A Lifecycle Analysis of the GHG Emissions of Corn-Based Ethanol

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Background

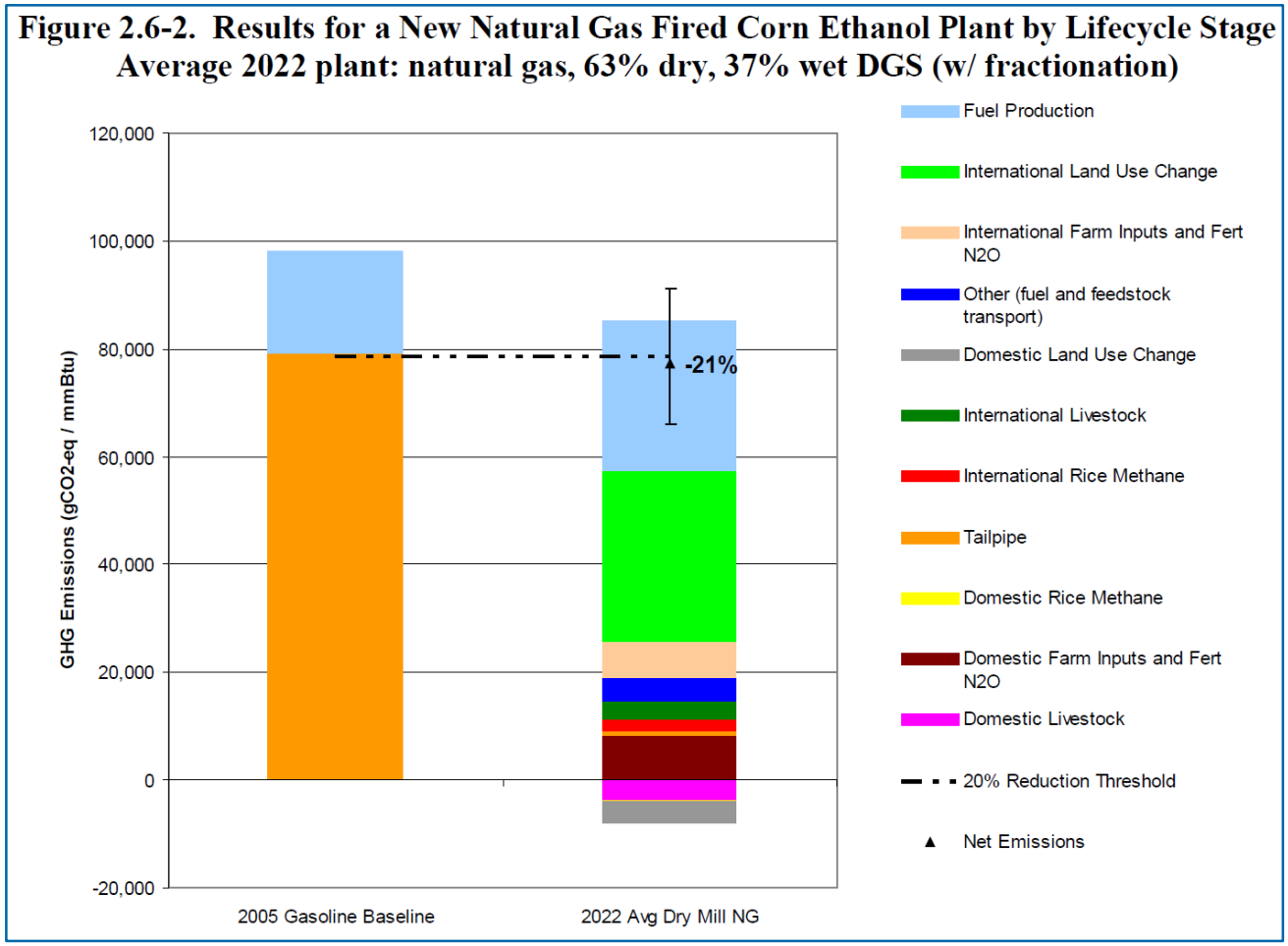
- In 2010 EPA released a Regulatory Impact Assessment (RIA) for the revised Renewable Fuel Standard (RFS2). The RIA included a Life-cycle Assessment (LCA) of the GHG emissions associated with the production of corn-based ethanol in the U.S.

- 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



Background

- The RIA GHG profile of corn ethanol has persisted in discussions and actions related renewable energy and GHG policies since 2010.

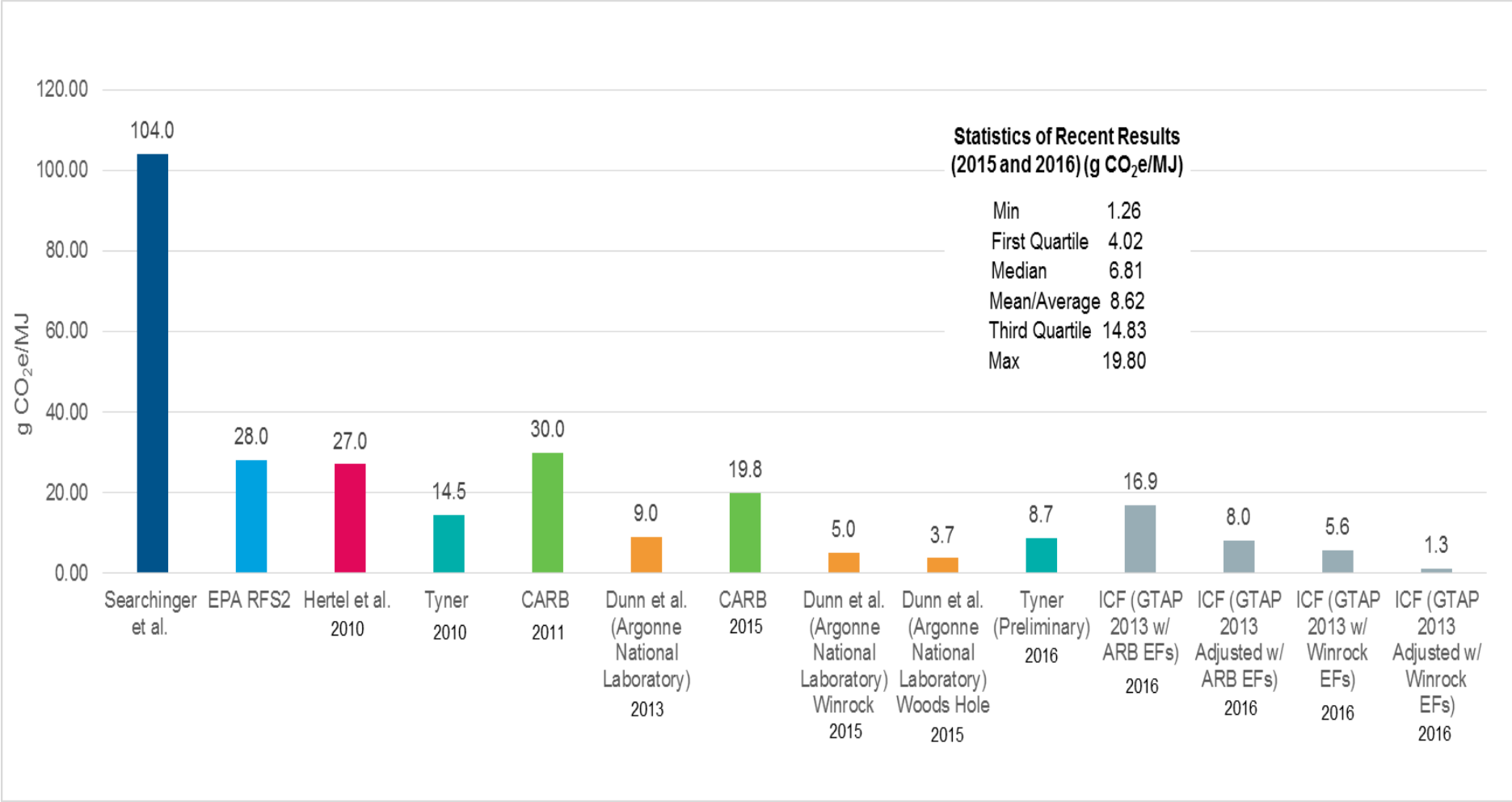
- Since 2010, a variety of new studies, data, and industry trends show that the emissions paths of several key categories have not developed as projected. Most of this new evidence supports the view that the RIA LCA significantly over estimated the GHG profile of U.S. corn ethanol.

- Some 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

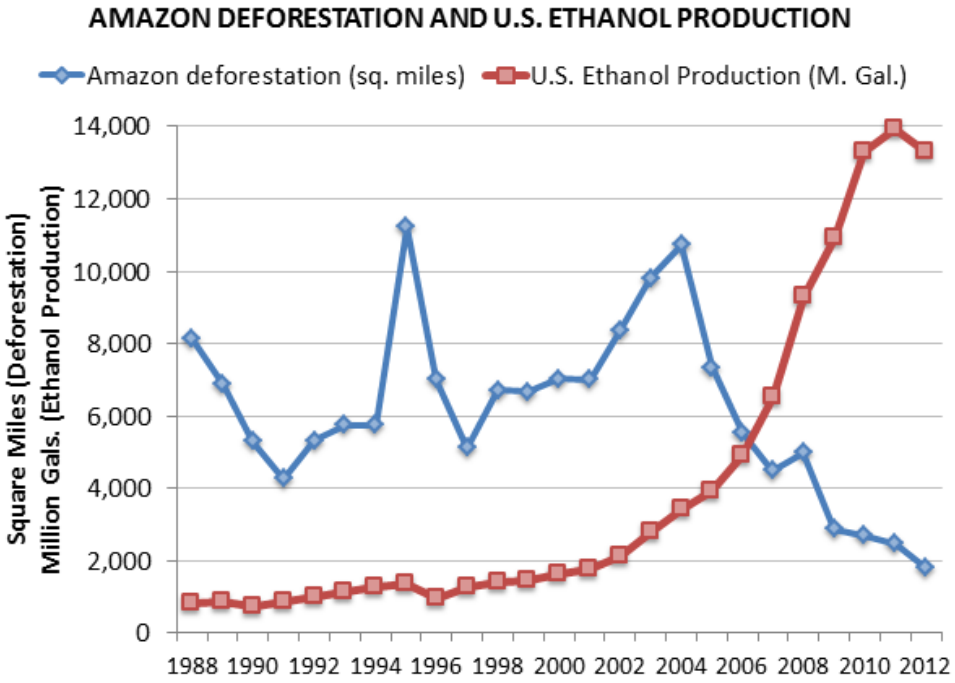
Showed the primary LUC response of the world's farmers from 2004 to 2012 was to use available cropland more efficiently rather than to bring new land into production.

Comparison of International Land-use Change from Various Sources



Example 3: Actual Amazon deforestation and US ethanol production

The largest RIA source category is emissions from iLUC - due to future clearing of tropical forest (mainly in Brazil) to expand commodity production.



Data show that in the period that 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. The **current GHG LCA** for U.S. corn ethanol – the GHG profile of corn ethanol today.

2. **Business-as-usual 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 (also called the Medium-Emissions Scenario).

3. **USDA Building Blocks 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 (also called the Low-Emissions Scenario).

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

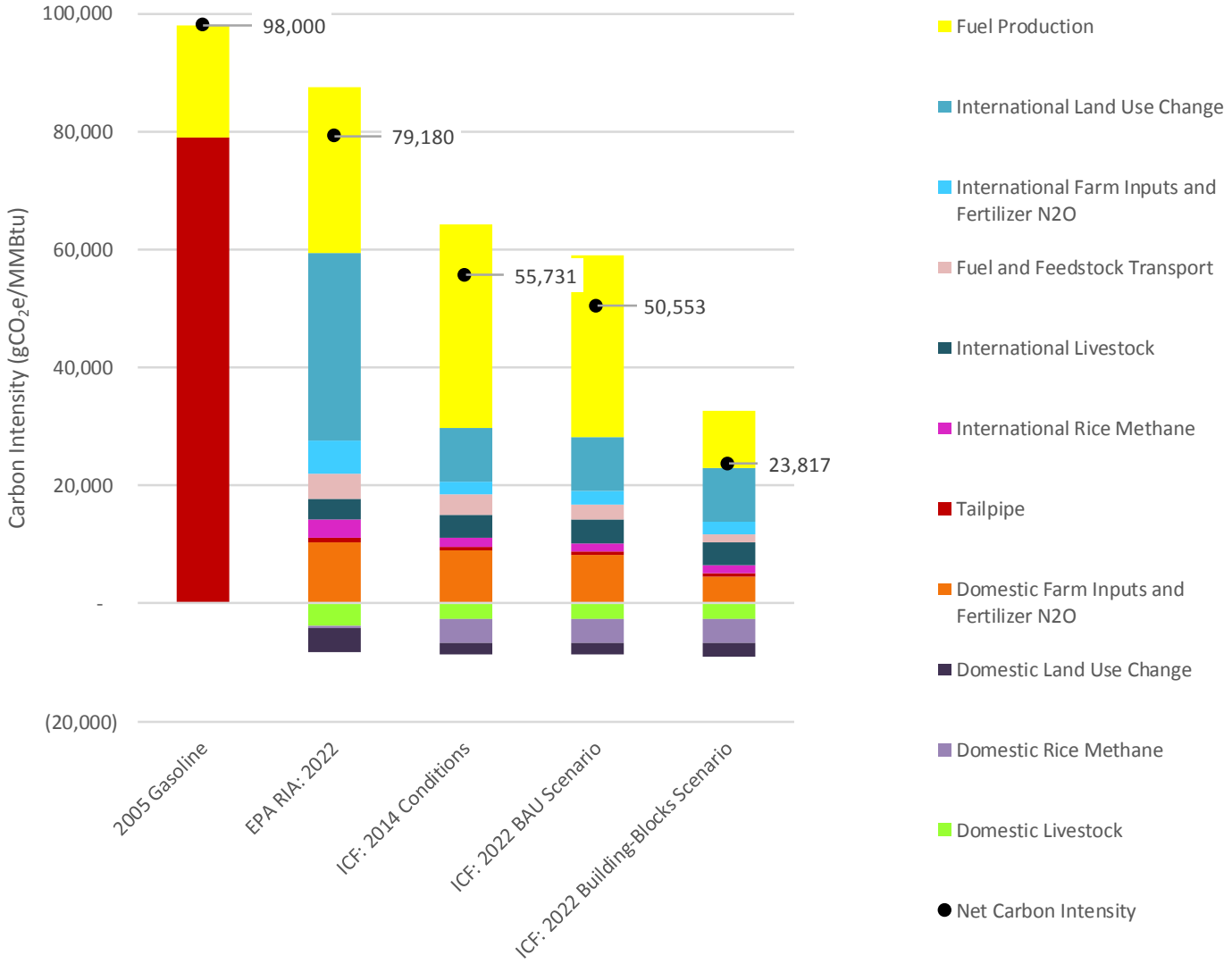
Key Parameters and Scenarios Considered for ICF 2022 Medium and Low Emissions Cases

Source Category	Variables to Consider for Emissions Cases	ICF: 2022 BAU Scenario	ICF: 2022 Building-Blocks 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	• Tillage system		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 and biomass	Process fuel switching + 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 efficiency w/ fuel switching to natural gas	Increased truck efficiency w/ fuel switching to natural gas or another lower carbon intensity fuel + Co-location of CAFOs

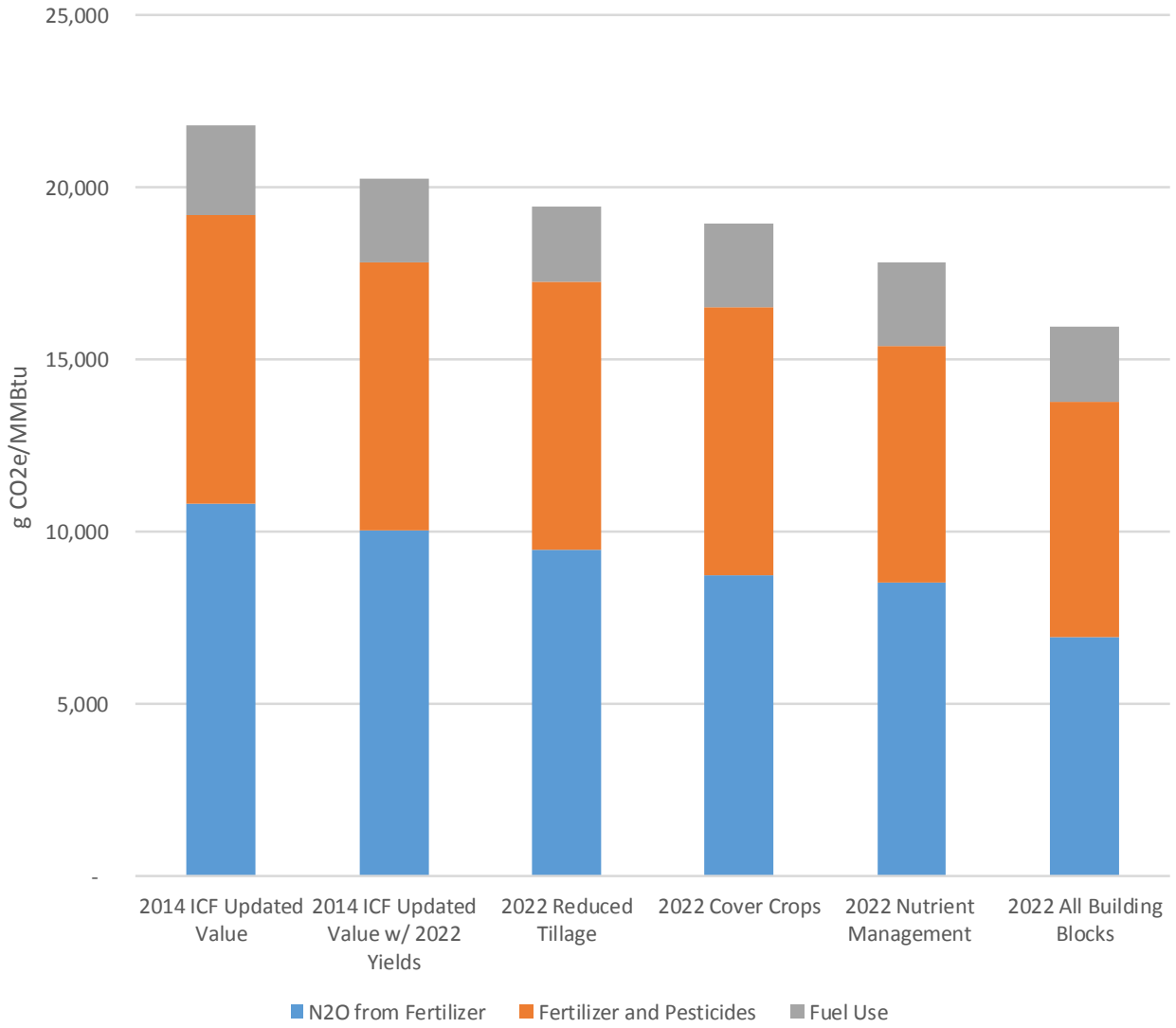
Comparison of RIA and ICF LCA's by emissions category and in total

	Estimated GHG Emissions	
	RIA (2010)	Current
	gCO2e/MMBtu	
Domestic Farm Inputs	10,313	9,065
Domestic LUC	-4,000	-2,038
Domestic Rice CH4	-500	-4,034
Domestic Livestock	-3,746	-2,463
International LUC	31,790	9,082
International Farm inputs	5,720	2,217
International Rice CH4	3,000	1,480
International Livestock	3,458	3,894
Fuel and Feedstock Transport	4,265	3,432
Fuel Production	28,000	34,518
Tailpipe	880	578
Total	79,180	55,731

Comparison of EPA-RIA and ICF Carbon Intensities



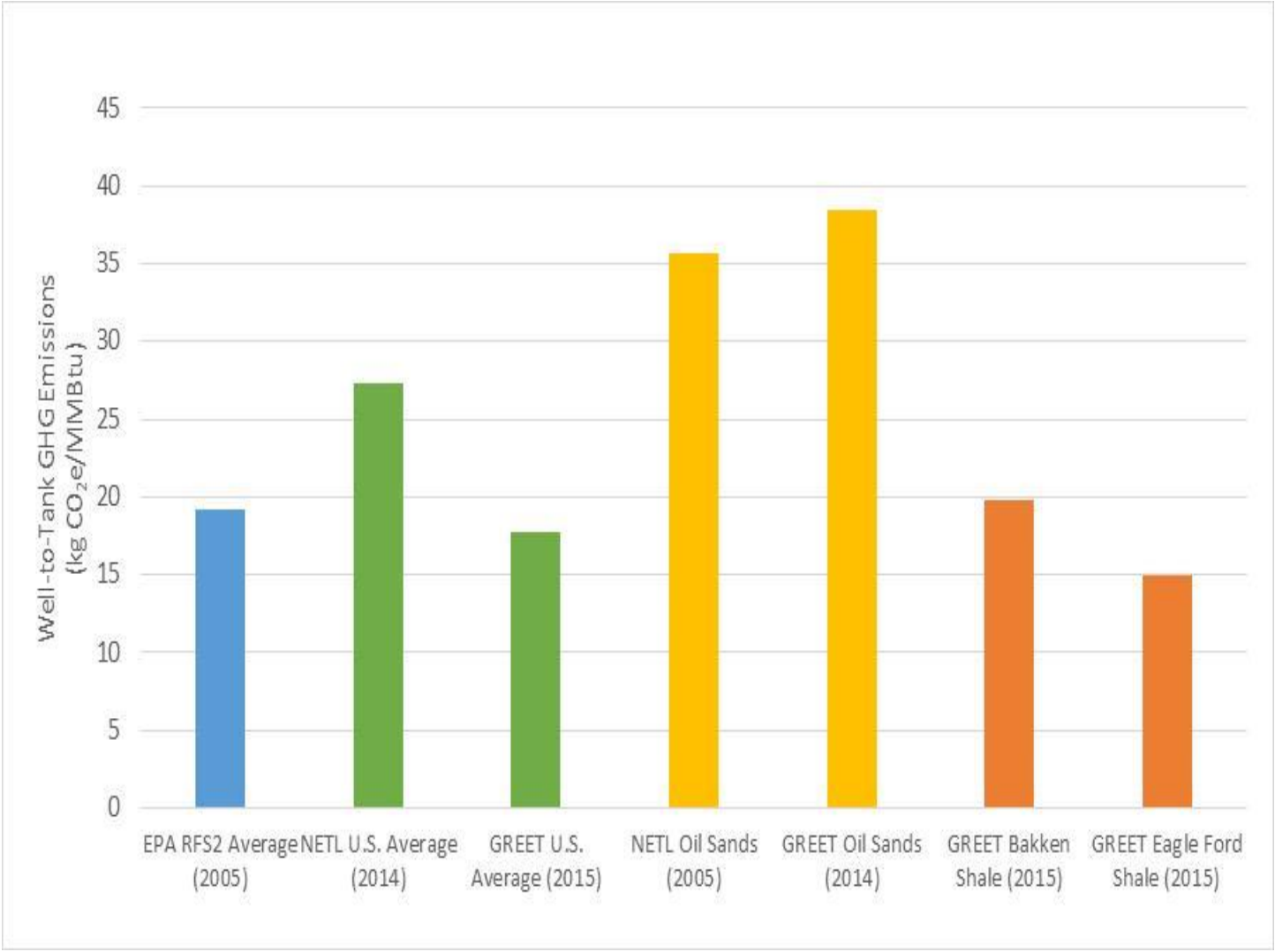
Impacts of *Building Blocks* on Domestic Farm Inputs and Fertilizer N_2O Source Category



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 2016	ICF: 2014 Conditions	53	All 11 source categories
	ICF: 2022 BAU Scenario	48	
	ICF: 2022 Building-Blocks Scenario	22	

Life-cycle Carbon Intensities of Gasoline



Questions?