Impacts of Renewable Fuels Standard

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Transition to Bioeconomy
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Overview

- Short History
- Update of EPA's ongoing lifecycle GHG work

Short History

Recent Events

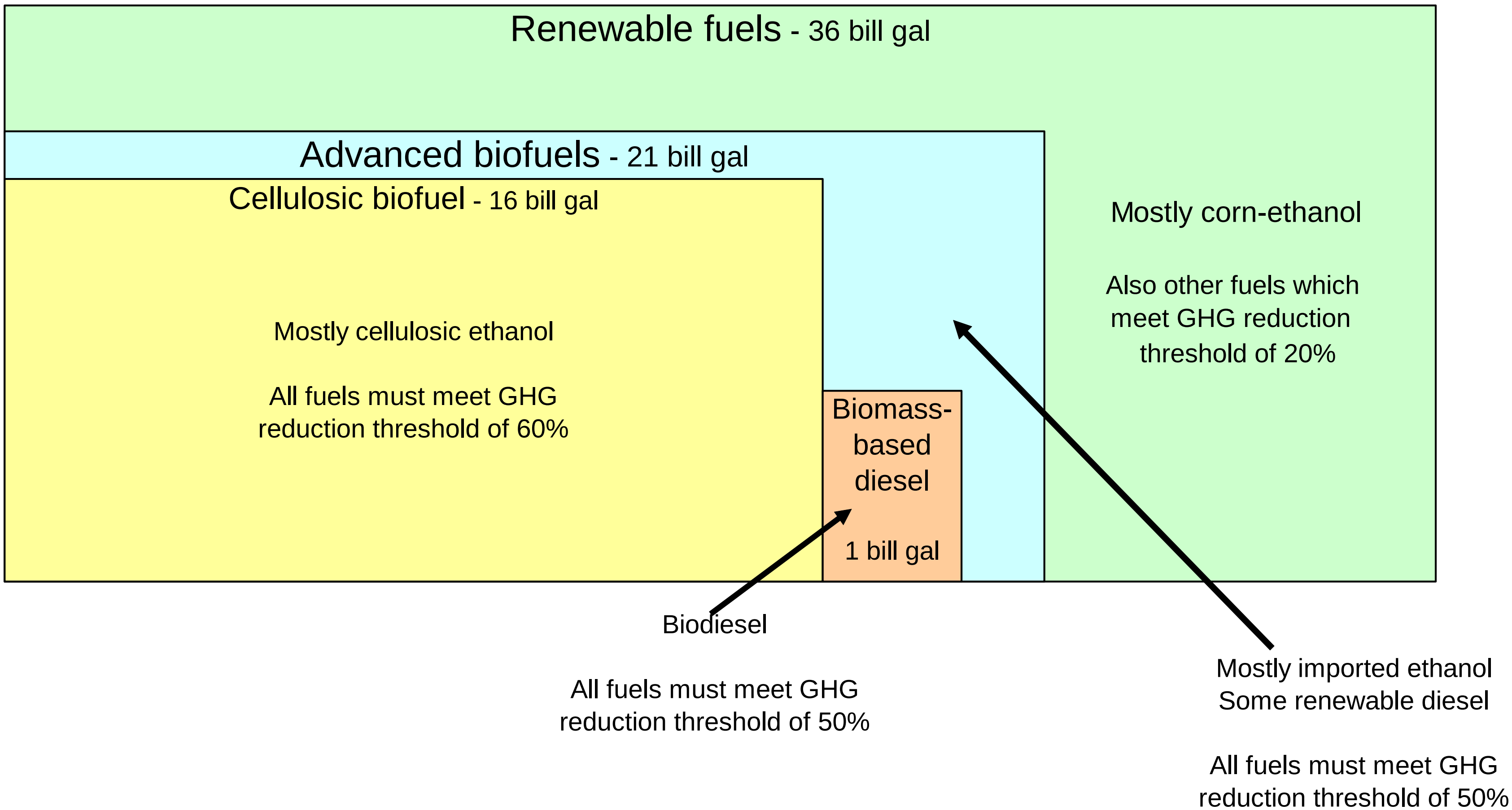
January 2007	State of the Union Address—20-in-10 goal
April 2007	Supreme Court Decision
May 2007	First Renewable Fuels regulations published
May 2007	President's Announcement and Executive Order (35 billion gallons renewable and alternative fuel)
December 2007	Energy Independence and Security Act (H.R. 6) was passed by Congress and signed by President Bush on December 19, including a 36 billion gallon renewable fuel mandate

4 Separate Standards

Year	Advanced Biofuel			Total Renewable Fuel
	Biomass-Based Diesel	Cellulosic Biofuel	Total Advanced Biofuel	
2006				4.0
2007				4.7
2008				9.0
2009	0.5		0.6	11.1
2010	0.65	0.1	0.95	12.95
2011	0.80	0.25	1.35	13.95
2012	1.0	0.5	2.0	15.2
2013	1.0	1.0	2.75	16.55
2014	1.0	1.75	3.75	18.15
2015	1.0	3.0	5.5	20.5
2016	1.0	4.25	7.25	22.25
2017	1.0	5.5	9.0	24.0
2018	1.0	7.0	11.0	26.0
2019	1.0	8.5	13.0	28.0

The Standards are Nested

Shown with 2022 volumes



EPA’s Lifecycle GHG Work

EISA Requires Lifecycle Assessment

- Each fuel category required to meet mandated GHG performance thresholds (reduction compared to baseline petroleum fuel replaced)
  - **Conventional Biofuel** (ethanol derived from corn starch)
    - Must meet 20% lifecycle GHG threshold
    - Only applies to fuel produced in new facilities
  - **Advanced Biofuel**
    - Essentially anything but corn starch ethanol
    - Includes cellulosic ethanol and biomass-based diesel
    - Must meet a 50% lifecycle GHG threshold
  - **Biomass-Based Diesel**
    - E.g., Biodiesel, "renewable diesel" if fats and oils not co-processed with petroleum
    - Must meet a 50% lifecycle GHG threshold
    - 20-50% still counts as renewable fuel
  - **Cellulosic Biofuel**
    - Renewable fuel produced from cellulose, hemicellulose, or lignin
    - E.g., cellulosic ethanol, BTL diesel
    - Must meet a 60% lifecycle GHG threshold
- EISA language permits EPA to adjust the lifecycle GHG thresholds by as much as 10%
- Baseline fuel for comparison is gasoline and diesel fuel in 2005

Definition of Lifecycle GHG Emissions

‘‘(H) LIFECYCLE GREENHOUSE GAS EMISSIONS.—The term ‘lifecycle greenhouse gas emissions’ means the aggregate quantity of greenhouse gas emissions (including direct emissions and significant indirect emissions such as significant emissions from land use changes), as determined by the Administrator, related to the full fuel lifecycle, including all stages of fuel and feedstock production and distribution, from feedstock generation or extraction through the distribution and delivery and use of the finished fuel to the ultimate consumer, where the mass values for all greenhouse gases are adjusted to account for their relative global warming potential.

Life Cycle Boundaries- Components Included

- **Direct Impacts:**
  - Agricultural inputs (e.g., fuel used in tractor, energy used to produce and transporting fertilizer to the field) used to grow crops directly used in biofuel production
  - Fertilizer N2O emissions associated with crops directly used in biofuel production
  - Land use change associated with converting land to grow crops directly used in biofuel production
  - Energy use and GHG emissions at production facility
  - Energy used to transporting feedstock to plant
  - Energy used to transporting fuel to end use
  - Vehicle tailpipe GHG emissions
- **Indirect Impacts:**
  - Agricultural inputs (e.g., fuel used in tractor, energy used to produce and transporting fertilizer to the field) and fertilizer N2O emissions from growing crops indirectly impacted by use of feedstock for biofuel production (domestically and internationally)
  - Amount of new land converted to crops, location of land converted to crops, type of land converted to crops, GHG emissions associated with type of land converted indirectly impacted by using feedstocks for biofuel production (e.g., to make up for lost exports)
  - Emissions from changes in livestock numbers that are indirectly impacted by feed prices & availability due to the use of feedstocks to produce biofuels
  - Rice methane emissions indirectly impacted by shifts in acres to produce feedstocks for biofuel production

Life Cycle Boundaries – Components Excluded

- Elements excluded were determined based on internationally accepted life cycle assessment standards, developed by the International Organization for Standardization (ISO), using environmental significance as the cut-off criteria
- Infrastructure-related activities are not included (e.g., emissions associated with the production of tractor or farm equipment)
- Construction-related emissions are also not included (e.g., steel or concrete needed to construct a refinery)

Overview of What We Need

- Need to develop life cycle GHG values for each potential fuel and production pathway, for example:
  - Corn ethanol (dry mill, wet mill, coal, natural gas, etc.)
  - Biodiesel / Renewable Diesel
    - Soybean oil
    - Waste grease
  - Cellulosic Ethanol (enzymatic, thermochemical)
    - Agricultural residue (e.g., corn stover)
    - Forest wastes
    - Switchgrass / other energy crops
  - Imports
    - Sugarcane ethanol

- The components of the analysis are generally the same for all biofuels, but each has own set of assumptions and issues

Methodology

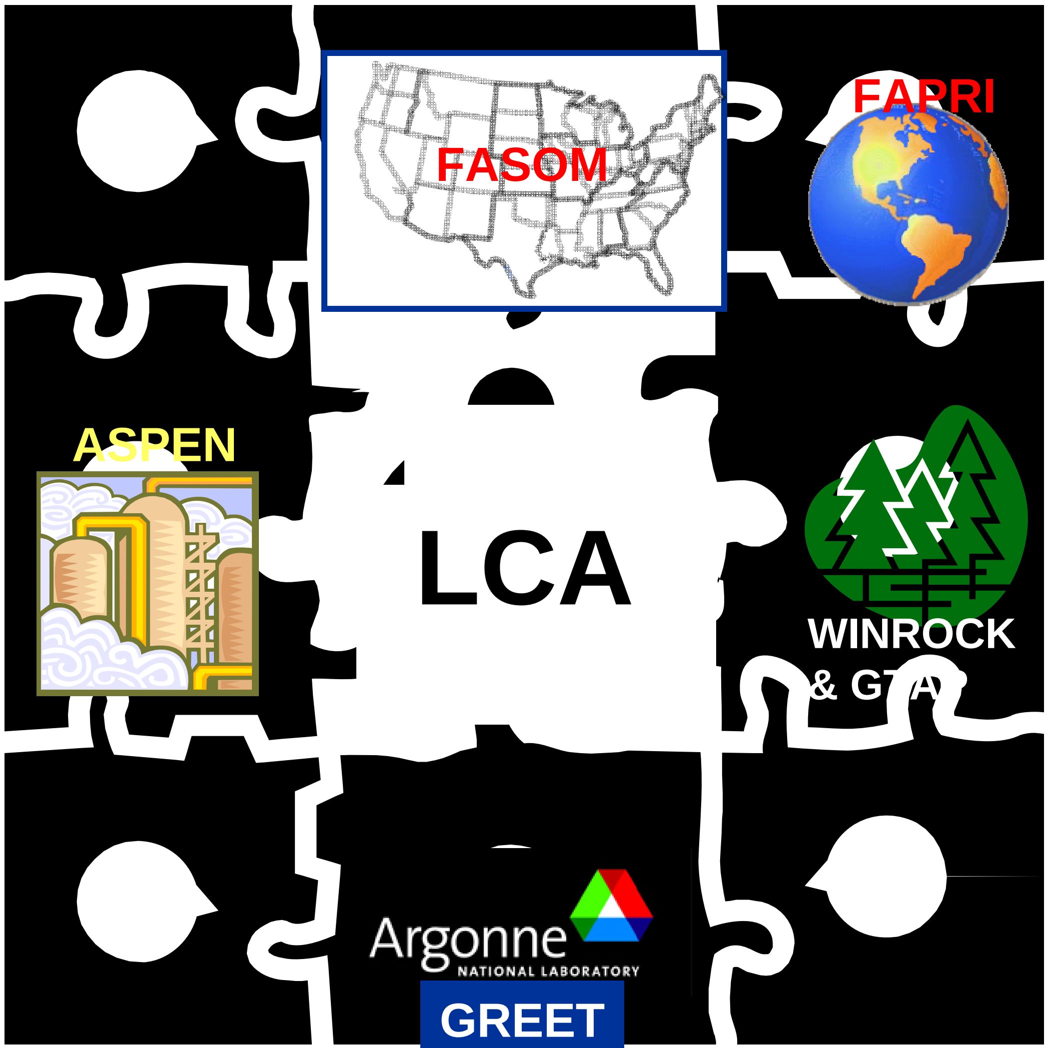
- EISA definition requires the use of a number of models and tools
  - Including direct and indirect impacts such as land use change requires analysis of markets
    - Typical life cycle analysis tools are based on process modeling
    - To capture market impacts need to use economic models
  - We are also conducting our own process and emissions modeling as part of rulemaking

- For areas of uncertainty, we plan to test our primary approach and key assumptions with sensitivity analyses and different methods

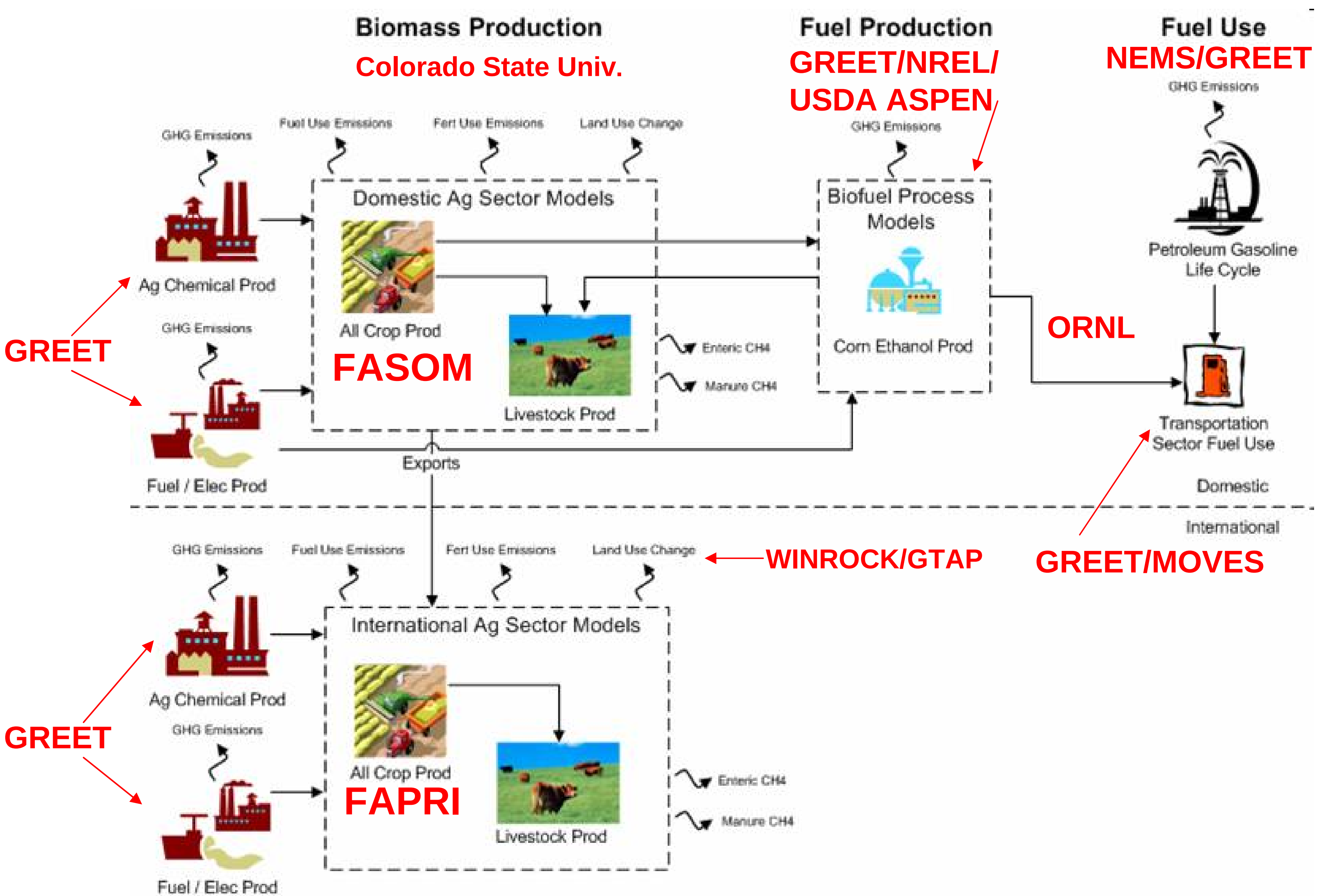
Key Models and Data Sources

- Emission factors (GREET, Winrock, Woods Hole)
- Agricultural sector models (FASOM, FAPRI, GTAP, BESS)
- Land use changes (FASOM, FAPRI, Winrock, GTAP)
- Fertilizer N_2O modeling (CSU DAYCENT/CENTURY)
- Fuel production process models (GREET, USDA & NREL ASPEN models, BESS)
- Tailpipe emissions (MOVES)
- Energy sector modeling (NEMS)

Application of Ag Sector Modeling to Lifecycle Analysis



EPA Lifecycle Analysis Uses Several Models



Domestic Agriculture Sector Analysis

- Working with FASOM and FAPRI modelers to establish consistent set of domestic assumptions
  - Crop yields
  - Ethanol yields and co-product use
  - CRP acres
  - Export response
  - Livestock demand and feed use
- Also conducting sensitivity analyses for many of these assumptions

International Agriculture and Land Use Change

- Questions we need to address in this analysis:
  - How much land is converted internationally?
  - What are the emissions trends from international crop production?
  - Where does land use change occur?
  - What types of land are converted?
  - What are the GHG factors from that land conversion?
  - How do we account for the time dimension of GHG releases?

- In order to address uncertainty around these factors, we are performing sensitivity analyses and examining two approaches

International Land Use Change—Two Approaches

1) Winrock/FASOM/FAPRI

- FASOM and FAPRI determine net acreage change by country
- Winrock provides recent historical data on land use conversions by country
  - Data is for 2001- 2004: most recent satellite data available
  - Provides within country detail
  - Includes range of land types (forest, cropland, grassland, savanna, shrub)
- Assume recent land use changes are based on economics that will predict future trends

2) GTAP

- Based on modeling interactions of land types as opposed to use of historic trends
  - Can provide: acres by country, different total acreage conversion amounts, and different types of land conversion
- However, GTAP has several shortcomings
  - It is a static model based on a 2001 economy and does not take into account economic and agricultural commodity trends out through 2022
  - Does not currently contain unmanaged land, which is a significant potential source of GHG emissions
  - Does not provide same level of detail of commodities markets (e.g. does not individually represent corn as a feedstock)

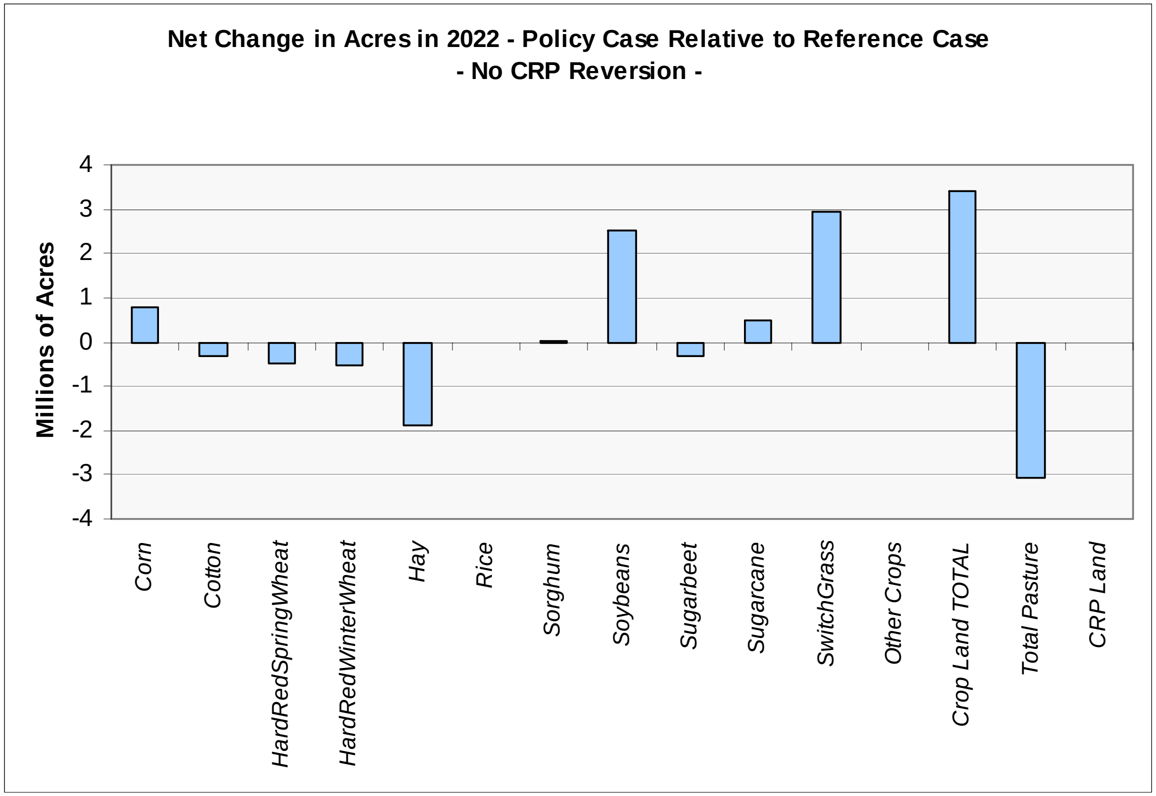
Biofuel Production Modeling

- Corn ethanol
  - Working with USDA and industry
  - Considering different configurations (fuel source, technologies, carbon capture)
- Cellulosic ethanol
  - Looking at modeling by NREL & GREET that projects use of biomass lignin for process energy, enabling plants to sell electricity to the grid
  - Offsets grid electricity production and results in GHG benefits
- Imported Sugarcane Ethanol Production
  - Like cellulosic, can produce excess electricity from burning bagasse

A few results

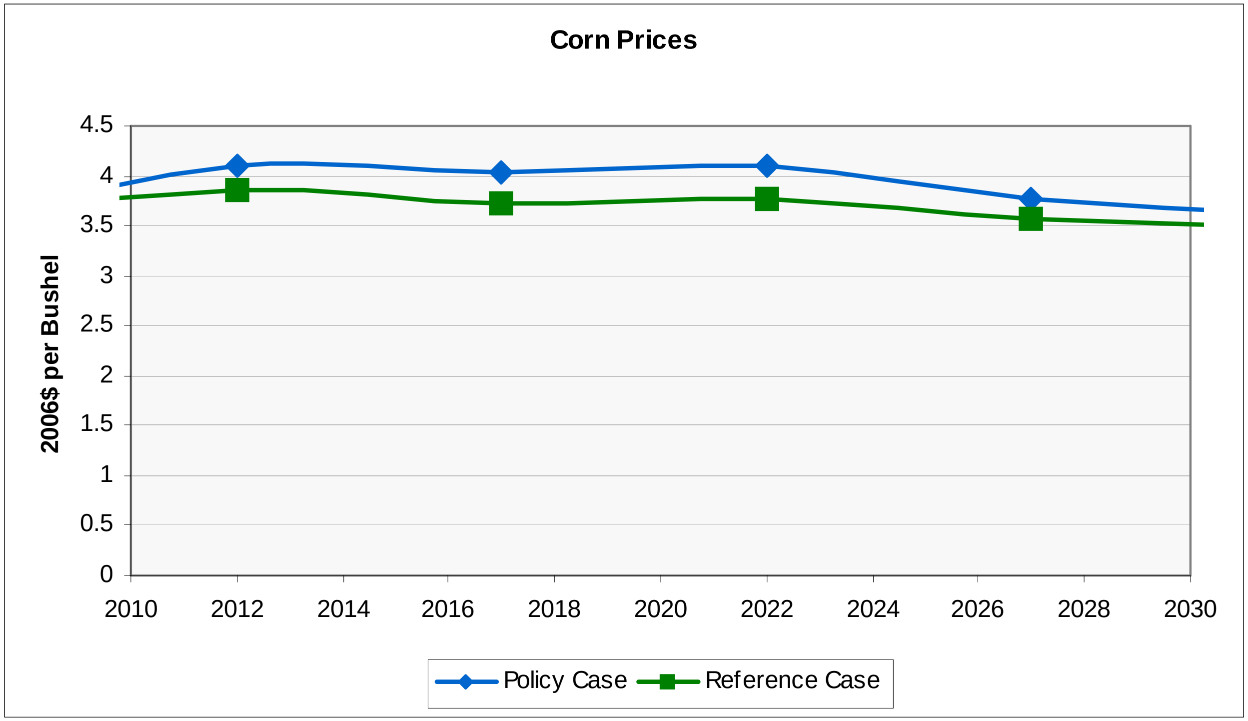
Summary of Agricultural Sector Modeling Results

- FASOM models the change in several domestic crops as increased demand for certain crops (i.e., corn, switchgrass, and soybeans) economically competes for land and other resources against other crops (i.e., cotton, hay, and rice)



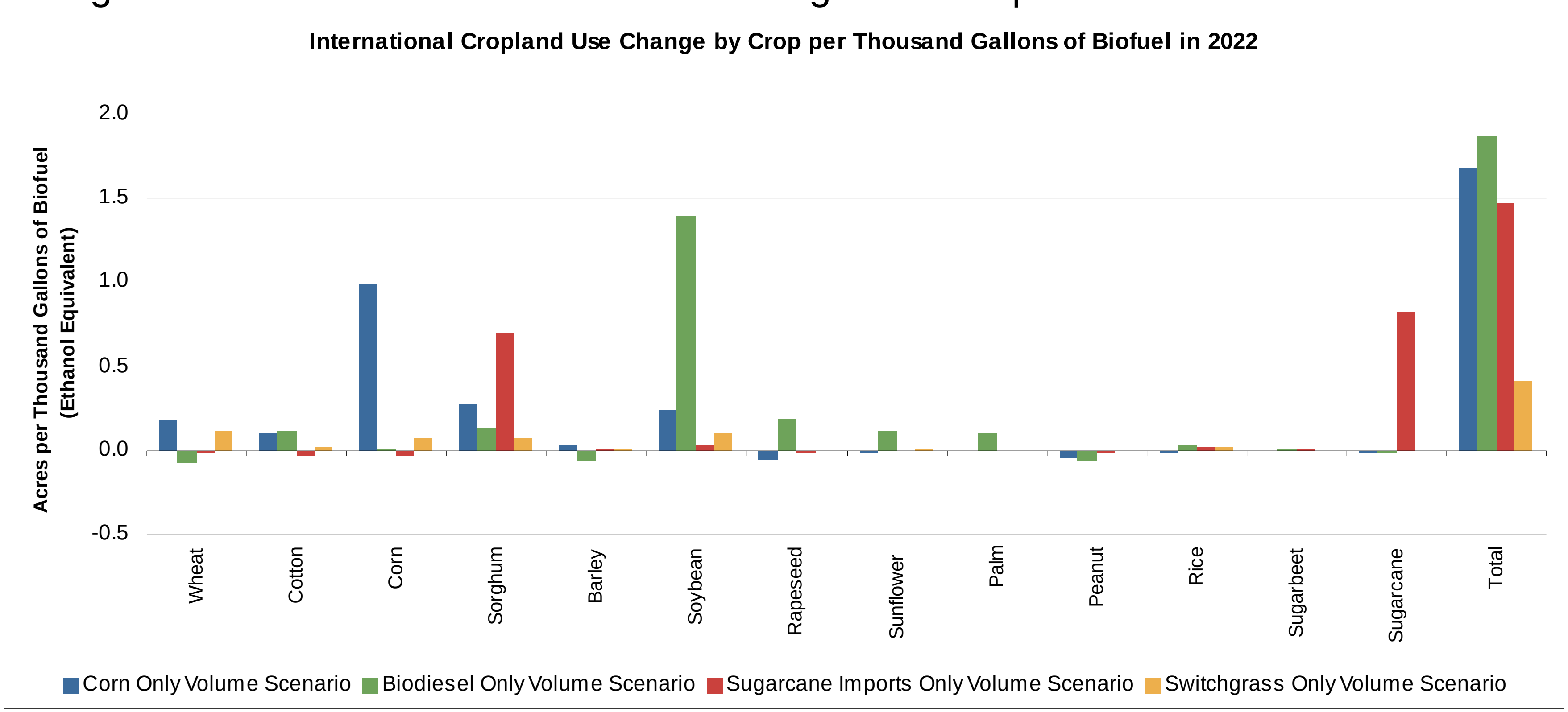
Summary of Agricultural Sector Modeling Results

- FASOM also models commodity prices (e.g., corn)

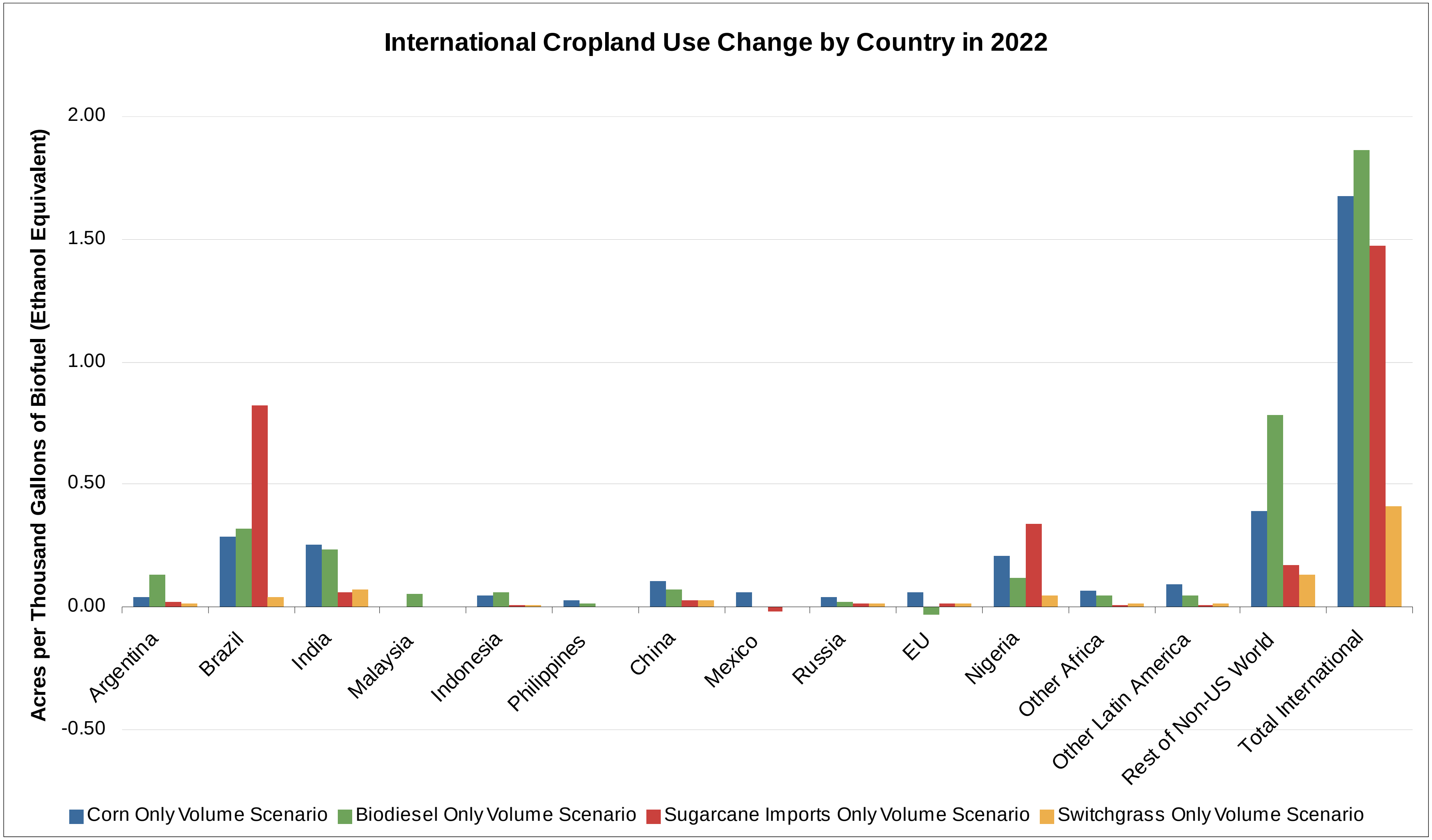


FAPRI International Acreage Change

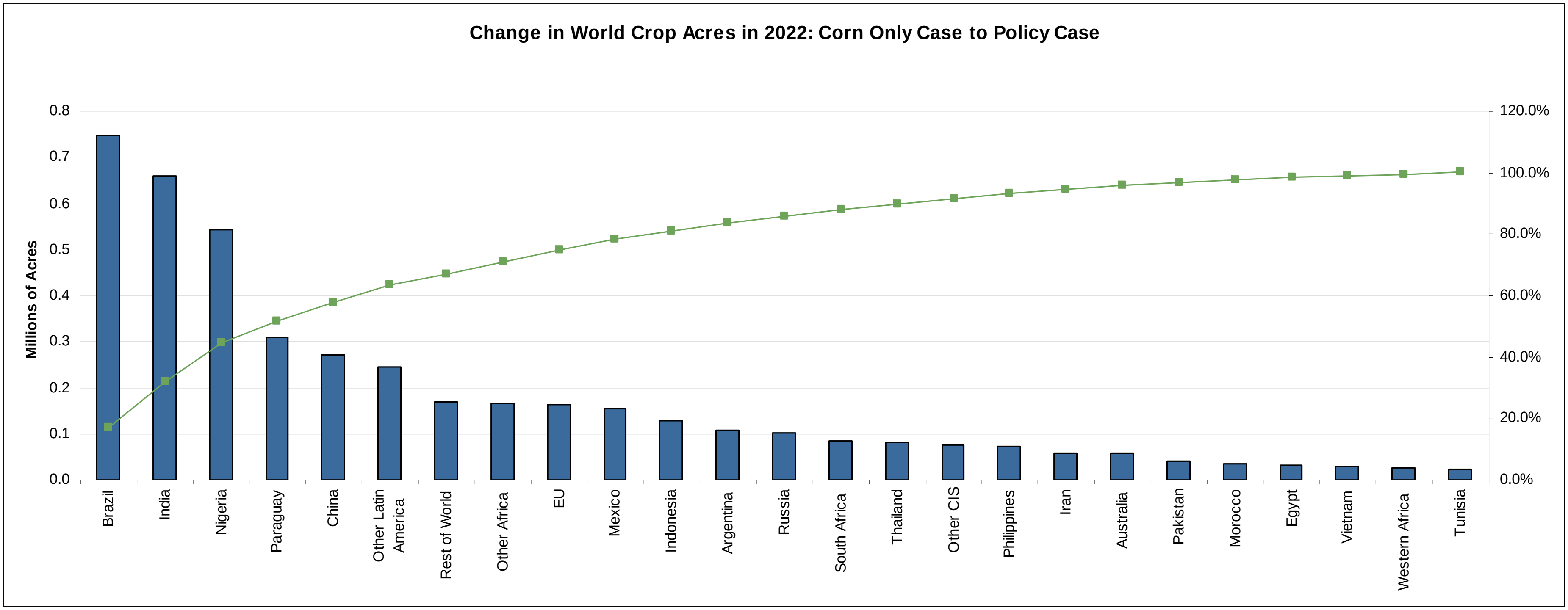
- Decrease in U.S. exports result in increased crop production internationally
  - Although not all export losses are made up with production – shifts in crops and decrease in demand also occur
- Changes in crop acres based on yields in different countries
  - No price induced yield changes or decrease from marginal yields
- Assume the net increase in all crop acres results in land being converted into agriculture with associated land use change GHG impacts



Summary of International Land Use Change by Fuel



International Land Use Change – By Country



Summary and Next Steps

- In developing the lifecycle methodology, our approach has been to use the best models, tools and resources available
- In addition, we are using sensitivity analysis and examining multiple approaches to address key areas of uncertainty
- The Notice of Proposed Rulemaking provides an important opportunity for EPA to present our work and to seek comment
- This input along with the additional analysis we will be conducting between now and the final rule will further improve our methodology