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# U.S. Renewable Fuel Standard Program (RFS2) Lifecycle Analysis

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Global Bioenergy Partnership  
GHG Taskforce  
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# Overview

- Key Changes Required by EISA
- The 2010 Standards
- Renewable Biomass Provisions
- Application of Lifecycle Results
- Summary of Impacts
- Questions

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# Key Changes Required by EISA

- **Energy Independence and Security Act (December 2007) required changes to the RFS program**
  - Significantly increased volumes of renewable fuel – to 36 billion gallons
  - Separation of the volume requirements into four separate categories of renewable fuel: cellulosic biofuel, biomass-based diesel, advanced biofuel, total renewable fuel
  - Changes to the definition of renewable fuels to include minimum lifecycle GHG reduction thresholds and grandfathering of volume from certain facilities
  - Restrictions on the types of feedstocks that can be used to make renewable fuel, and the types of land that can be used to grow and harvest feedstocks
  - Inclusion of specific types of waivers and EPA-generated credits for cellulosic biofuel

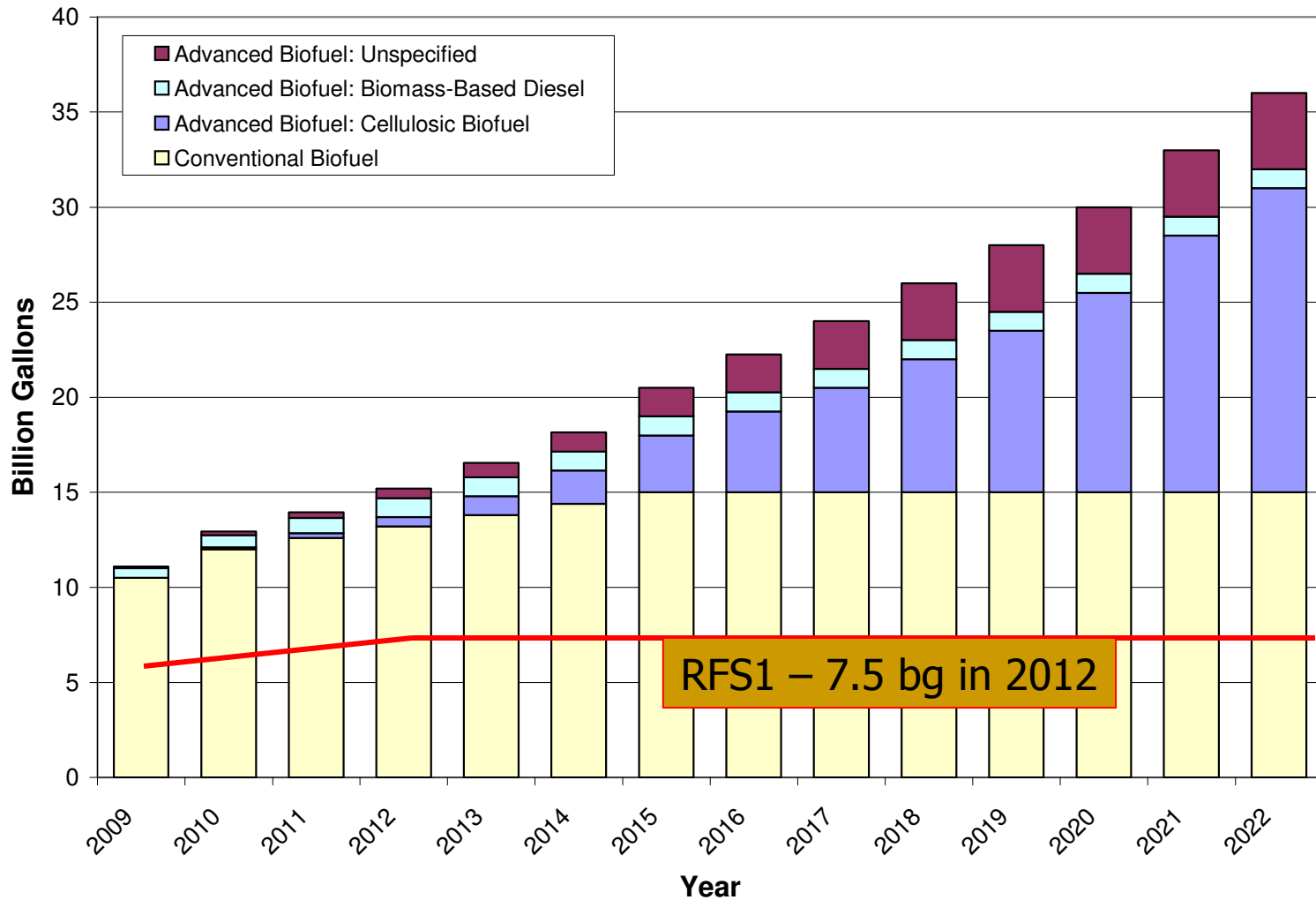
# What are the Four Categories and Standards?

## ■ Four Separate Standards

- **Biomass-Based Diesel: 1 Bgal by 2012 and beyond**
  - E.g., Biodiesel, “renewable diesel” if fats and oils not co-processed with petroleum
  - Must meet a 50% lifecycle GHG threshold
- **Cellulosic Biofuel: 16 Bgal by 2022**
  - Renewable fuel produced from cellulose, hemicellulose, or lignin
  - E.g., cellulosic ethanol, BTL diesel, green gasoline, etc.
  - Must meet a 60% lifecycle GHG threshold
- **Advanced Biofuel: Total of 21 Bgal by 2022 (Minimum of 4 billion additional)**
  - Essentially anything but corn starch ethanol
  - Includes cellulosic biofuels and biomass-based diesel
  - Must meet a 50% lifecycle GHG threshold
- **Renewable Biofuel: Total of 36 Bgal by 2022 (Minimum of 15 Bgal additional)**
  - Ethanol derived from corn starch – or any other qualifying renewable fuel
  - Must meet 20% lifecycle GHG threshold - Only applies to fuel produced in new facilities

**NOTE: Existing biofuel facilities (domestic and foreign) are not required to meet GHG threshold for general renewable fuel category – facilities are “Grandfathered.”**

# RFS2 Volumes



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# Application of Lifecycle Results

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# Updates to Lifecycle Modeling

- **Based on peer review results as well as other comments received we have made several updates to our modeling since the NPRM analysis**
  
- **Updates to Domestic Agricultural Sector Modeling:**
  - Incorporated forestry model results in our analysis
  - Added new land classifications; cropland, cropland-pasture, rangeland, forest-pasture, forest, CRP, developed land
  - Reflected new data on projected switchgrass yields
  - Updated N<sub>2</sub>O / soil carbon numbers
    - Worked with Colorado State University DAYCENT/CENTURY models to update factors
  
- **Updates to International Agricultural Sector Modeling:**
  - Incorporated a Brazil module into the international model framework
    - Regional breakout of agriculture and pasture land
    - Includes pasture / cropland interactions
  - Added price induced yield changes -- Based on work by CARD at Missouri and Iowa State that provides factors by crop and by country (e.g., long term elasticity for the U.S. Corn Belt)
  - Updated international agricultural GHG emission estimates based in part on new data from the International Fertilizer Industry Association (IFA)
  
- **Updates to Biofuel Processing in Both Domestic and International Agricultural Sector Modeling:**
  - Added corn fractionation pathway (w/ co-product markets, etc.)
  - Adjusted DDG co-product replacement rates --
    - Reflected results of new studies from Argonne and the University of Minnesota that indicate more efficient use of co-product
  - Added biodiesel glycerin co-product credit
  - Updated process energy use
  
- **Updates to Land Use Change Modeling:**
  - Included more geographic coverage of satellite data from 35 countries in the NPRM to 160 countries in the FRM
  - Used longer time coverage of satellite data - 2001-2007
  - Used higher resolution satellite data from the latest MODIS V5 release, 500m<sup>2</sup> resolution
    - Also augmented global satellite data with country / region specific data where available (e.g., data from Brazil on pasture intensification)

# Addressing Uncertainty in Analysis

- **For the final rule analysis we specifically addressed the uncertainty of the lifecycle results with three primary approaches:**
  1. Updated the analysis with the best currently available information to narrow the uncertainty
  2. Performed sensitivity analysis around key factors to test the impact on the results
  3. Established reasonable ranges of uncertainty and used probability distributions within these ranges in threshold assessment
  
- **Crop Yields – A key sensitivity analysis performed**
  - Reviewers and public comments identified economic modeling inputs (particularly, crop yield projections) as an area of the proposed LCA that generally underestimated potential yield growth.
  - We analyzed a base yield and a high yield scenario to test the impact of this assumption.
  
- **Two key drivers of land use change – performed an uncertainty analysis and developed a range and distribution of results around the LUC emissions**
  1. Types of land converted (satellite data)
  2. GHG emission factors associated with different types of land conversion
  
- **For key methodology choices we have selected approaches based on feedback from the comment process and peer review**
  - Where appropriate conducted sensitivity analysis around these decisions

# Compliance Determination from LCA Results

- **Modeling accounts for the typical feedstock and fuel production pathway from which significant production and contribution to RFS2 volumes are expected (2022)**
- **Modeled fuel pathways meeting compliance:**
  - Ethanol produced from corn starch at a new natural gas, biomass, or biogas fired facility using advanced efficient technologies meets 20% threshold (Coal fired will not)
  - Butanol from corn starch meets 20% threshold
  - Biodiesel (soy, wastes, algae) meets 50% threshold
  - Sugarcane ethanol (multiple pathways) meets 50% threshold
  - Cellulosic ethanol and diesel fuel (Thermal and Biochemical from Stover, Switchgrass) meets 60% threshold
- **Results extended to same fuel type and feedstock as a modeled pathway but with feedstock production sources that were not included in the analysis (e.g., corn ethanol and soybean biodiesel produced in another country)**
  - If agricultural production from a source are significantly different from those modeled and fuel volumes from the source increase, EPA retains the authority to perform a full analysis of the different pathway for compliance determination
- **Results extended to other fuel pathways with low risk of not complying:**
  - Crop residues such as corn stover, wheat straw, rice straw, and citrus residue providing starch or cellulosic feedstock
  - Forest material including eligible forest thinnings and solid residue remaining from forest product production providing cellulosic feedstock
  - Secondary annual crops planted on existing crop land such as winter cover crops and providing cellulosic material, starch, or oil for biofuel production
  - Separated food and yard wastes, including food and beverage wastes from food production and processing
  - Perennial grasses including switchgrass and miscanthus

# Continued Work on Lifecycle Analysis

- **EPA recognizes that the state of scientific knowledge underlying lifecycle analysis of biofuels continues to evolve.**
- **EPA is committing to further reassess on a regular basis the lifecycle estimates and the determinations described in the RFS Final Rulemaking.**
  - EPA will request that the U.S. National Academy of Sciences (NAS) to further evaluate over the next two years –
    - the approach taken in the current RFS rule,
    - the underlying science of lifecycle assessment – in particular, indirect land use change andand make recommendations for subsequent rulemakings with regard to lifecycle analysis of biofuels.
  - The assessment by NAS could result in new determinations of threshold compliance compared to those included in this rule that would apply to future production (from plants that are constructed after each subsequent rule).

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# Questions?

- For Additional information:  
<http://www.epa.gov/otaq/renewablefuels/index.htm>
  - Includes Factsheets
  - RFS2 Rulemaking Package
    - Preamble
    - Regulations
    - Regulatory Impact Analysis
  - Links to Other Information
  - Frequently Asked Questions
  
- Send new questions to: [EPAFuelsPrograms@epa.gov](mailto:EPAFuelsPrograms@epa.gov)
  
- Look for announcements for upcoming implementation workshops as well.