# GHG Lifecycle Modeling of Renewable Fuels

**U.S. Environmental Protection Agency**
**Office of Transportation & Air Quality**

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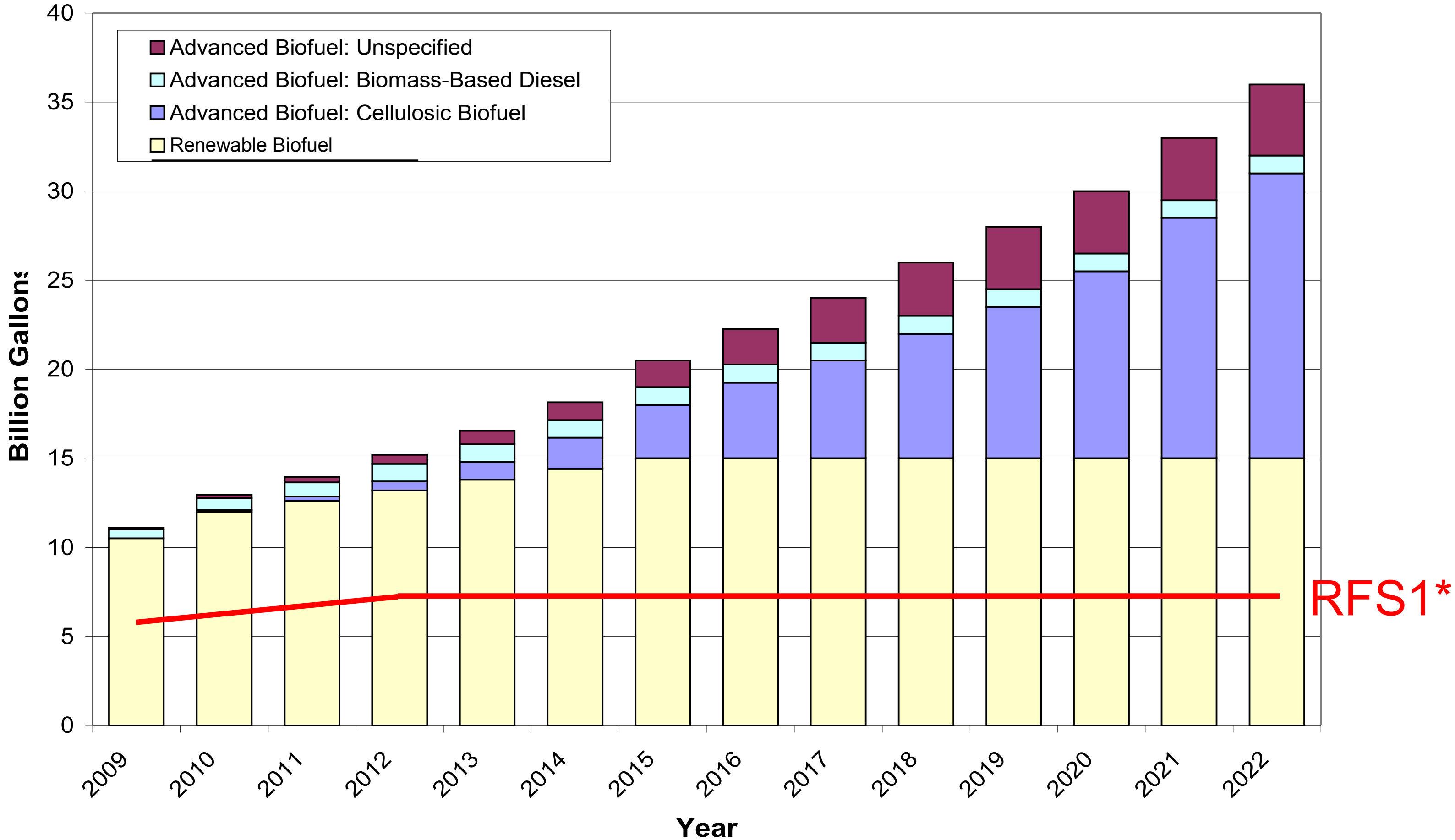
# Outline

- **Overview of EISA / Renewable Fuel Standard**
- **Lifecycle Methodological Approach**
- **Summary and Next Steps**

# Energy Independence & Security Act

- **Passed by Congress in December 2007**
- **Modifies current Renewable Fuels Standard (RFS) program**
  - Volumes increase to 36 billion gallons per year by 2022
  - Establishes new renewable fuel categories and requirements
  - Establishes lifecycle GHG thresholds for each fuel category
  - Provides new waivers
- **EPA converts mandated renewable fuel volumes into percent of gasoline**
  - Based on annual EIA predictions of gasoline consumption each Oct
  - Refiners, importers, gasoline blenders must include EPA-ruled percentage of renewable fuel in the fuel it sells/distributes/imports.
- **Includes new studies and reports**

# EISA RFS2 Volumes




* RFS1 – As established by Energy Policy Act of 2005

# Sustainability Requirements

- **Definition of Renewable Fuels**
  - Must meet lifecycle GHG reduction thresholds
  - Must be produced from renewable biomass:
    - Non-federal lands: Planted trees and thinnings must come from non-federal lands
    - Existing cropland criterion: Both crop and tree material must be harvested from land "cleared or cultivated" prior to enactment of EISA
    - Other sources include animal waste and byproducts, yard and food waste, biomass from immediate vicinity of buildings at risk from wildfire, and algae

- **Environmental and Resource Conservation Impacts Study**
  - EPA shall assess and report to Congress on the impacts to date and likely future impacts of Section 211(o) of CAA (within 3 years, and every 3 years after)

- **Anti-Backsliding Study**
  - EPA to study whether renewable fuel volumes adversely affect air quality as result of changes in vehicle emissions (within 18 months). Includes study of different blend levels. Requires promulgation of fuel regulations to mitigate to greatest extent possible any adverse impacts (within 3 years).

- **Study of the Impact of the RFS**
  - DOE (in consultation with EPA and USDA) to enter into an agreement with NAS to assess the impacts on the production of feed grains, livestock, food, forest products, and energy. Must submit results to Congress (within 18 months).

# EISA Requires Lifecycle Assessment

- Each fuel category required to meet mandated GHG performance thresholds
  - **Renewable Biofuel**
    - Must meet 20% lifecycle GHG threshold
    - Only applies to fuel produced in new facilities
    - Up to 15 billion gallons conventional corn starch ethanol can qualify
  - **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% GHG reduction qualifies as general 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%
- 2005 gasoline and diesel fuel used for comparison (mandated by EISA)

# 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.

# Overall Lifecycle Methodological Approach

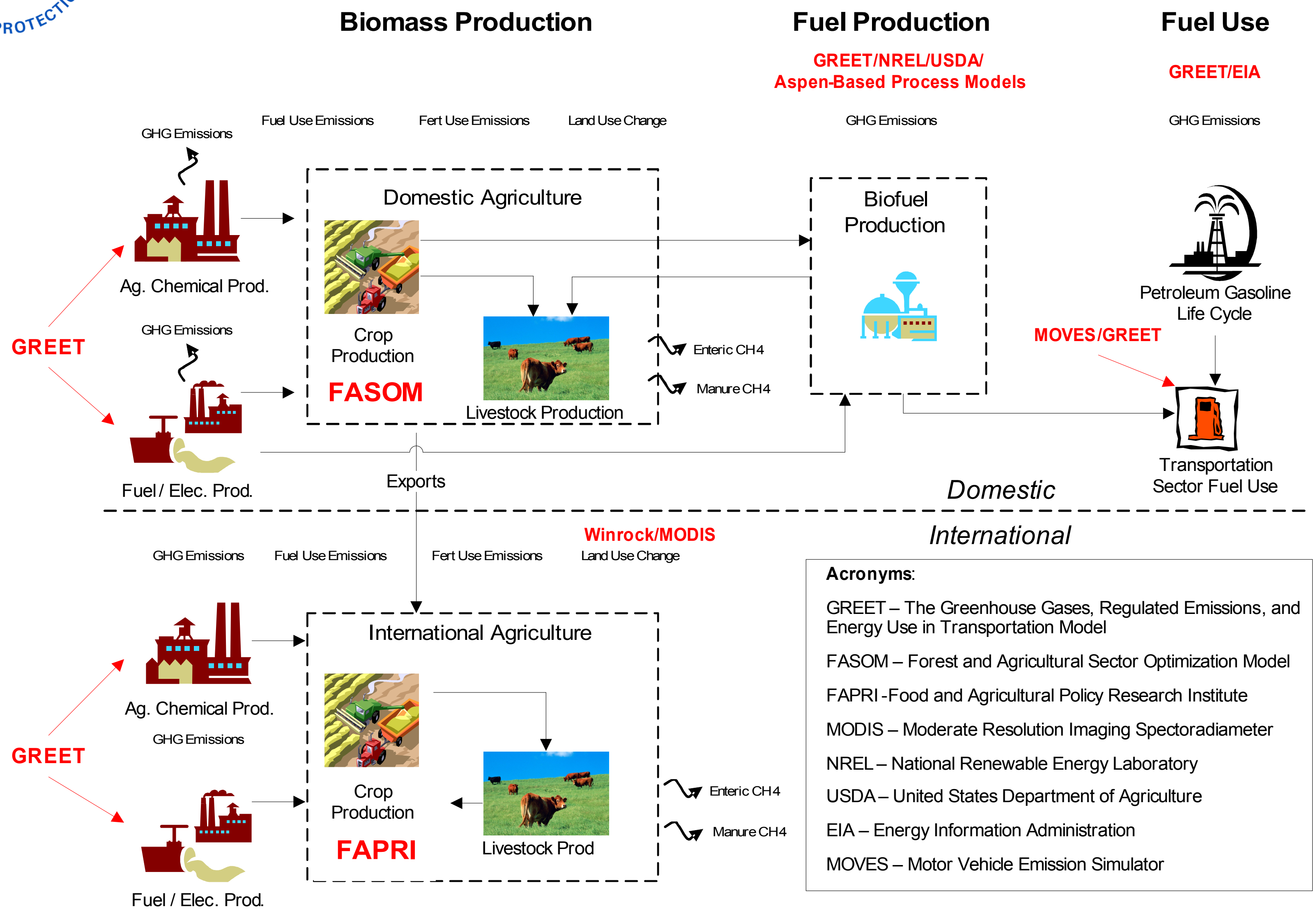
# Methodology

- EISA definition requires the use of a number of models and tools to capture *all* indirect emissions
  - Including direct and indirect impacts (e.g., land use change) requires analysis of markets
    - Most life cycle analysis tools / databases are based on process modeling (set up for attributional LCA)
    - To capture market impacts need to use economic models (consequential approach)
  - Conducting our own process and emissions modeling as part of rulemaking

- Scenario Comparison: Run models with different volume scenarios to isolate the impact of specific fuel
  - Consider change between baseline projected fuel volume in 2022 (i.e., without RFS2) and projected RFS2 mandated volume.
  - Hold volumes of other fuels constant at RFS2 mandated levels

- For areas of uncertainty, we have tested our primary approach and key assumptions with sensitivity analyses and different methods

# Key Models and Data Sources



# Agriculture Sector Modeling Issues

## *Key Land Use Change Questions*

How much land is converted?

Where is land newly converted to cropland?

What types of land are converted?

What are the GHG factors for each type of land conversion?

How to account for time dimension of GHG emissions?

## *Agricultural Production Questions*

What are emissions trends of crop production?

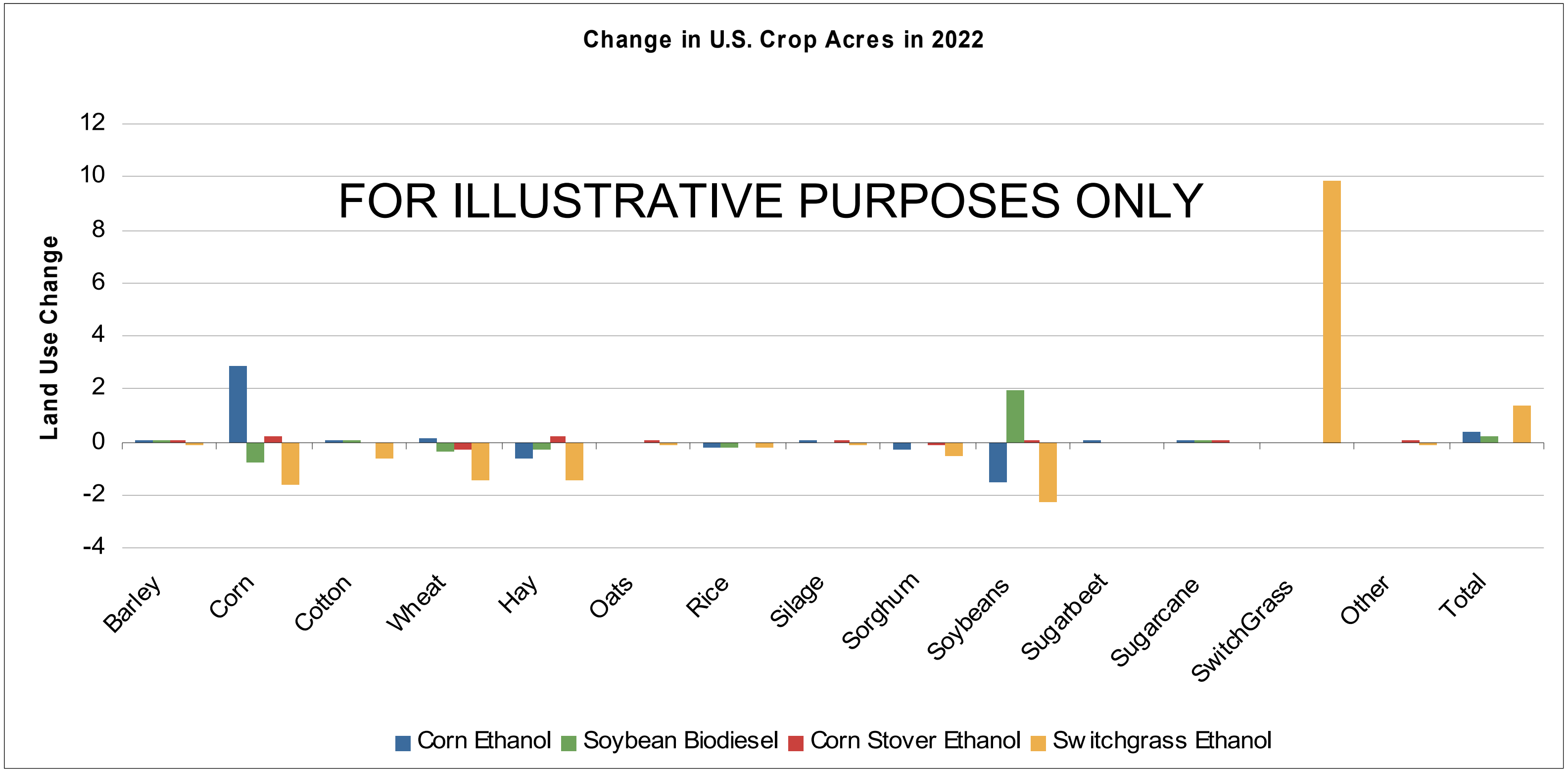
# Land Use Change Methodology

| Key Question | Domestic | International |
|---|---|---|
| Amount, or area, of land converted? | FASOM | CARD |
| Location of land use changes? | FASOM (region-level) | CARD (region-level)<br>MODIS (sub-region) |
| Land types, or biomes, converted? | FASOM (modeled interactions with cropland, pasture, CRP, and forest) | MODIS (recent trends of land conversion between, cropland, savanna, grassland, shrub land, and forest ) |
| GHG emissions from land conversion? | FASOM (e.g., DAYCENT for soil carbon changes) | Winrock / IPCC |

# Domestic Agricultural Sector Impacts

Increased biofuel production shifts domestic crop patterns

- Increase in total crop acres result in land use emissions
- Decrease in rice and livestock production (due to increased feed prices) provide GHG reductions
- Some crop production inputs and emissions increase, but are offset by reduction from less production of other crops
- Models account for co-product use (e.g., animal feed)

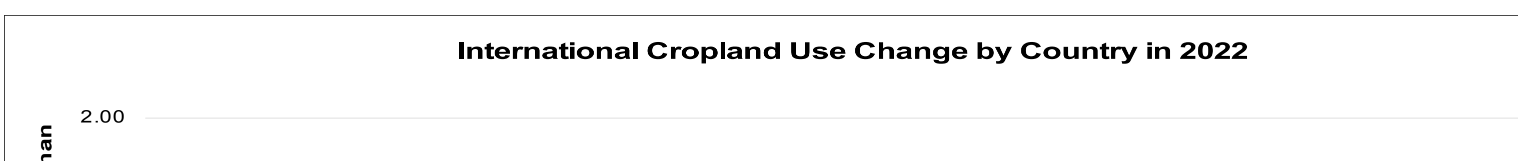


# International Agricultural Sector Impacts

Accounts for impacts indirectly resulting from domestic biofuel feedstocks production

- Agricultural inputs (e.g., tractor fuel, energy for fertilizer production and transportation, fertilizer N20)
- Cropland expansion and associated GHG emissions
- Emissions from changes in livestock production impacted by feed prices & availability
- Rice methane emissions indirectly impacted by acreage shifts

**FOR ILLUSTRATIVE PURPOSES ONLY**



# What Type of Land is Converted?

- Our primary approach is to use recent historical data on land use conversions provided by Winrock to determine what type of land will be converted in the future
  - Data is for 2001- 2004
  - Provides within country detail
  - Includes range of land types (forest, cropland, grassland, savanna, shrub)
  - New analysis done for this rulemaking (does not rely on existing work)

- Assume recent land use changes are based on economics that will predict future trends

- Performed sensitivity analyses on this key parameter
  - Also looking at other approaches (e.g., GTAP model)

# Example of Types of Land Converted to Cropland MODIS Satellite Data 2001-2004

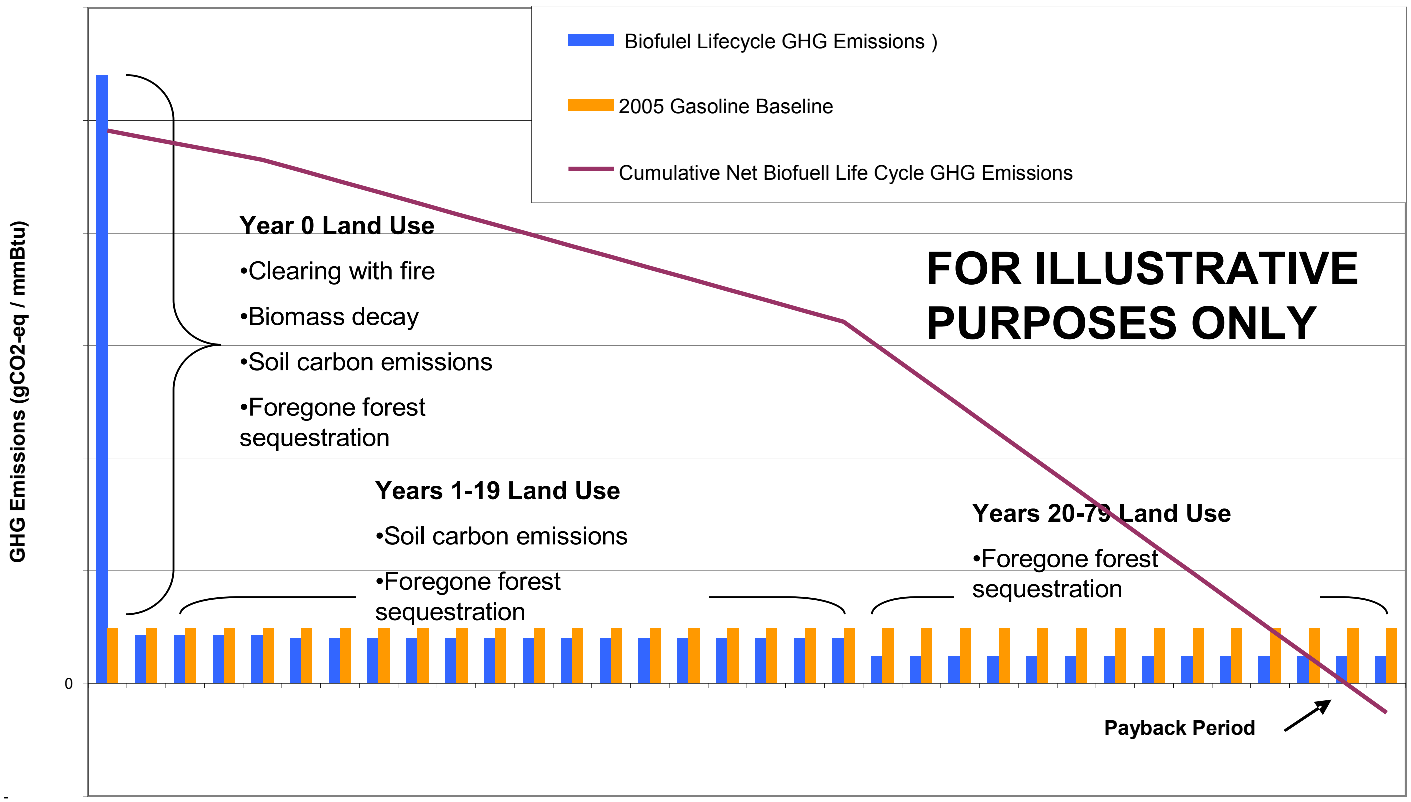
| Country | Forest | Grassland | Savanna | Shrub |
|---|---|---|---|---|
| Argentina | 8% | 40% | 45% | 8% |
| Brazil | 4% | 18% | 74% | 4% |
| China | 17% | 38% | 23% | 21% |
| E.U. | 27% | 16% | 36% | 21% |
| India | 7% | 7% | 33% | 53% |
| Indonesia | 34% | 5% | 58% | 4% |
| Malaysia | 74% | 3% | 19% | 3% |
| Nigeria | 4% | 56% | 36% | 4% |
| Philippines | 49% | 5% | 44% | 3% |
| South Africa | 10% | 22% | 53% | 15% |

# GHG Releases from Land Conversion

- State-specific emissions factors were calculated using 2006 IPCC AFOLU Guidelines
- Accounts for immediate emissions
  - Biomass C stocks
    - Account for different C stocks in annual versus perennial crops
  - Soil C stock change
    - Immediate release and ongoing releases (annual emissions over 20 years)
    - Carbon stocks in top 30cm estimated using FAO soil map of the world
  - Non-CO2 Emissions
    - Assume clearing with fire for all conversions to cropland for all countries except China and Argentina. For other conversion types, no fire was assumed.
- Lost forest sequestration
  - Foregone sequestration from forests over time (what would have been sequestered if forest was not converted) – over 80 years

# Time Dimension of Land Conversion Emissions

- Land use change results in stream of emissions that change over time
- Need to define a lifecycle GHG value applicable to all gallons across time
- Test sensitivity of results based on key factors:
  - Length of renewable fuels program
  - Time horizon of emissions
  - Discount rate or amortization



# Other Aspects Considered

- **Fuel production**
  - **Energy use and GHG emissions at production facility**
- **Fuel / feedstock distribution**
  - **Transporting feedstock to plant**
  - **Transporting fuel to end use**
- **Tailpipe emissions**
  - **Vehicle GHG emissions**
- **Baseline petroleum fuel**
  - **Assuming 2005 mix of crude**
    - **Included Tar Sands and Venezuela extra heavy and heavy crude**
  - **Also working to include energy sector impacts**

# Summary and Next Steps

- **In developing the lifecycle methodology, our approach has been to use the best models, tools and resources available**
  - **Using sensitivity analysis and examining multiple approaches to address key areas of uncertainty**
- **The notice of proposed rule-making (NPRM) provides an important opportunity for EPA to present our work and to seek comment on proposed approaches and alternative approaches**
  - **Planning to hold workshops on lifecycle analysis following release of the NPRM**
- **Engage experts between proposal and final to ensure expert-level feedback**
  - **Consulting EPA's Science Advisory Board (SAB)**
  - **Plan to conduct formal external peer-reviews of key components**
- **This input along with the additional analysis we will be conducting between now and the final rule will further improve our methodology**
- **Anticipate 3-5 year cycles for updating the analysis**

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