Chemical Reaction** is a change in which one or more chemical elements or compounds (the reactants) form new compounds (the products).

A **Chemical Process** is a method or means of somehow changing one or more chemical elements or compounds (the reactants) into new compounds (the products)..

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Waste-to-Energy: Manure Example - NC I

Opportunity & Problem ⟶ ZNC Farms' Solution

Opportunity

- Increasing global population and awareness on food safety
- High demand for organic fresh produce:
  - Year-round, consistent quality
  - Reduced field to shelf time
  - Reliable supply

Problem

- High carbon footprint of current agriculture:
  - Fuel use
  - Fossil fuel-based fertilizers
  - Distance from field to consumer
- Pollution from poultry and livestock manure
- Land use and demand for clean water

ZNC Farms' Solution – Integrated production of Fresh Produce, Renewable Fuel and Organic Fertilizer

Collect and Transport Animal Waste to ZNC Farms

Electric tractors

Digest Organic Materials

Produce Renewable Fuel

Indoor growing of Produce

Produce Organic Fertilizer

Financial Summary - NC I Project

			Year 1	Year 2	Year 3	Year 4	Year 5
INPUT	amount	*units*					
Manure	457,000	*tons*		228,500	457,000	457,000	457,000
OUTPUT							
Organic Produce	28,400	*tons*	0	14,200	28,400	28,400	28,400
Renewable CNG	1,047,100	*MMBTU*	0	523,550	1,047,100	1,047,100	1,047,100
Organic Fertilizer	83,584	*tons*	0	41,792	83,584	83,584	83,584
REVENUES							
Organic Produce		*$USM*	$ 0.0	$ 60.5	$ 123.4	$ 125.9	$ 128.4
Renewable CNG		*$USM*	$ 0.0	$ 8.4	$ 17.0	$ 17.3	$ 17.7
Organic Fertilizer		*$USM*	$ 0.0	$ 11.7	$ 23.8	$ 24.3	$ 24.8
Total Sales Revenues		*$US*	$ 0.0	$ 80.6	$ 164.2	$ 167.5	$ 170.8
Total Expenses		*$US*	$ 0.0	$ 36.0	$ 73.4	$ 74.9	$ 76.4
EBITDA		*$US*	$ 0.0	$ 44.6	$ 90.8	$ 92.6	$ 94.5
		%	0%	55%	55%	55%	55%

CAPEX	
Category	**US$ M**
Land	$ 3.8
Collection	$ 16.0
Digester	$ 49.8
Fuel	$ 5.0
Fertilizer	$ 15.8
Growhouses	$ 317.6
CHP	$ 4.8
Total	$ 412.8

Project is fully scalable and replicable.

North Carolina manure alone could supply 20 projects