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Presentation - Bio-Ethanol Production Novel Technology

Additional submitted attachment is included below.

BIO-ETHANOL PRODUCTION NOVEL TECHNOLOGY

March 29, 2018
Modified October 31, 2018

Atlantic Greenfuels, LLC
and
LeMar Industries, Inc.

Ethanol

- Ethanol (ethyl alcohol) is used as a motor fuel, mainly as a additive for gasoline. It boosts octane value while improving combustion of hydrocarbons resulting in a cleaner exhaust.
- World demand is growing with several governments ruling to add ethanol to gasoline for environmental protection; notable examples are Japan and China.
- Until 2002, there were two main technologies to produce ethanol: fermentation from grain or sugar cane/beets and gasification-catalytic synthesis, a long process from gasification to methanol; then conversion into ethanol.
- The combined technology is a thermo-bio process that converts synthesis gas (syngas) into ethanol via acetogenic microbes. The syngas is produced from gasification of non-edible biomass feedstocks and from municipal solid wastes.

Novel ethanol production technology

- In 2000s, in USA, Canada and New Zealand, laboratories developed new strains of bacteria for fermentation of ethanol directly from syngas.
- The first demo plant was built in Gridley, California in 2004 by NREL with Chemex/LeMar partial engineering and procurement participation.
- Based on this process four plants were built: by BRI in Tennessee, by Ineos in Florida, Coskata in Illinois, and LanzaTech in New Zealand.

- Syngas, primarily containing CO and H2 with CO2, is fermented to ethanol by acetogenic organisms. This process at ambient conditions contrasts with syngas conversion at 900 C in petro-refineries.
- **LeMar with Atlantic Greenfuels, LLC cooperates with Oklahoma City University (OSU)** Research Laboratory on improvement of the process of biological conversion, which increases yield of ethanol more than 200%. LeMar licenses this technology as full process design with equipment.
- An advantage of the OSU patented acetogens is their ability to
- metabolize on CO only, generating H2 via internal bio-mechanism.

We Offer:

- Full plant engineering;
- LeMar designed own gasification process with partial oxidation for the best syngas output. We cooperate with Eclipse and Clayton Industries for most efficient POX (Partial Oxidation) complex;
- Other Projects: with Clariant (Fischer Tropsch catalysts), UOP-Honeywell (hydrogenation to green diesel), Dow Chemical (flocculants), LLNL for underground coal gasification, UC-Davis for advanced biodigesters.
- Under licensing Oklahoma State U. provides microbes that grow on syngases (rather than sugars, as in traditional fermentation);
- LeMar designed a two-stage digester and provides procurement for the whole process to make fuel-grade ethanol;
- In cooperation with the Maleta Group, we supply efficient ethanol distillation, key to lower process energy to earn D3 RINs;
- (Renewable Identification Numbers) are control mechanism of EPA.

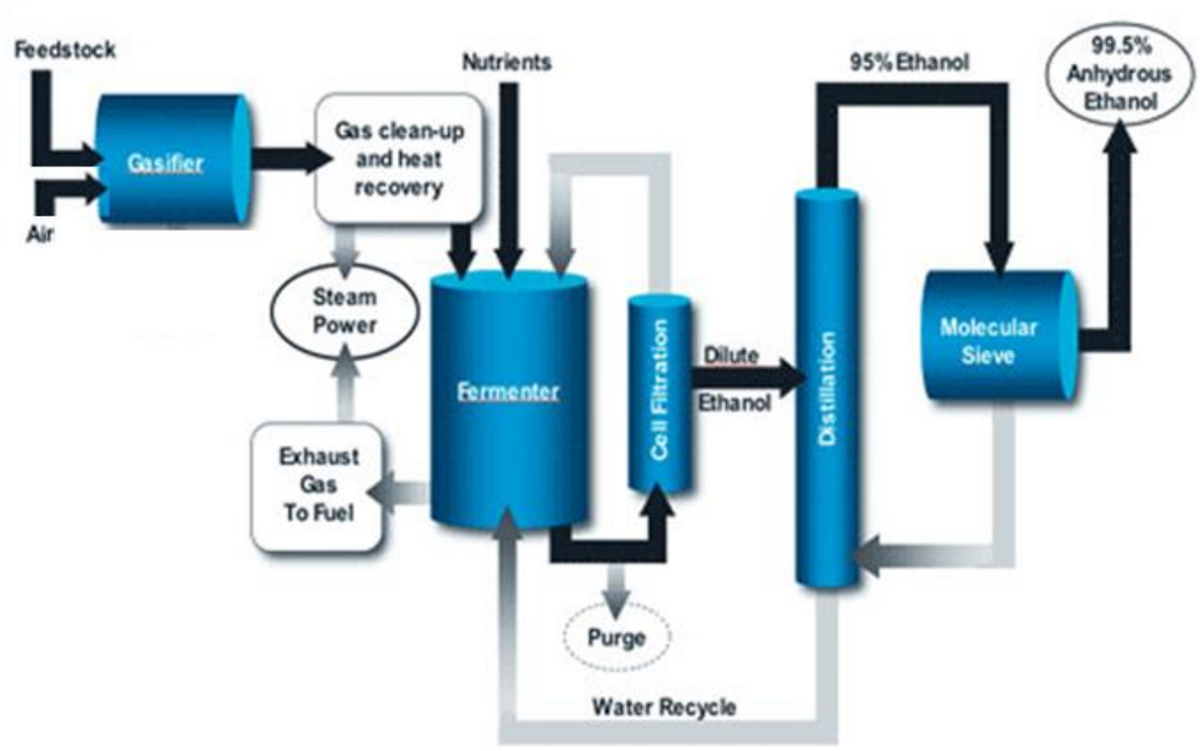
PROCESS

Largest Market Interest is for stranded natural gas deposits and associated gas from crude oil deposits

POX GASIFIERS THE GASIFICATION TEHCNOLOGY ALLOWS TO PROCESS:

- Natural Gas and Crude Oil Gas (ISU plant in North Carolina, BRI in Canada)

GENERAL SCHEMATIC

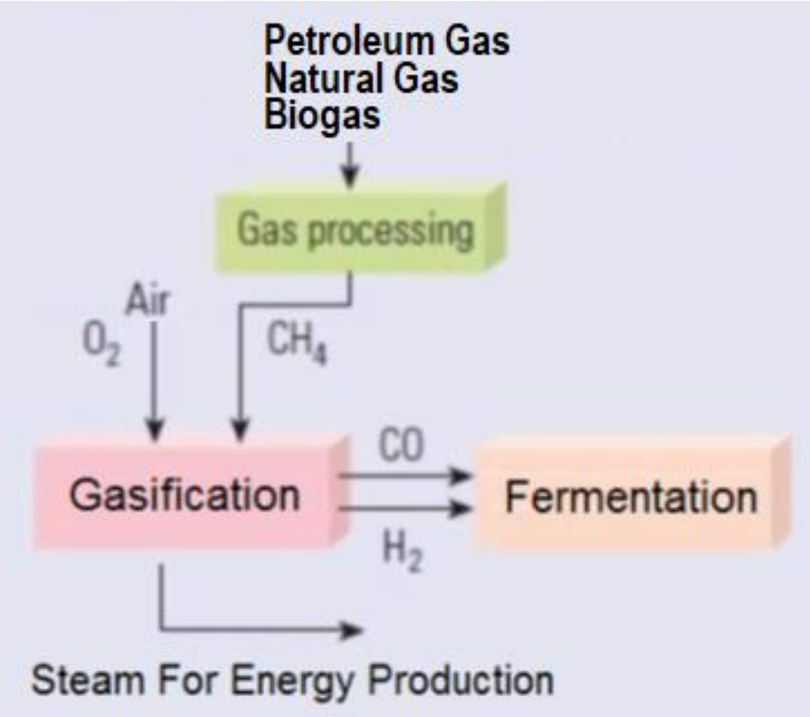


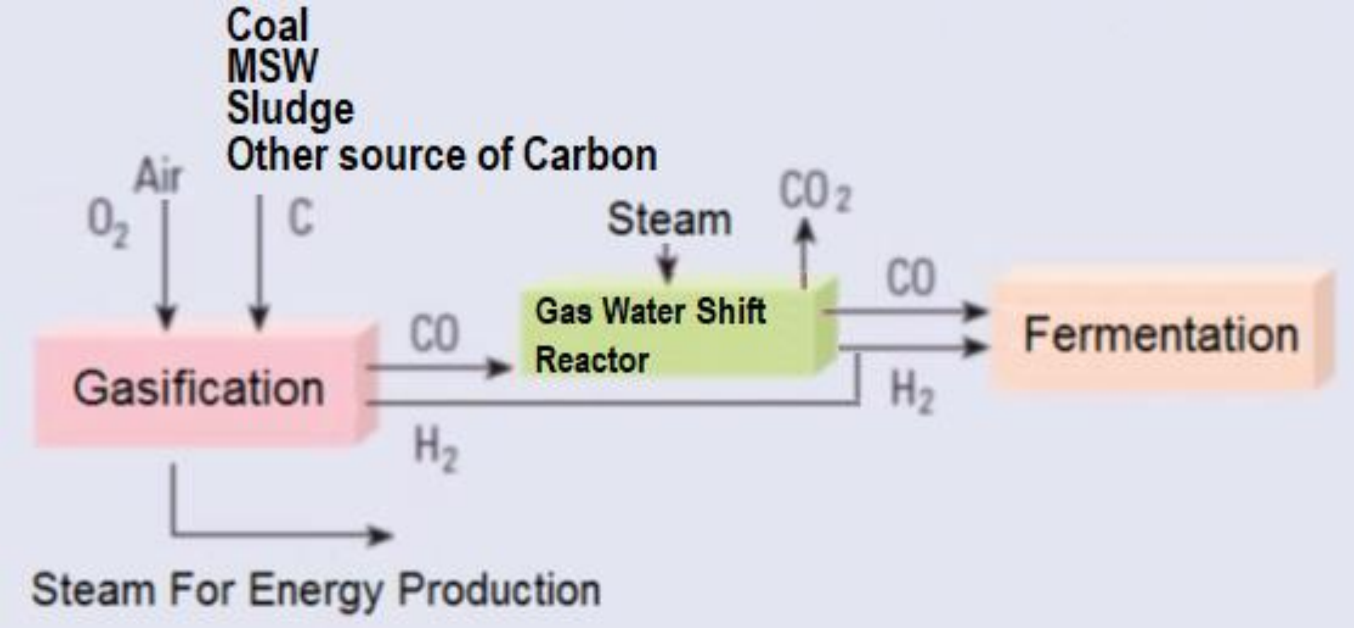
PROCESS

GASIFICATION

LeMar developed technology and equipment to process variety of feedstock:

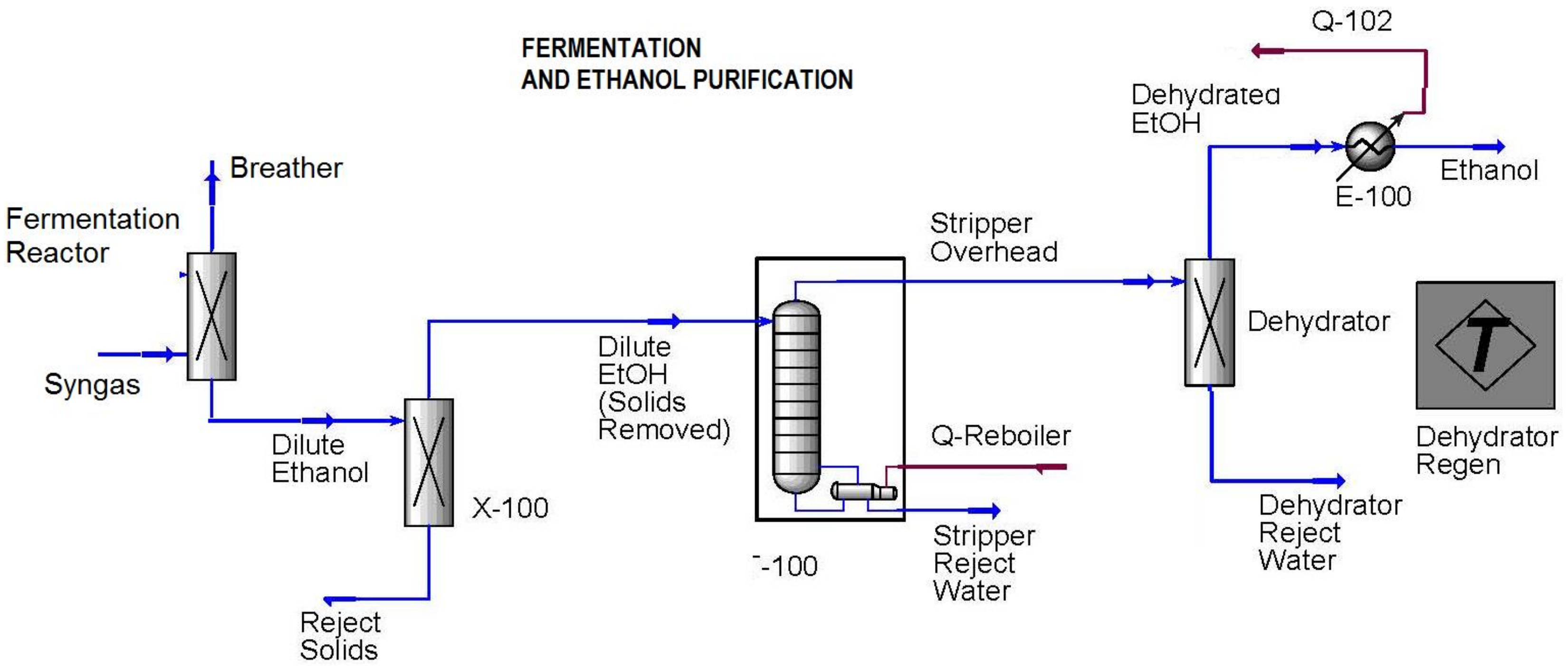
- Gas: natural, petroleum and bio gas;
- Carbon Materials: coal, MSW, sludge, any other source of carbon





PROCESS

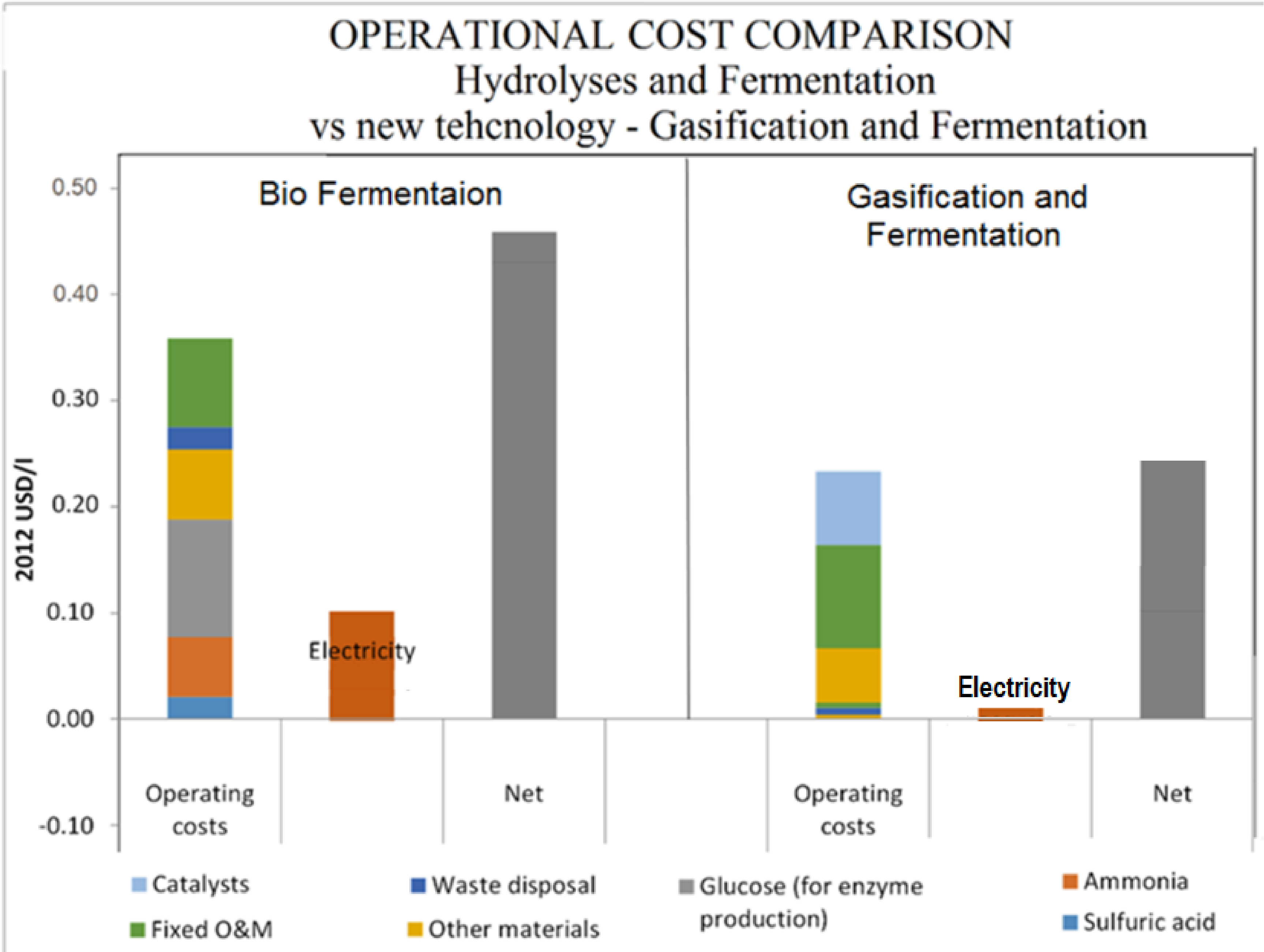
FERMENTATION AND ETHANOL PREPARATION



Syngas is cleaned, cooled, and sent to a bioreactor that converts it to a crude ethanol/water mixture;

Produced ethanol is processed by cyclic distillation to remove impurities and attain final low-water quality

Process Economics



Future considerations

1. **The novel process offered by LeMar & AGI combines the gasification with co-generation of electricity. In comparison with other technologies, the combined technology with energy production lowers cost of the product while improving the GHG (GreenHouse Gas) score**
2. These cheaper production costs with high GHG justify D3-equivalent ethanol via a project in the Dominican Republic, and the first in China in Shandong Province.
3. U.S. Ethanol demand is set to rise with the October 2018 mandate requiring refiners to blend 15% ethanol into gasoline year-round.

Project Economics

Potential Project for stranded natural gas deposit to process 5 million cubic feet of natural gas per day.

Production Program	t/year
Ethanol	26,800
Fertilizer	38,000

Capital Investment (with VAT), mln. $	2018	2019
Engineering	0.605	0.300
Equipment Group 1 (10 years lifetime)	1.305	0.420
Equipment Group 2 (20 years lifetime)	2.670	2.000
Equipment Group 3 (up to 30 years lifetime)	3.000	1.200
Working Capital for Materials, tooling and tools	0.000	2.340
Construction Cost (20 years amortization)	2.180	1.540
	9.760	7.800

Production Data and Costs	
Gas Processing volume, t	34,200
Number of personnel, people	35
Cost of gas, $/1000 cub.feet	1.96
Average Salary, $/month	0.965
Materials, Equipment and Service, mln.$	0.673
Overhead Expenses, mln.$	0.782
General Process Expenses, mln.$	1,126

Project Economics

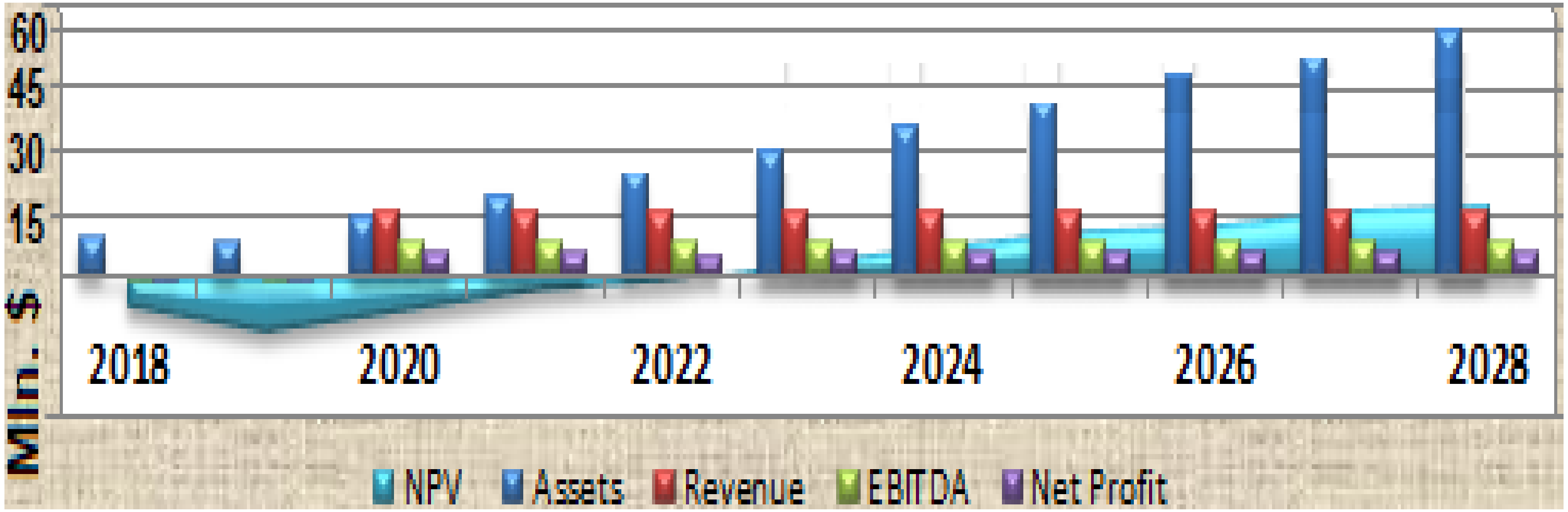
Sales Prices with VAT	
Ethanol Price, $/т	380
Fertilizer, $/t	220

Economical Efficiency											
	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Assets	9	8	14	20	25	31	37	42	48	54	60
Revenue	0	0	16	16	16	16	16	16	16	16	16
EBITDA	(0)	(0)	8	8	8	8	8	8	8	8	8
Net Profit	(0)	(1)	6	6	5	6	6	6	6	6	6
NPV	(8)	(14)	(9)	(4)	(1)	3	7	10	12	15	17
IRR for period			-49%	-8%	6%	17%	24%	28%	29%	31%	32%

Indicators of financial and economic efficiency	
Internal rate of return (IRR), %	34.37%
Net Present Value (NPV), Mln.$	32.57
Profitability index (PI)	4.34
Payback period (PP), years	4.51
Discounted Payback Period (DPP), years	5.30

Project Economics

- PROJECT EFFICIENCY GRAPH



Conclusion

The bio-ethanol production from syngas is economically efficient even for small-scale industrial sized plant for processing of natural gas at stranded deposits and associated gas at crude oil development deposits.

Other considerations

1. Not only natural gas, liquid hydrocarbons or coal, but any carbon-containing material such as municipal solid waste, agricultural wastes, sewage and wood/paper waste can be used as long as it contains less than 40% water. Approximately 75 – 115 gallons of ethanol per ton of solid waste can be expected
2. Presented to Board of Commissioners Portage County, OH; copy to Monroe Energy, Marcus Hook, PA

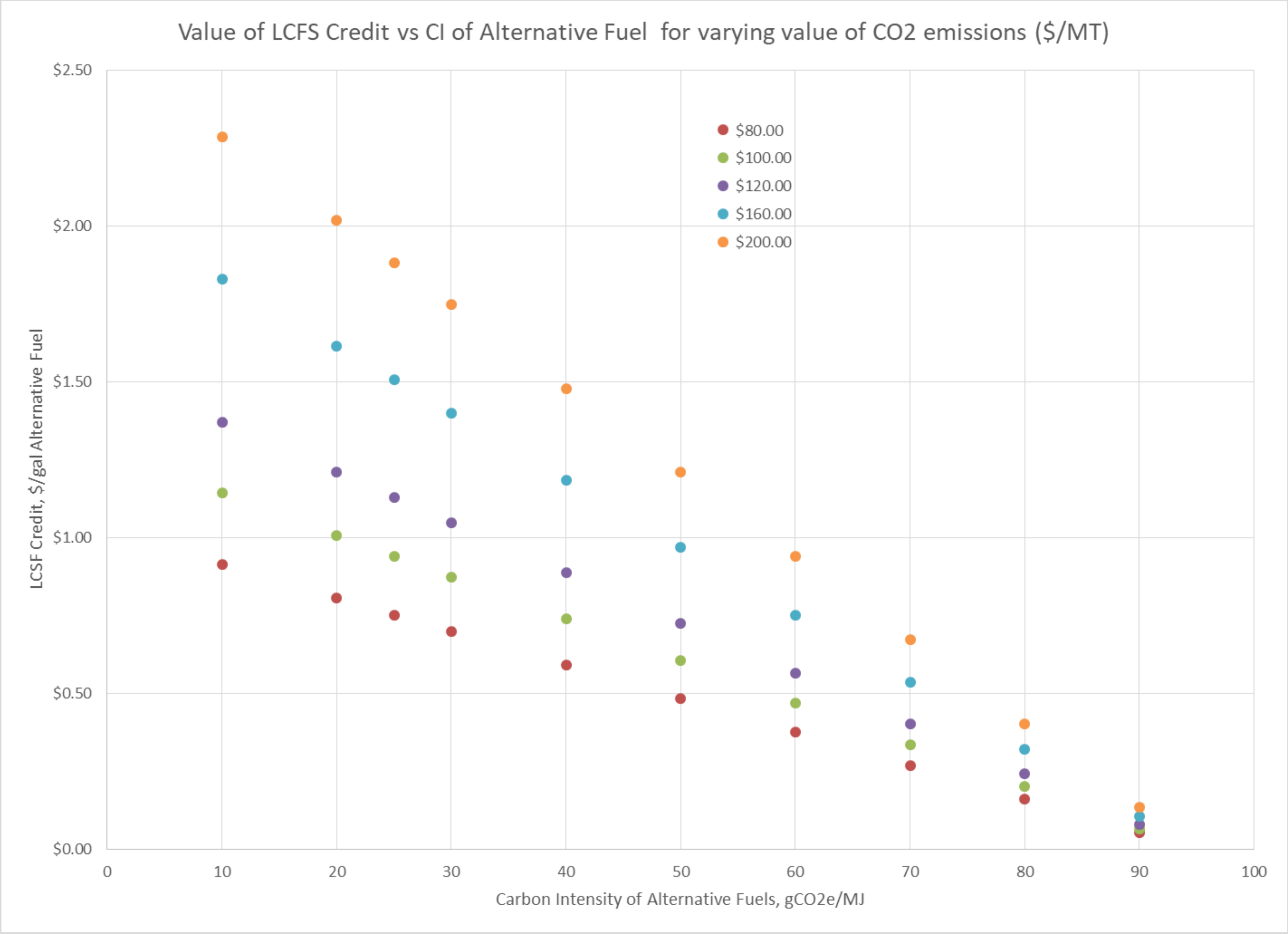
Joseph R. Degenfelder
Atlantic Greenfuels, LLC

Leon Popik
LeMar Industries, Inc

California LCFS Considerations by Dr. Robert Freerks

- A Life Cycle Assessment will need to be completed on the process
- Carbon intensity expressed in grams CO2e emissions per megaJoule (gCO2e/MJ) will determine total credits obtained under LCFS
  - D3 RIN's requires 60% reduction in CI from fossil fuel baseline
  - Target CI is 38 gCO2e/MJ for maximum EPA RFS credit
    - Currently D-3 RINs are valued at $2.554/gal (no multiplier for EtOH)
  - California values LCFS credits based on CI of fuel and market value of CO2 emissions
    - Assuming CI of 10 gCO2e/MJ for EtOH syngas fermentation to EtOH and $188/MT CO2 emissions
    - CA LCFS credit would be $2.16/gal in addition to RINs
- Total EPA and CA credits would be $5.77/gal

California LCFS CI credits vary with CI of fuel and value of CO2 (in $/MT of CO2 emissions)



Data Sources and Requirements

- California ARB provides spread sheet for calculating LCFS credits vs cost of CO2 and CI of fuel
- California also tracks RINS
- Progressive Fuels Limited publishes RIN and LCSF values weekly
- LCA of process needs to be estimated to determine level of RINs and LCSF
- LCA pathway will need to be validated by EPA and CARB
- Actual RINs D-value and LCSF CI value will depend on actual running plant data determined once steady state operation is achieved

Atlantic Greenfuels, LLC

Atlantic Greenfuels, LLC - Joseph R. Degenfelder

Creator:

- Biofuels in the 21st Century - November 2004
- Biofuels in 21st Century (2): Competitive U.S. Ethanol - March 2018

  Coordination with GREET Model and USDA to correct Jan. 12, 2017 report "A Life-Cycle Analysis of the Greenhouse Gas Emissions of Corn-Based Ethanol"

  The corrected report was posted October 26, 2018;

- see summary in next two following slides: report is at www.usda.gov/oce/climate_change/mitigation_technologies/LCA_of_Corn_Ethanol_2018_Report.pdf
-

USDA Update October 26, 2018

Ethanol GHG Balance Highlights

- Between 2005 and 2015, corn ethanol production in the United States increased from 3.9 to 14.8 billion gallons per year.

- The current LCA value for corn ethanol produced in an “average” plant (corn refinery) is 39 percent lower than gasoline. The value for ethanol refined at a natural gas powered plant is 43 percent lower.

- Given current trends, by 2022 the LCA emissions for corn ethanol will be 44.3 percent lower than gasoline.

- If refineries take steps to reduce emissions, by 2022 the LCA emissions for corn ethanol could be over 70 percent lower than gasoline (see next slide.)

- Refineries can reduce LCA emissions 7 percent by contracting with farmers to grow corn using low GHG-emitting practices (e.g., reduced tillage, cover crops, and nitrogen management).

- Ethanol produced in refineries powered by natural gas and that also contract with farmers to use low-emitting production practice has an LCA value 47 percent lower than gasoline.

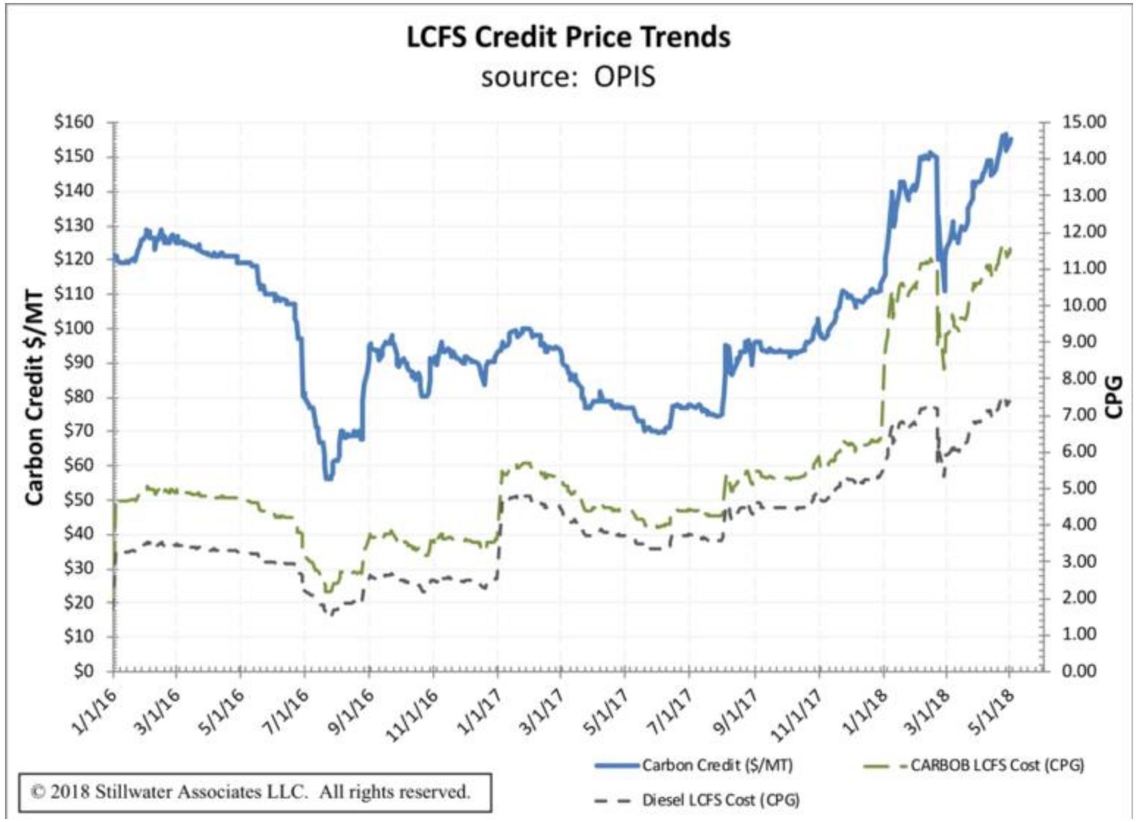
USDA Update October 26, 2018
Best case scenario for 2022

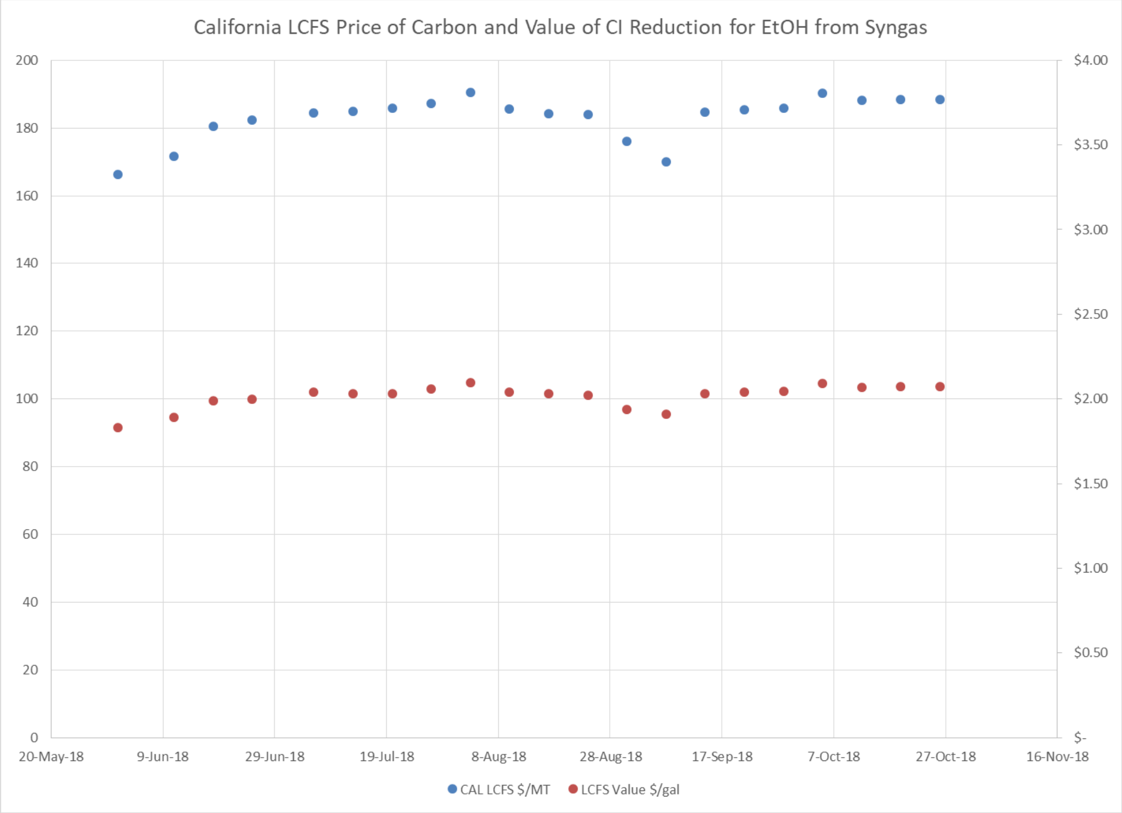
Our HEHC scenario assumes refineries takes steps in their value chain to reduce emissions associated with their ethanol. Refineries use sustainable biomass for the process fuel, contract with farmers to grow corn using low-emission practices and locate confined livestock operations near refineries. Projected emissions for corn ethanol in 2022 are 27,852 g CO2e/MMBtu, which is a 71.6 percent reduction in GHG emissions relative to gasoline. The main source of emissions reductions is the shift to sustainable biomass as the process fuel. While it is not likely the ethanol industry as a whole will undertake these changes, it does highlight the emissions reductions that are technically possible with currently available technologies. Given appropriate incentives, some refineries will likely undertake these changes. The most likely source of such incentives are opportunities to participate in new or expanding markets for low-carbon transportation fuels in California and outside of the United States.

LCFS Background

- Established through CA AB32, the 2006 Global Warming Solutions Act
- Coal to reduce the Carbon Intensity (CI) of transportation fuel by 10% by 2020
  - Since modified to reduce CI of fuel by 20% by 2030
- Administered by California Air Resourced Board (CARB)
- Scheduled reductions in fuel CI over 10 year period
- "Regulated Parties" required to track fuel volume and CI through LCFS Reporting Tool (LRT)
- Fuels included in LCSF
  - Ethanol
  - Biodiesel
  - Renewable diesel
  - CNG/RNG/LNG
  - Hydrogen
  - Electricity for EV's
  - Jet Fuel

LCFS Price of Carbon and Credits

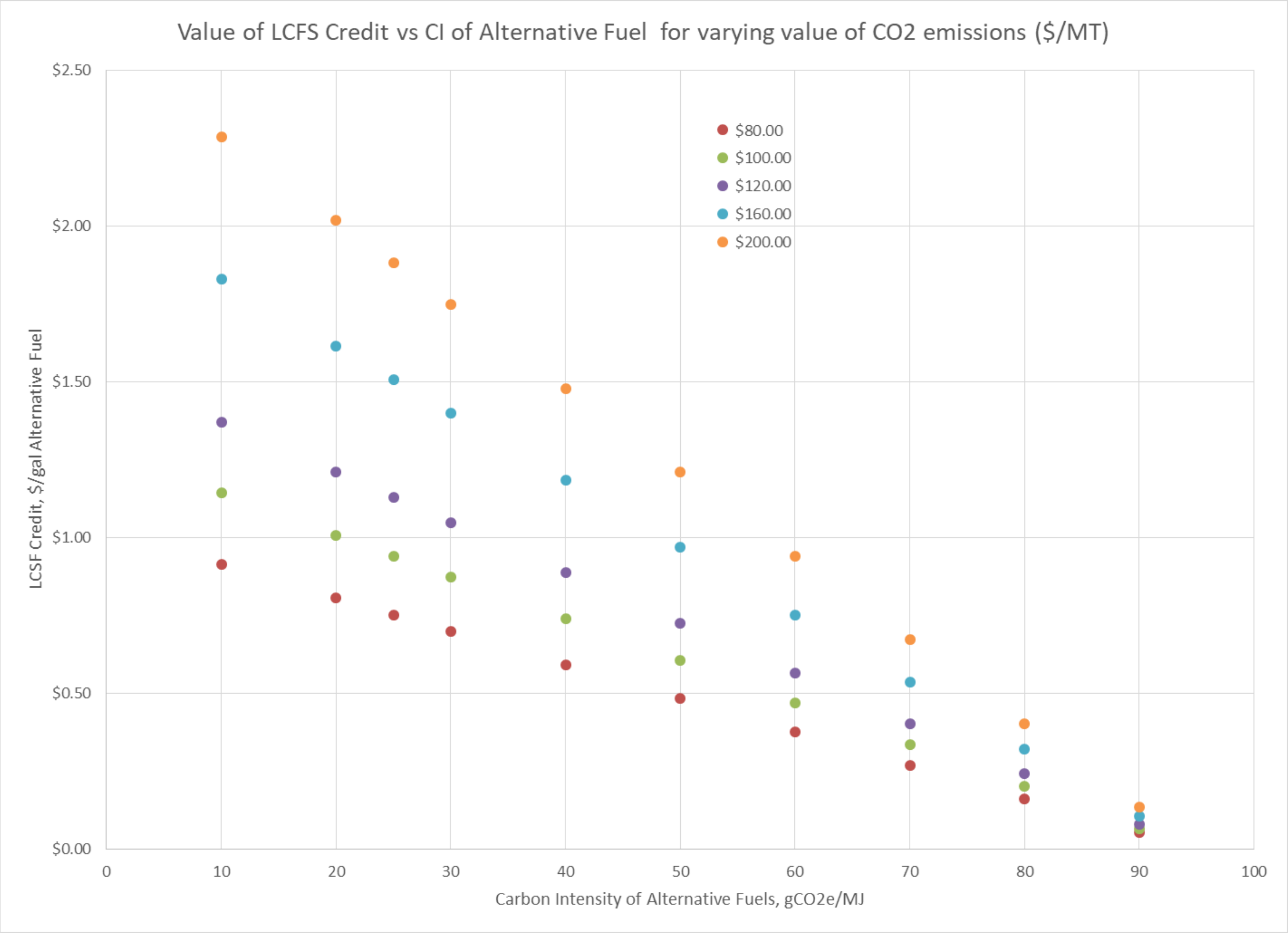




Through 5-18, Value of CO2 was <$160/MT, Increased to nearly $200/MT in 10-2018
Value of CI reduction for EtOH with CI of 13 is ~$2.00/gal in 10-2018

https://stillwaterassociates.com/lcfs-101-an-update/

California LCFS CI credits vary with CI of fuel and value of CO2 (in $/MT of CO2 emissions)



Ambient and Emission Trends of Toxic Air Contaminants in California – ARB 2015 report Emission Trends for 1990-2012 (excerpts) https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b02766

While CA population increased 31% and
Gross State product increased 74%:
- Diesel particulate matter declined 69%
- Benzene declined 88%
- 1,3 Butadiene declined 85%
- Formaldehyde declined 20%*
- Acetaldehyde declined 20%*
- Collective cancer risk declined 76%

*Aldehydes increase with 10% blended ethanol

Green fuel imports to California now matched by in-state production

2017: 235 million gallons green distillate fuel imported from Neste Oil's Singapore refinery; is 33 percent of Neste world production

2018: World Energy purchases AltAir Paramount refinery; announces CAPEX of $350 million to produce 306 million gals/year

2018: ICM/The Andersons ELEMENT plant in Kansas, built for CA LCFS market, utilizes combined starch-celluosic ethanol plus wood for process power for GHG score of 70 (target in USDA report)

2018: Aemetis with InEnTech and LanzaTech to build 40 million gal/year cellulosic ethanol at $153 million CAPEX with nut waste to syngas to ethanol via acetogenic bacteria conversion