Assessing the Climate Change Impact of Biofuels

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Why Pay Attention to the Carbon?

- Biofuels are becoming an integral part of modern “green” technology as well as efforts to reduce the appetite for imported oil
- Several Low Carbon Incentive Mechanisms Guide Biofuels Development
  - Regulatory systems such as Low Carbon Fuel Standards (LCFS) emerge that have significant implications for the way biofuels such as ethanol and biodiesel are produced
  - Carbon credits from trading mechanisms like the Chicago Climate Exchange (CCX) may also influence production methods of biofuels
- Low Carbon Incentive Mechanisms may influence technology choices
  - Location of future biorefineries
  - Energy systems used at biorefineries
  - Production/Fermentation Processes employed by biorefineries
  - Agricultural practices
  - Other technologies/practices (engine development etc.)

Structure of this Presentation

- Provide Background on Low Carbon Incentive Mechanisms
- Showcase UIC – Energy Resources Center work in this area

Low Carbon Fuel Standards

- In January 2007, California Governor Arnold Schwarzenegger signed an order establishing a Low Carbon Fuel Standard (LCFS) for transportation fuels sold in California
- LCFS will affect fuels produced in and out of state
- By 2020 the standard will reduce the **Global Warming Intensity (GWI)** of California's passenger vehicle fuels by at least 10 percent

Low Carbon Fuel Standards (cont'd)

- Besides California, eleven other states are considering the implementation of LCFS: MA, NY, OR, CT, NJ, ME, VT, PA, RI, WA, AZ
- Compliance with the LCFS will require an examination of the GWI of all transportation fuels on a full fuel cycle or life cycle basis
  - The direct emissions from fuel combustion, fuel production, distribution, and delivery will also be included

Low Carbon Fuel Standards (cont'd)

Life Cycle Analysis of Biofuels	**Life Cycle Analysis of Petroleum-based Fuels**
Feedstock Production including agricultural inputs and on-farm energy use: Irrigation energy, fertilizer inputs, till/no-till practices etc.	Oil Exploration and Extraction
Transportation from the field/farm to the Biorefinery	Transportation to the Refinery
Conversion at the Biorefinery (Ethanol Plant, Biodiesel Plant)	Conversion at the Refinery
Distribution to the Enduser/Gas Station	Distribution to the Enduser/Gas Station
Combustion in the Vehicle	Combustion in the Vehicle

Low Carbon Fuel Standards (cont'd)

- Petroleum-based transportation fuels generally have a GWI of 95,000-105,000 gCO_2eq/MMMBtu.
- The GWI of biofuels has the potential to be much lower:
  – Since the carbon released during biofuel combustion was recently removed from the atmosphere during feedstock growth, this carbon is not considered to contribute to global warming
- The GWI of biofuels is more variable than the GWI content of petroleum fuels,
  – since the entire GWI for biofuels is due to production processes,
  – whereas 90% of the GWI of petroleum fuels is due to the carbon constituting the fuel itself

Low Carbon Fuel Standards (cont'd)

- In fuel markets that regulate global warming intensity, biofuels will shift from being commodity goods to being quality-differentiated goods:

  Price premium associated with lower GWI

- This poses great opportunities and potential financial advantages for biofuel producers who **can** reduce the GWI of their product by utilizing more efficient conversion methods or low-GWI inputs
- The first step is to understand the GWI of the biofuels as currently produced

Carbon Credits

- Carbon Credits Constitute Another Low Carbon Incentive Mechanism
- Chicago Climate Exchange (CCX):
  - "CCX accepts proposals for energy efficiency and fuel switching offset projects, on the basis of displacement of CO2 emissions from fossil-fuel based energy sources, on a project-by-project basis"
- In a recent press release the Corn Plus ethanol plant in Minnesota announced that it will reduce its greenhouse gas emissions to 30 percent below its plant emission baseline by switching from natural gas fired boilers to biomass gasification systems.
  - This fuel switching arrangement will enable Corn Plus to obtain carbon credits from CCX.
- The first step is to understand the GWI added by energy systems to biofuels

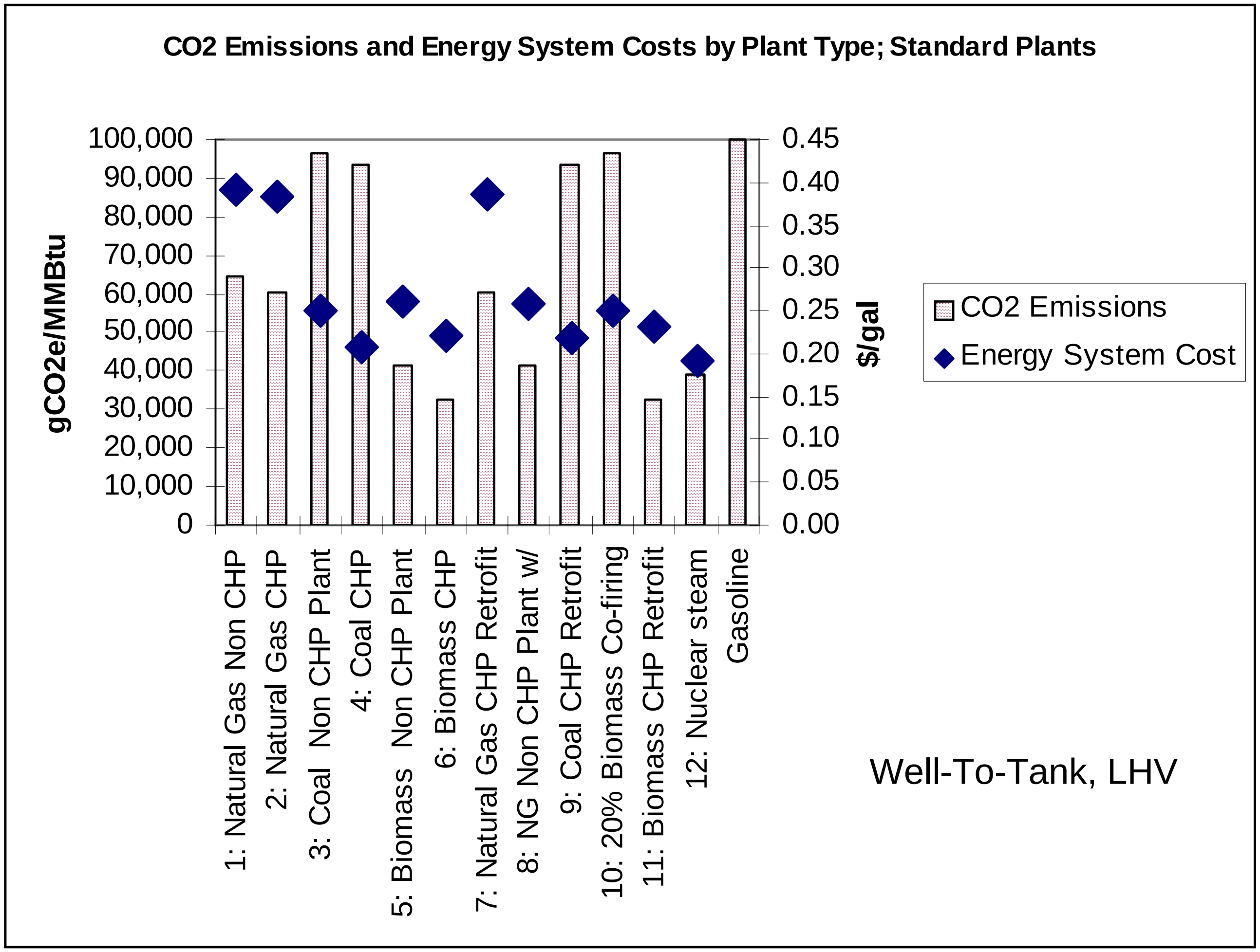
UIC-ERC Efforts:
Understanding the Cost and GWI of Corn Ethanol

- UIC-ERC with Life Cycle Associates has developed a fuel and electricity model (BEACCON) of current and future corn ethanol energy systems that incorporates:
  - Energy balance & cost requirements associated with 12 different ethanol plant energy system configurations
  - Expected efficiency improvements to plant energy systems through 2030
  - Prevailing energy prices in 9 different states (home to over 80% of the current installed ethanol plant capacity)
  - Life cycle global warming intensity of different NERC electricity grid regions
  - Coal, natural gas, and biomass fired ethanol plants
  - Different Ethanol Production Processes (Fractionation, Cold Cook Process, etc.)
  - **The Model is available at www.lifecycleassociates.com**

Understanding the Cost and GWI of Corn Ethanol

Current Research Example 1:

Work with the Illinois Department of Commerce and Economic Opportunity to Develop a GWI Assessment Tool that can be used for Ethanol Incentive Programs

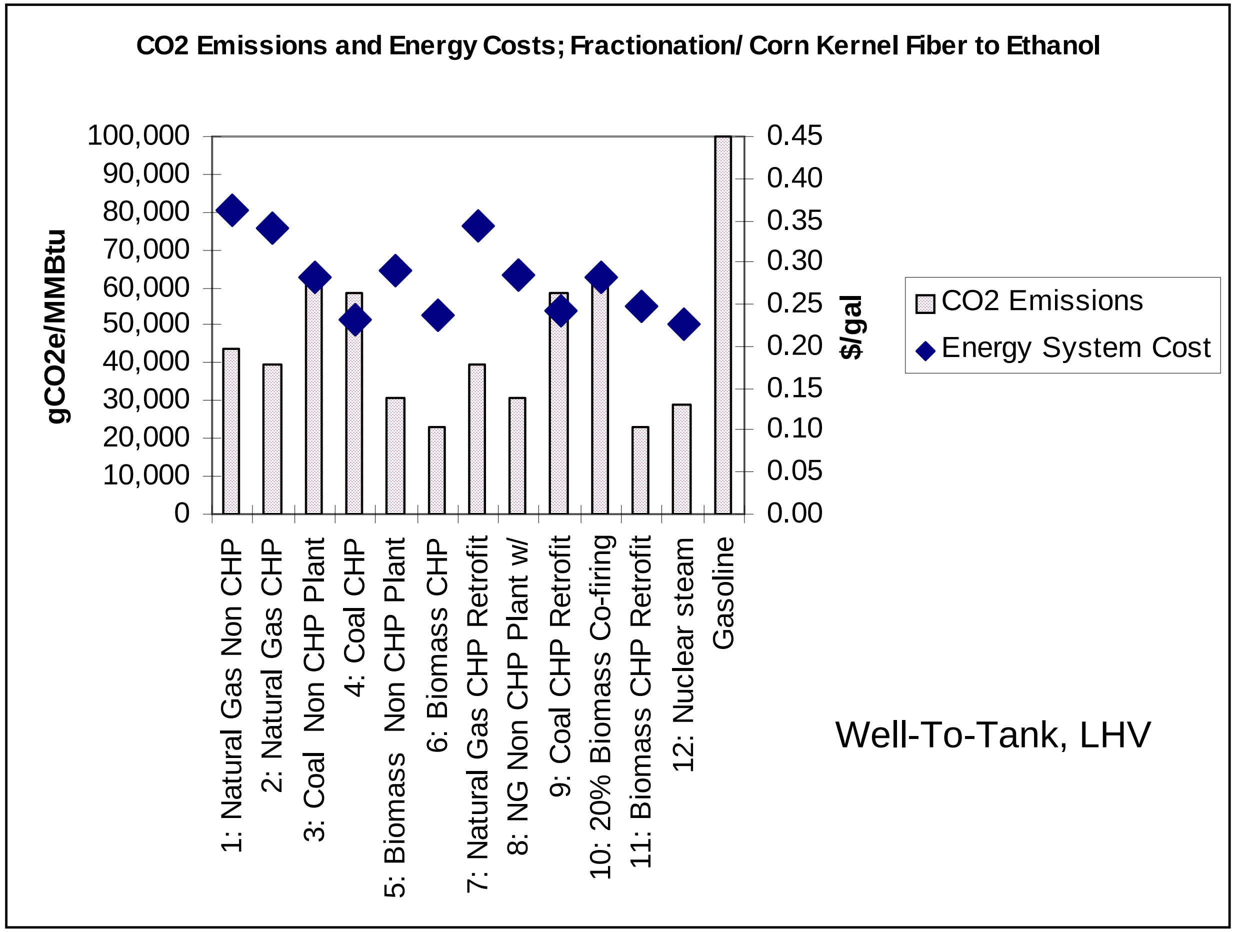


Understanding the Cost and GWI of Corn Ethanol

Current Research Example 2:

Evaluate the Benefits of Employing Different Corn Ethanol Production Processes:

- Corn Oil Extraction
- Fractionation
- Kernel Fiber to Ethanol
- Cold Cook Processes



Understanding the Cost and GWI of Corn Ethanol

- Current Research Example 3: The GWI of Future Corn Ethanol
- Study funded by the Illinois Corn Marketing Board
  - ProExporter Network determined future corn ethanol agricultural practices
  - National Corn to Ethanol Research Center commented on selected input parameters
  - UIC-ERC modeled fuel and electricity consumption of future corn ethanol energy systems
  - UIC-ERC modeled adoption of new ethanol production processes
  - UIC-ERC and Stefan Unnasch with Life Cycle Associates translated input parameters for use in GREET
  - Stefan Unnasch using GREET and BEACCON modeled how GWI of ethanol will change through 2030 as a function of these parameters

The GWI of Future Corn Ethanol – Study Results

- Energy consumption of Future Corn Ethanol Plants
  - Weighted Average Assumes Diffusion Rate for Each Plant Type
- New Process Technologies Employed by Future Corn Ethanol Plants

	2007	2010	2015	2020	2025	2030
Thermal	**Btu/gal**	**Btu/gal**	**Btu/gal**	**Btu/gal**	**Btu/gal**	**Btu/gal**
Natural Gas Boiler, GREET Default	35,676	35,676	35,676	35,676	35,676	35,676
Natural Gas Boiler	31,581	30,316	28,395	26,326	24,272	23,393
Natural Gas CHP	34,048	32,684	30,614	28,383	26,168	25,220
Coal Boiler	39,476	37,895	35,494	32,908	30,340	29,241
Coal CHP	43,424	41,684	39,044	36,199	33,374	32,165
Biomass Boiler*	39,476	37,895	35,494	32,908	30,340	29,241
Biomass CHP*	43,424	41,684	39,044	36,199	33,374	32,165
Integ. Biogas Energy System	14,310	13,737	12,867	11,929	10,998	10,600
Weighted Average Efficiency	32,257	30,902	28,886	26,727	24,591	23,652

Percent of all Plants Adopting Process						
Process Improvement	**2007**	**2010**	**2015**	**2020**	**2025**	**2030**
Corn Oil Extraction	5%	10%	15%	20%	25%	30%
Raw Starch Hydrolysis	5%	10%	15%	20%	25%	30%
Dry Mill Corn Fractionation/ Corn Kernel Fiber to Ethanol	1%	7%	13%	18%	24%	30%
Energy Reduction from Base Process (Thermal)						
	Btu/gal	**Btu/gal**	**Btu/gal**	**Btu/gal**	**Btu/gal**	**Btu/gal**
Corn Oil Extraction	4%	4%	4%	4%	5%	5%
Raw Starch Hydrolysis	16%	16%	16%	16%	17%	17%
Dry Mill Corn Fractionation/ Corn Kernel Fiber to Ethanol	31%	31%	31%	31%	31%	32%
Weighted Average Savings from Process Adjustments (Thermal)	1.3%	4.1%	6.9%	9.7%	13.1%	16.2%

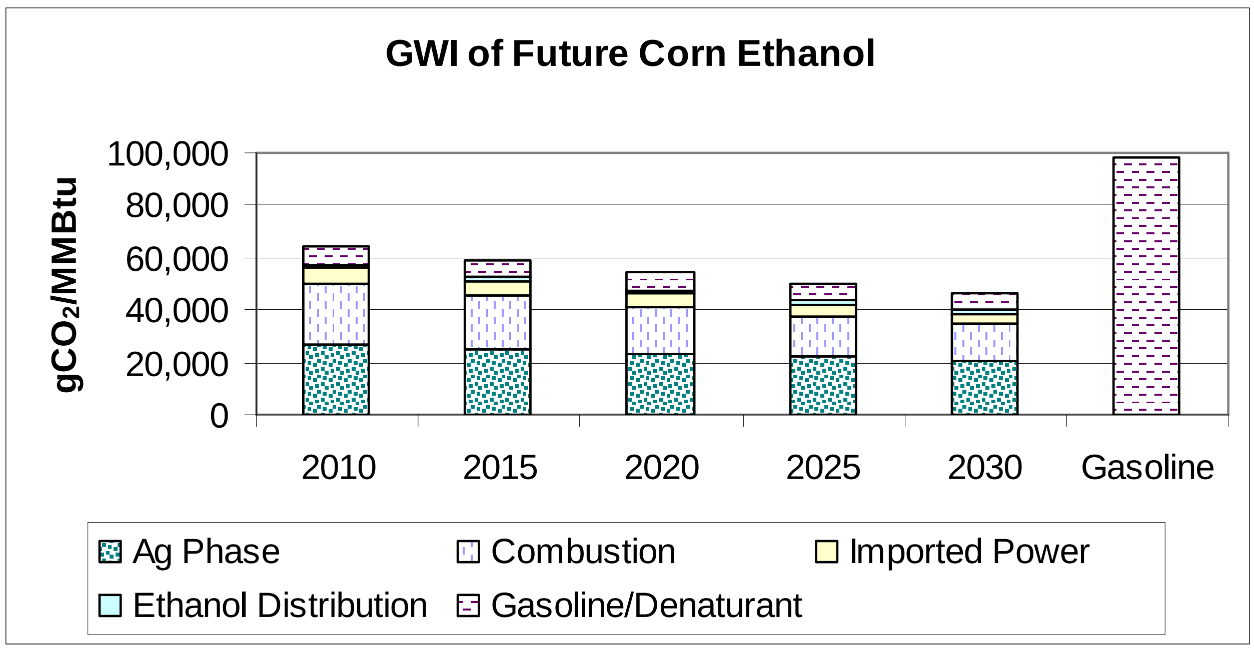
The GWI of Future Corn Ethanol – Study Results

- Agricultural Efficiency Assumptions provided by ProExporter Network

	2007	2010	2015	2020	2025	2030
Corn Yield (bushels/acre)	153	162	185	226	255	289
Nitrogen applied (lbs/bushel)	0.92	0.88	0.81	0.73	0.66	0.59
No-till Practice (%)	20	20	27	35	43	50
Irrigation Efficiency Improvement (%)		3	3	3	3	3

The GWI of Future Corn Ethanol – Study Results

- The Graph shows GWI contributions from all phases for average ethanol plant stock with one graph for each year and compares the ethanol GWI to the gasoline GWI.
- The GWI of the average ethanol plant stock declines from 64,000 to 46,500 g CO2eq/MMBtu by 2030, a 27% decline.
- The GWI of ethanol produced from the average ethanol plant stock in place in 2030 may likely be half of the GWI of gasoline.



Questions & Comments?

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