Assessing the Carbon Footprint of Corn-Based Ethanol



Jan Lewandrowski, Senior Economist

USDA, Office of the Chief Economist

Event : 2018 ACES Conference

Location: Arlington, VA

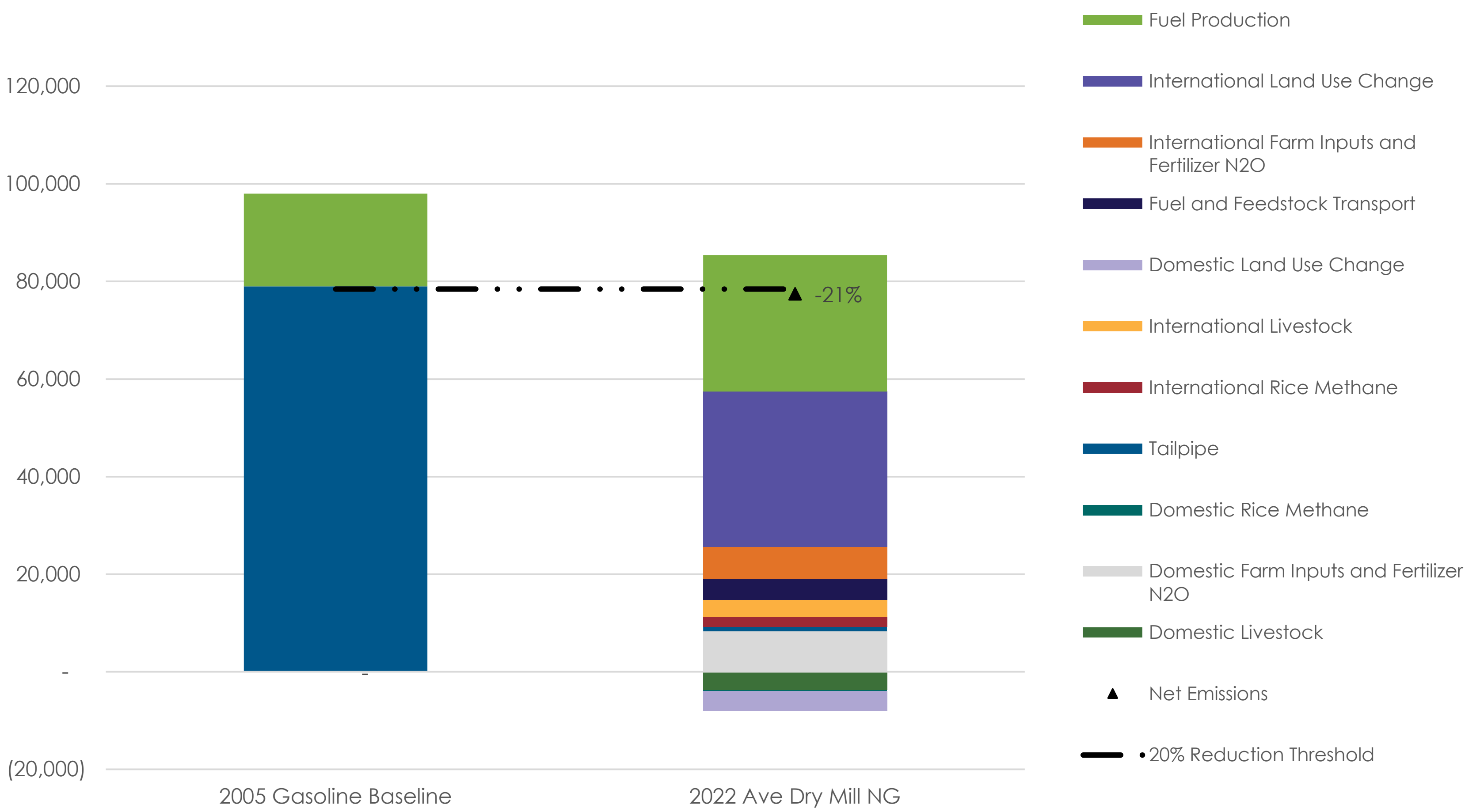
Date: December 6, 2018

Background

- In 2010 EPA released a Regulatory Impact Assessment (RIA) for the revised Renewable Fuel Standard (RFS2). The RIA included a Life-cycle Assessment (LCA) of the GHG emissions associated with the production of corn-based ethanol in the U.S.
- The RIA LCA concluded that - on an energy equivalent basis – substituting corn ethanol for gasoline in transportation fuels would result in a reduction in CO_2 emissions of 21 percent by 2022 (the last year of the RFS2).
- This conclusion was based on 2010 projections of emissions pathways through 2022 for 11 distinct GHG source categories associated with production of corn-ethanol (field to wheels).

Background

2010 RIA LCA Emissions by Category and vs. Energy-Equivalent unit of Average Gasoline in 2005



Results for a New Natural Gas Fired Corn Ethanol Plant by Lifecycle Stage Average 2022 Plant: natural gas, 63% dry, 37% wet DGS (w/fractionation)

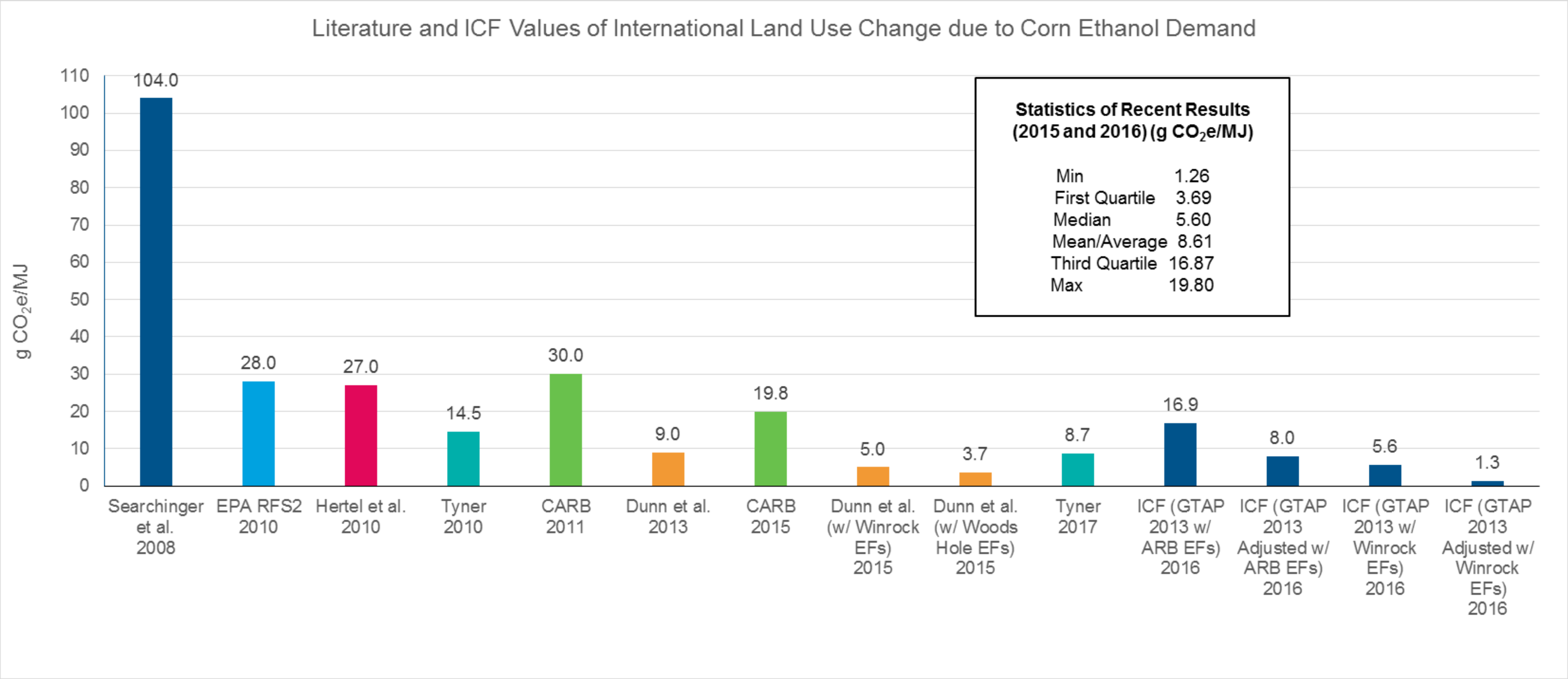
Background

- **The RIA GHG profile of corn ethanol has persisted in discussions and actions related to renewable energy and GHG policies since 2010.**
- **Since 2010, a variety of new studies, data, and industry trends show that the emissions paths of several key categories have not developed as projected.**
- **Most of this new evidence supports the view that the RIA LCA significantly over estimated the GHG profile of U.S. corn ethanol.**
- **Examples:**

Example 1: Babcock, B.A. and Iqbal, Z., 2014. "Using Recent Land Use Changes to Validate Land Use Change Models". Staff Report 14-SR 109. Center for Agricultural and Rural Development: Iowa State University. http://www.card.iastate.edu/publications/dbs/pdffiles/14sr109.pdf

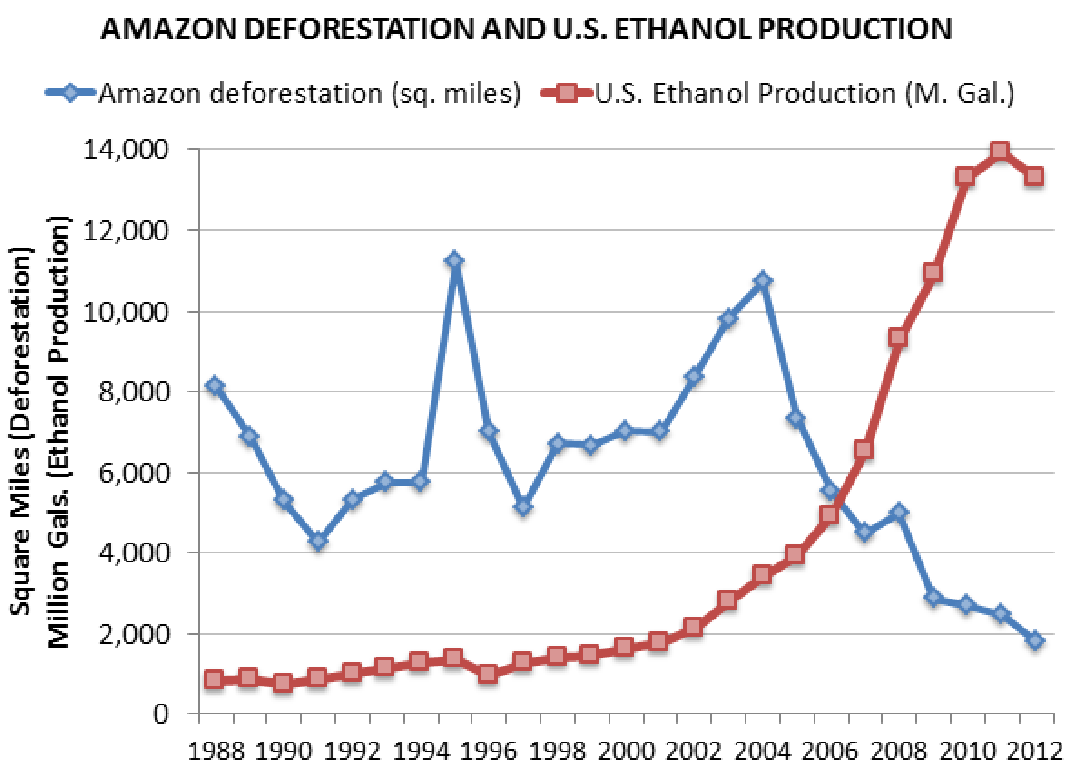
Showed the primary LUC response of the world's farmers from 2004 to 2012 was to use available cropland more efficiently rather than to bring new land into production.

Example 2: Comparison of International Land-use Change from Various Sources



USDA ICF

Example 3: Actual Amazon Deforestation and US Ethanol Production



The largest RIA source category is emissions from international LUC – largely due to future clearing of tropical forest (particularly in Brazil) to expand commodity production.

Data show that between 2004 and 2011 annual U.S. corn ethanol increased from 3.0 billion gallons to just under 14 billion gallons, deforestation in Brazil's Amazon dropped from 10,200 square miles to just under 2,400 square miles per year.

USDA-ICF Analysis: Scenarios

1. **Current GHG LCA** for U.S. corn ethanol:
   - The GHG profile of corn ethanol today.

2. **Business-as-usual (BAU) projected GHG LCA** for corn ethanol in 2022:
   - Projection of the GHG profile of corn ethanol in 2022, given a continuation of current trends in yields and other variables, including fuel switching to natural gas.

3. **High Efficiency-High Conservation (HEHC) projected GHG LCA** for corn ethanol in 2022:
   - Projection of the GHG profile of corn ethanol in 2022 given BAU plus ethanol sector adoption of currently available GHG reducing practices in corn production, fuel production, transportation, and co-products.

2010 RIA LCA Emissions Categories

- *Domestic Farm Inputs and Fertilizer N_2O*
- *Domestic Land-Use Change (LUC)*
- Domestic Rice CH_4
- Domestic Livestock
- International LUC
- International Farm Inputs and Fertilizer N_2O
- International Rice CH_4
- International Livestock
- *Fuel and Feedstock Transport*
- *Fuel Production*
- Tailpipe

USDA ICF

Key Parameters and Scenarios Considered for ICF 2022 BAU and HEHC Scenarios

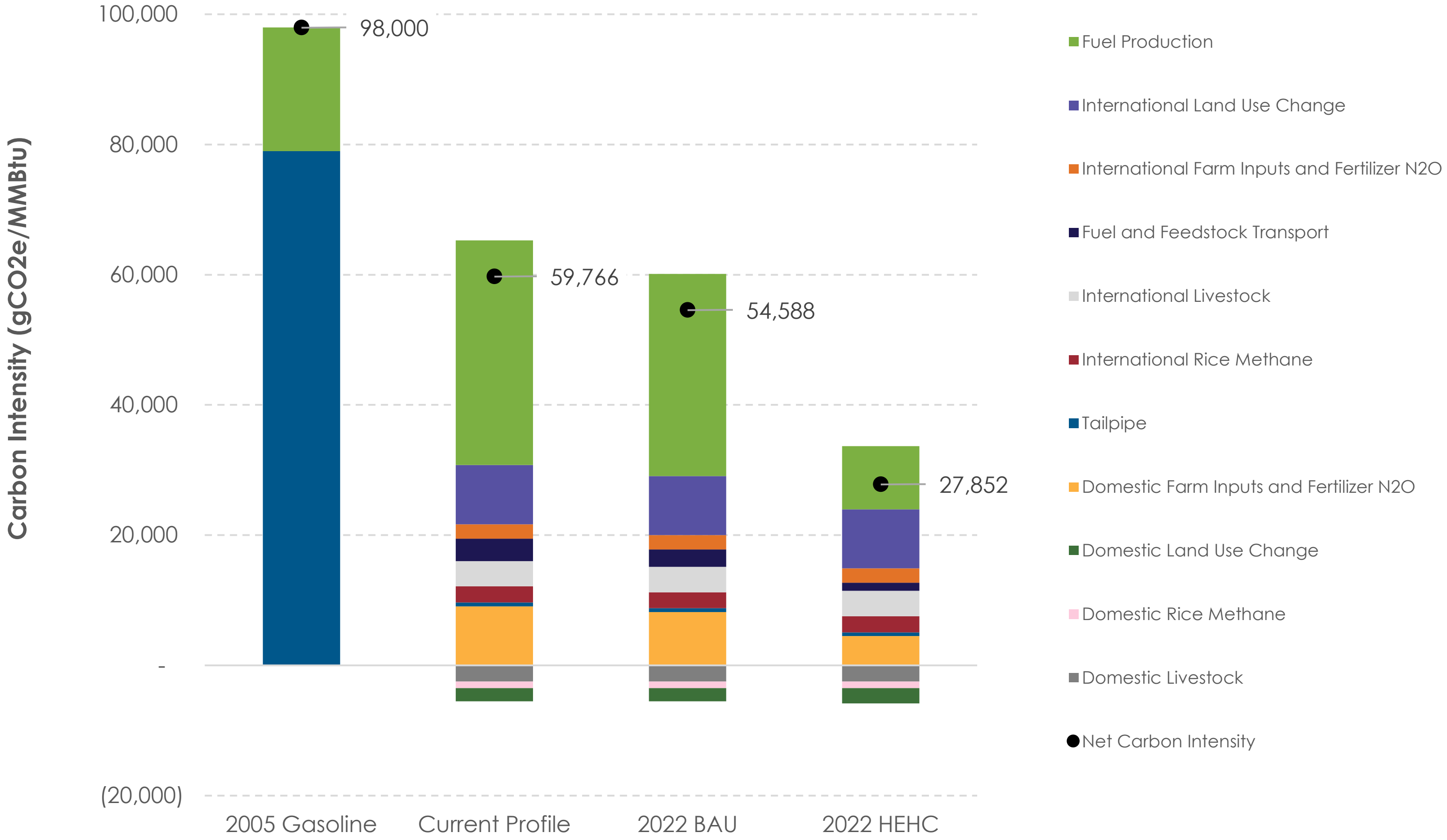
Source Category	Variables to Consider for Emission Cases	ICF: 2022 BAU Scenario	ICF: 2022 HEHC Scenario
Domestic Farm Inputs and Fertilizer N_2O	• Yield increases • Conservation technologies and practices: ▪ Reduced tillage ▪ Nutrient management ▪ Cover crops	Yield increases	Yield increase + Conservation technologies and practices
Domestic Land-Use Change	• Yield increases (intrinsic to yield-increase scenario used for the analysis using CCLUB) • Reduced tillage		Yield increases + Reduced tillage
Fuel Production	• Increased corn to corn ethanol yield (based on the literature) • Process fuel switching (natural gas and/or biomass)	Process fuel switching w/ push towards natural gas	Process fuel switching to biomass + Increased corn to corn ethanol yield
Fuel and Feedstock Transport	• Increased truck efficiency (natural gas, biodiesel, renewable diesel, renewable natural gas) • Co-location of CAFOs (reduced transportation distances for DGS)	Increased truck fuel efficiency w/ fuel switching to natural gas	Increased truck fuel efficiency + Co-location of CAFOs

USDA ICF

Comparison of RIA and ICF LCA's by Emission Category and in Total

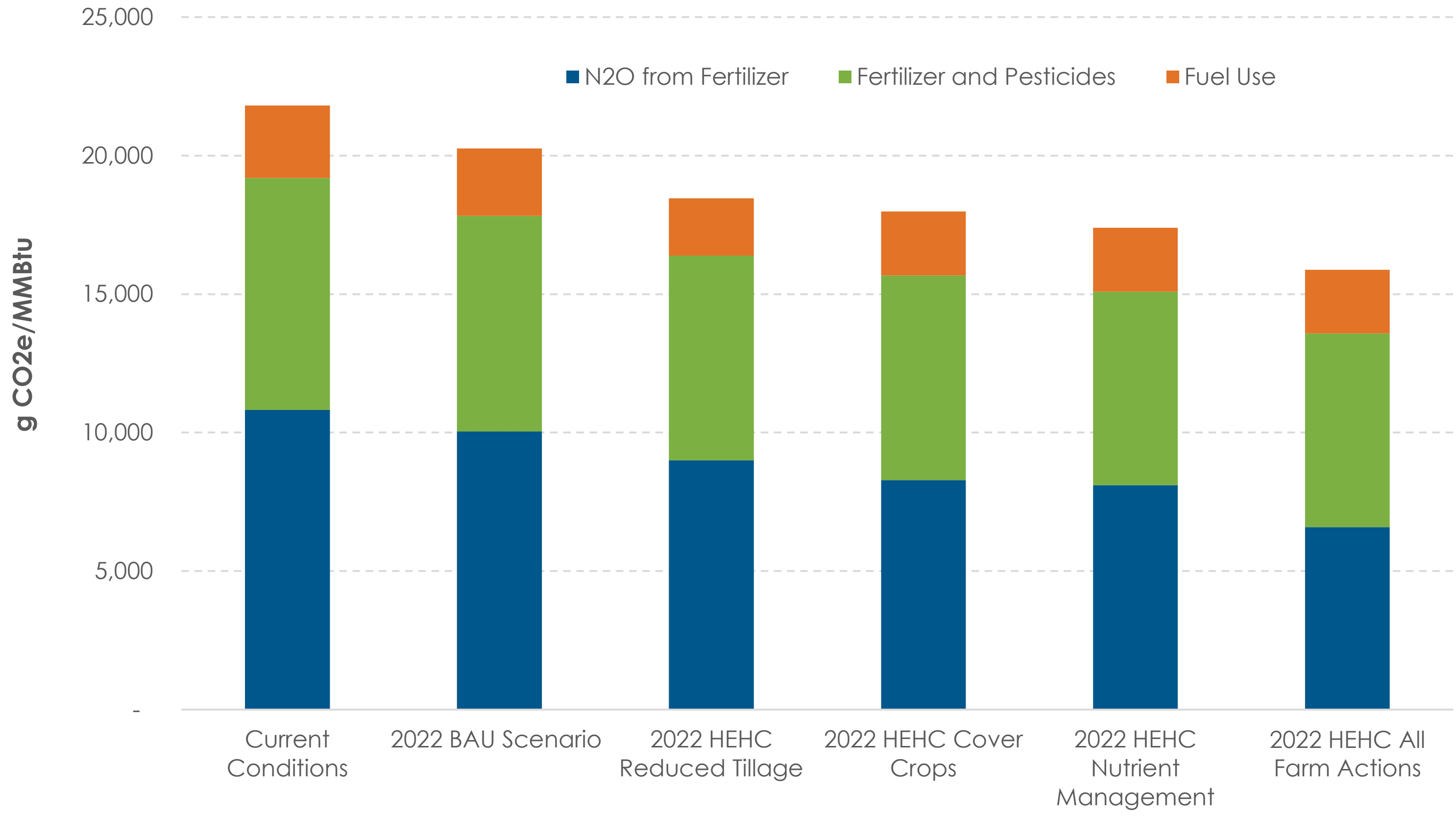
Emission Category	Estimated GHG Emissions	
	RIA (2010)	Current
	gCO_2e/MMBtu	
Domestic Farm Inputs	10,313	9,065
Domestic LUC	-4,000	-2,038
Domestic Rice CH_4	-209	-1,013
Domestic Livestock	-3,746	-2,463
International LUC	31,790	9,094
International Farm inputs	6,601	2,217
International Rice CH_4	2,089	2,482
International Livestock	3,458	3,894
Fuel and Feedstock Transport	4,265	3,432
Fuel Production	28,000	34,518
Tailpipe	880	578
Total	**79,441**	**59,766**

Comparison of ICF Scenario Carbon Intensities



USDA ICF

Ranges of Emissions Related to Adoption of USDA Conservation Practice Standards

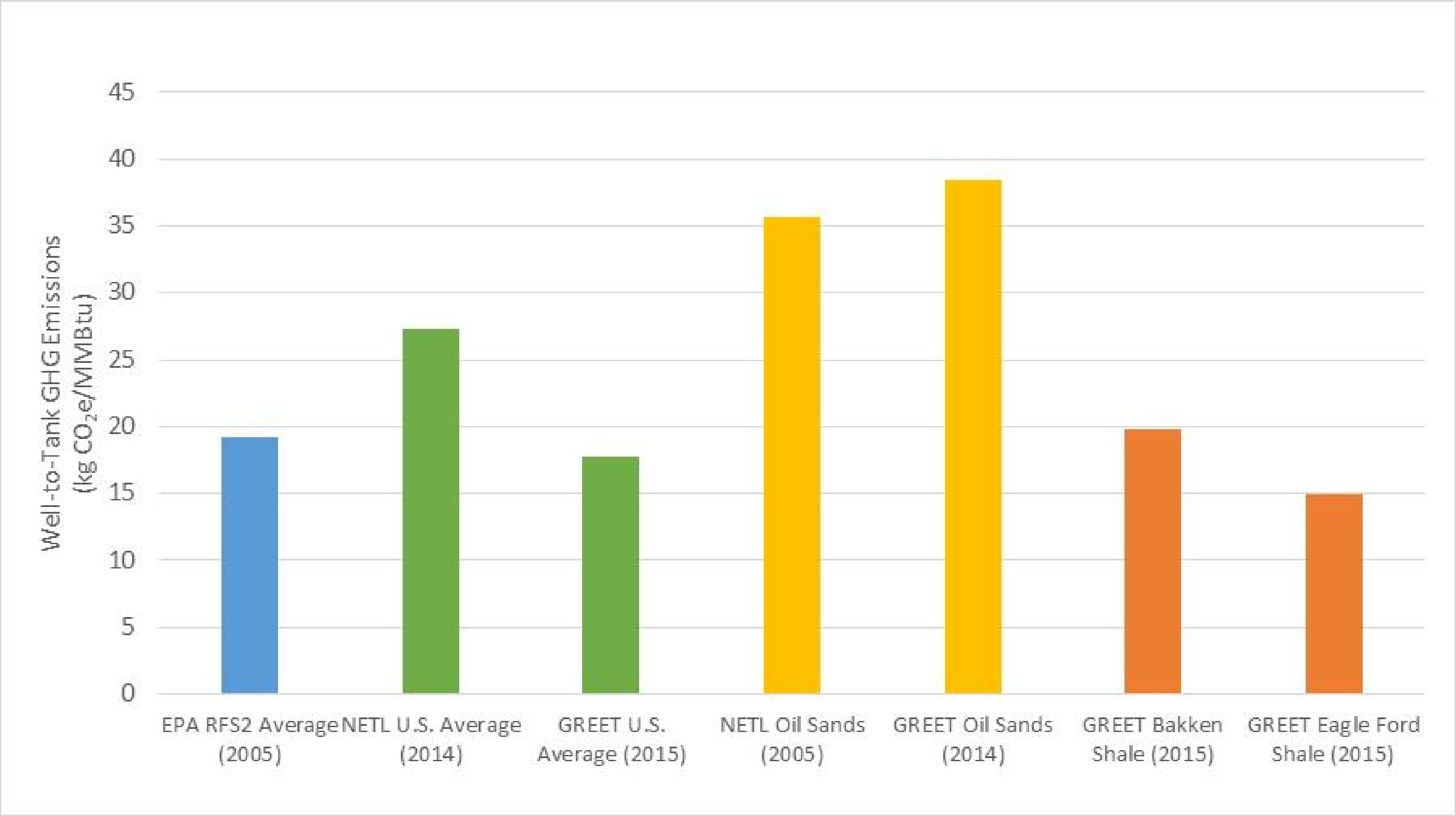


Comparison with Other Carbon Intensity Studies

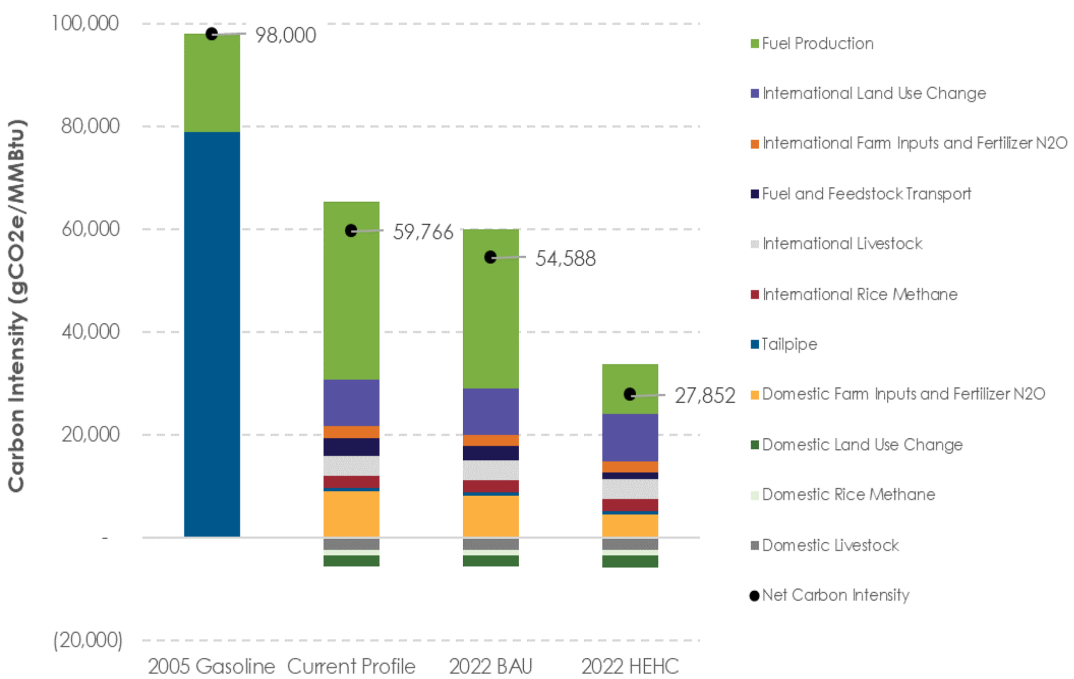
Study	Sub-Analysis	Emissions Impact (gCO_2e/MJ of corn ethanol)	Boundaries
EPA RIA	N/A	75	All 11 source categories
Wang et al. 2012	Without DGS Credit	76	Excludes domestic and international rice methane, domestic and international livestock, international farm inputs and fertilizer N_2O
	With DGS Credit	62	
Dunn et al. 2013	Maximum U.S. LUC	68	Excludes domestic and international rice methane, domestic and international livestock, international farm inputs and fertilizer N_2O
	Minimum U.S. LUC	62	
Wang et al. 2015	Displacement	61	Excludes domestic and international rice methane, domestic and international livestock, international farm inputs and fertilizer N_2O
	Marginal	62	
	Hybrid Allocation	59	
	Process-Level Energy Allocation	46	
ICF 2018	ICF: Current Profile	60	All 11 source categories
	ICF: 2022 BAU Scenario	54	
	ICF: 2022 High Efficiency – High Conservation Scenario	28	

USDA ICF

Life-cycle Carbon Intensities of Gasoline



Key Findings - General



- RIA LCA value for corn ethanol is 79,441 gCO_2e/MMBtu compared to 98,000 gCO_2e/MMBtu for gasoline.
- Current Conditions value is 59,766 gCO_2e/MMBtu, implying corn ethanol GHG profile is 39 percent lower than gasoline.
- 2022 BAU Scenario is a 44% GHG reduction compared to gasoline and a 8.7% reduction compared to Current Conditions.
- 2022 HEHC Scenario is a 72% reduction compared to gasoline and a 53% reduction compared to Current Conditions.

USDA ICF

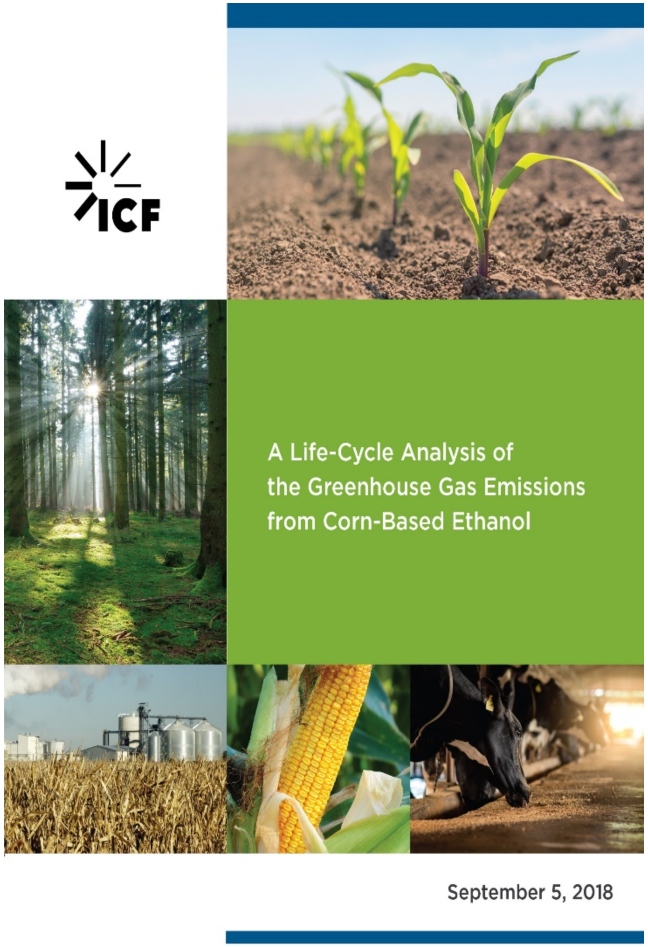
Key Findings – A closer look at current emissions

- The current LCA value for corn ethanol produced in an “average” refinery is 39 percent lower than gasoline. The value for ethanol refined at a natural gas powered plant is 42.6 percent lower than gasoline.
- Refineries can contract with farmers to use GHG reducing production practices, resulting in ethanol with a GHG profile 43.1 percent lower than gasoline.
- Ethanol produced in refinieries using natural gas technology and refineries contracting with farmers to use GHG reducing practices has a GHG profile 46.7 percent better than gasoline.
- Given current trends, by 2022 the LCA emissions for corn ethanol will be 44.3 percent lower than gasoline.
- Refineries and farmers taking steps to reduce emissions could resulti in the LCA emissions for corn ethanol to be over 70 percent lower than gasoline bu 2022.

A Life-Cycle Analysis of the Greenhouse Gas Emissions from Corn-Based Ethanol

Report Available at:

https://www.usda.gov/oce/climate_change/mitigation_technologies/LCA_of_Corn_Ethanol_2018_Report.pdf



USDA ICF