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NOVA Technical Workshop 2017

GREENHOUSE GAS EMISSION UPDATE

Liquid Fuels are Viable Pathway to a Low/No-Carbon 2050

Overview – The Great Debate

- A Few Words on the All Electric Future of 2050
- An Update on GHG Emissions from Biodiesel Blends with 15 ppm Sulfur Diesel
- A Few Unanswered Questions on the Above

Devil is in the Details

The vision proposed … narrows generation options but includes a wide range of currently uncosted innovations that would have to be deployed at large scale:

- *replacement of our current aviation system with yet-to-be-developed hydrogen-powered planes.*
- *assumes the availability of energy storage systems that are not yet proven at scale and deploys them at a capacity twice that of the entire United States' generating and storage capacity today.*
- *underground thermal energy storage (UTES) systems deployed in nearly every community to provide services for every home, business, office building, hospital, school, and factory in the United States.*

However, the analysis does not include an accounting of the costs of the physical infrastructure (pipes and distribution lines) to support these systems.

Complete Decarbonization of the Electric Grid Not Likely by 2050?

"Given unlimited resources to build variable energy production facilities, while expanding the transmission grid and accompanying energy storage capacity enormously, one would eventually be able to meet any conceivable load. However, in developing a strategy to effectively mitigate global energy-related CO_2 emissions, it is critical that the scope of the challenge to achieve this in the real world is accurately defined and clearly communicated."

Source: "Evaluation of a proposal for reliable low-cost grid power with 100% wind, water, and solar", Christopher T. M. Clack, et, al., June 27, 2017, Proceedings of the National Academy of Sciences

Our View

- Fossil Fuels will be eliminated by 2050
- 100% Renewable Electric Grid is not likely by 2050
- We are working to develop one of the successful pathways to zero carbon using all renewable liquid fuels in the future.
- The following slides present our progress.

The Latest Liquid Fuels GHG Status - Assumptions

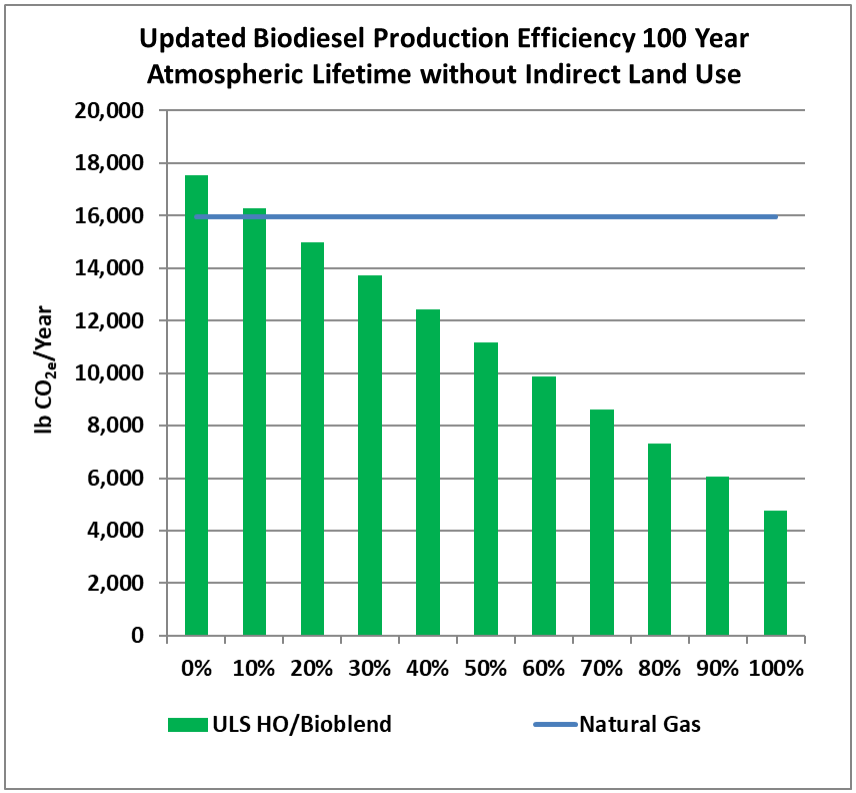
Boiler without DHW Comparison				Location					
System	Description	Thermal Eff. %	Idle Loss (%)	Baltimore, MD	Boston, MA	Madison, WI	New York, NY	Norfolk, VA	Seattle, WA
1	Average oil boiler currently sold	84	1	84.5	102.0	141.9	92.0	56.4	78.2
2	Average gas boiler currently sold	82	1	92.0	109.1	151.4	100.7	61.7	83.3
3	Current high efficiency oil boiler	86.5	0.15	74.9	91.6	127.8	79.1	48.6	71.1
4	Current high efficiency gas boiler	82	1	86.5	104.5	145.3	94.3	57.8	80.2
5	Condensing oil boiler with radiant floor	95	0.5	70.9	86.3	120.1	75.9	46.5	66.5
6	Condensing gas boiler with radiant floor	95	0.5	70.9	86.2	120.1	75.9	46.6	66.6
7	Condensing oil boiler with baseboard	90	0.6	75.6	91.8	127.9	81.3	49.8	70.8
8	Condensing gas boiler with baseboard	87.5	0.6	77.8	94.5	131.5	83.6	51.3	72.8
9	NAECA min oil boiler today 80% AFUE	80	1.5	93.2	111.8	155.3	103.2	63.2	85.4
10	NAECA min gas boiler today 80% AFUE	80	1.5	93.1	111.0	155.2	103.2	63.2	85.4
11	2015 NAECA oil boiler min efficiency	83	1	85.4	103.2	143.5	93.2	57.1	79.2
12	2015 NAECA gas boiler min efficiency	82	1	86.5	104.5	145.3	94.3	57.8	80.2
13	Average oil boiler now in field	73	2	107.0	127.7	177.1	120.3	73.6	97.2
14	Average gas boiler now in field	73	2	106.9	127.7	177.0	120.3	73.6	97.1

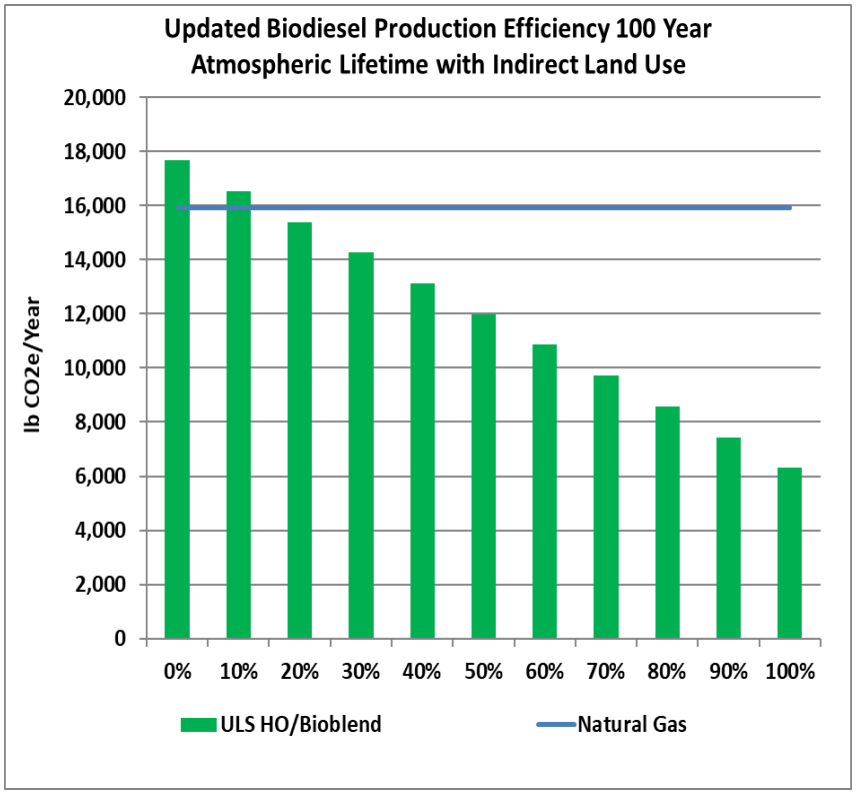
Source: Brookhaven 2,500 sq. ft. house heating performance model from 2009 ICF report entitled “Resource Analysis of Energy Use and Greenhouse Gas Emissions from Residential Boilers for Space Heating and Hot Water.

Key assumptions: Examining replacement residential boilers in the Mid-Atlantic and Northeast during the 2018 to 2038 timeframe, the majority will operating in an non-condensing manor regardless for boiler type because the building stock cannot acoelomate the surface area required for condensing without significant transformation requiring substantial cost and imbedded energy during the transformation.

Therefore, the ensuing slides are based on comparing the end-use performance of non-condensing boilers in Boston, MA.

The Latest Liquid Fuels GHG Status – Biodiesel Blends v. Natural Gas





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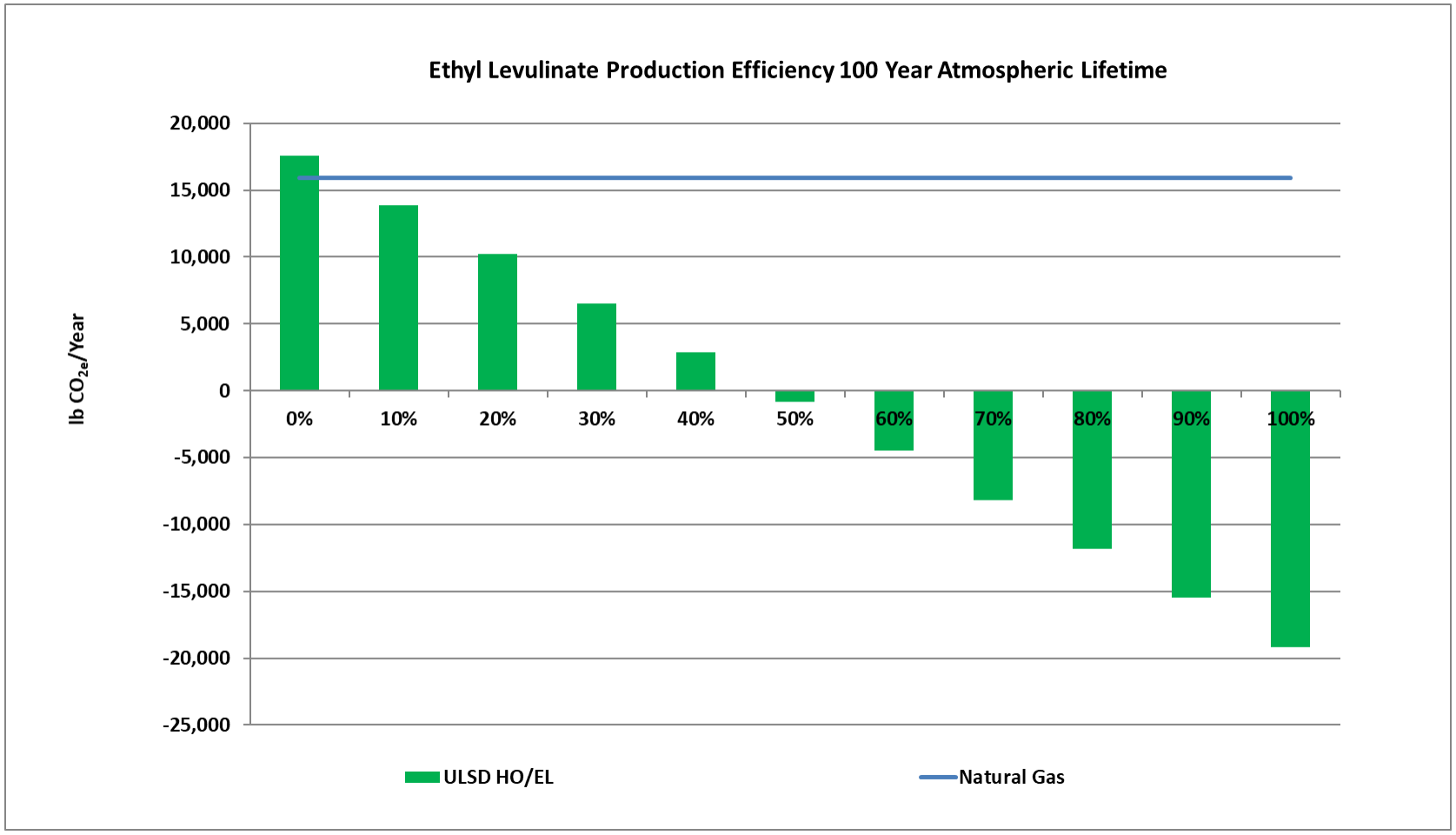
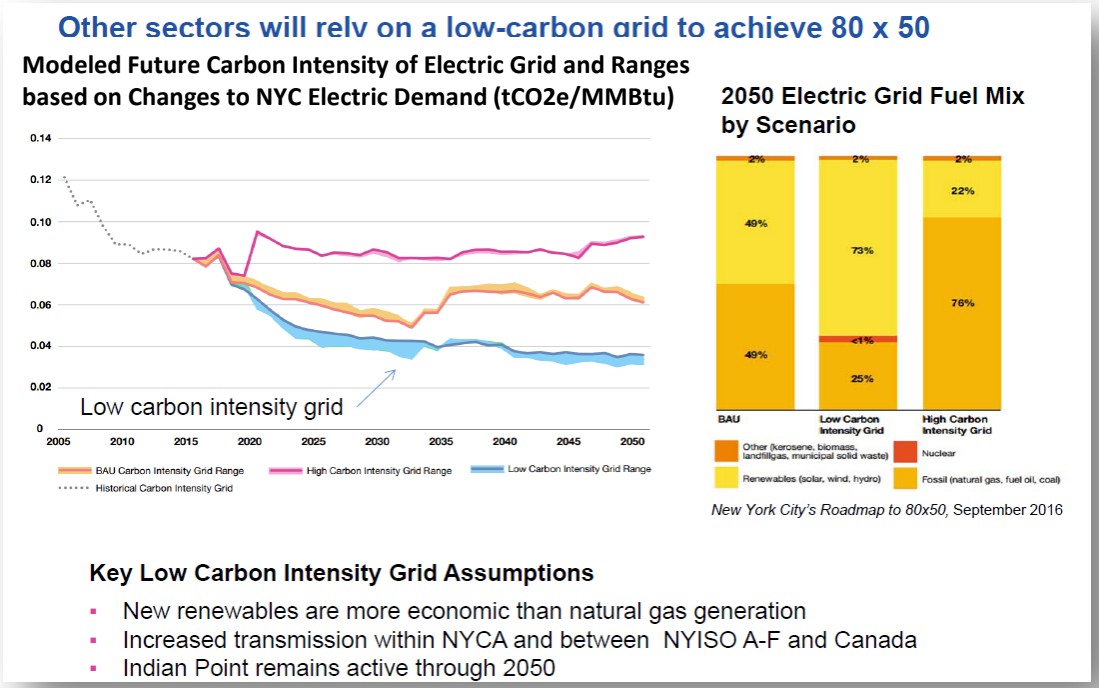
The Latest Liquid Fuels GHG Status – Ethyl Levulinate Blends v. Natural Gas



Source: Comparison of Ethyl Levulinate with Gasoline and Diesel: Well to Wheels Analysis, EarthShift, June, 2009

NYC 2050 Predictions for Low Carbon Electric Grid

NEEP data shows average cold climate heat pump COP @ 5°F = ~2.08 and @ 17°F = 2.41. Applying cold climate HP technology, according to the NYC low carbon grid of 2050 will still yield CO_2 emissions. EL 100 boilers and thermal heat pumps have the potential to have no GHG emissions.



Source: #ONENYC Presentation, July 18, 2017

Unanswered Questions for the Future of Liquid Fuels

- Technological/economic
  - Biodiesel will need to progress in capacity and production efficiency. Will Algae based products come on the market? Cold flow properties will need to be addressed.
  - Ethyl Levulinate will need to proceed to commercial scale production.

Unanswered Questions for an All-Renewable Electric Future

- Beside the technological challenges and general economic questions already presented three additional obstacles are:
- The transition from today to an all-electric energy supply system requires an immense infrastructure change. What is the embedded energy/environmental cost and does this change the policy calculus?
- If energy use shifts from fossil fuels to renewable fuels, supply/demand economics dictate rising renewable energy costs and lower fossil energy costs. This will impact customer choice in the future.
- Currently the world has essentially a uniform cost for oil. How will a switch to alternative fuels affect that cost and how will it impact manufacturing, food production, etc.

Liquid Fuel's Potential Role