THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

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U.S. EPA Renewable Fuel Standard 2

Final Rule Summary

On February 3, 2010, the United States Environmental Protection Agency (EPA) finalized revisions to the National Renewable Fuel Standard. The new rule (RFS2), which incorporates changes mandated by the 2007 Energy Independence and Security Act (EISA), is a major amendment of the original standard (RFS1) created under the Energy Policy Act of 2005.

RFS2 represents a hybrid approach that superimposes a performance-based standard on a set of volumetric targets. In contrast to RFS1, which was limited to gasoline, the new rule expands the RFS program to cover gasoline and diesel intended for use in highway and nonroad vehicles and engines. RFS2 classifies renewable fuels according to four nonexclusive categories, based on GHG-reduction thresholds and feedstock types, and sets volumetric requirements for each. EISA sets the total renewable fuel volume target for 2010 at 12.95 billion gallons. (The original target reflected in RFS1 for 2012, 7.5 billion gallons per year, has already been surpassed; total U.S. renewable fuel production in 2009 was 10.3 billion gallons).

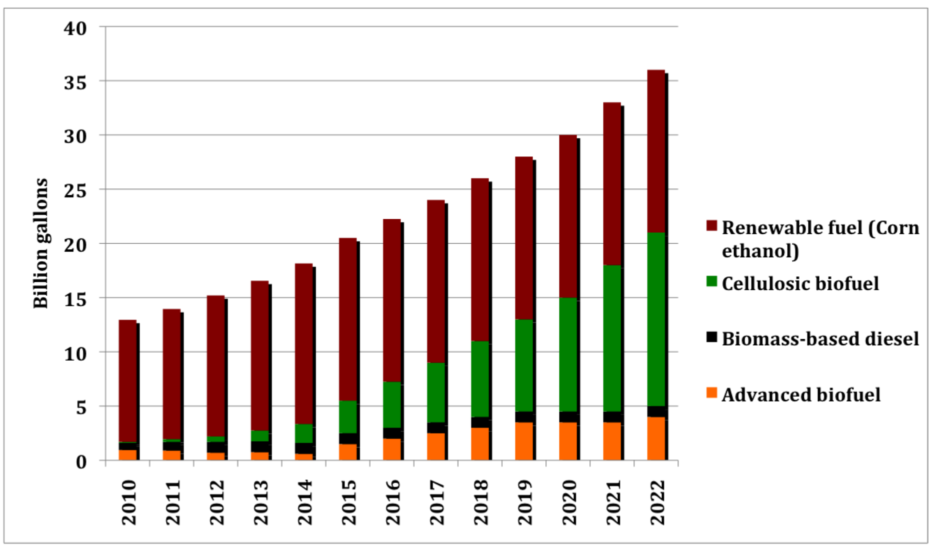

Fig. 1. Projected volumes of renewable fuels under RFS2. Source: EPA 2010a.

By requiring that any renewable fuel must meet a minimum GHG-reduction threshold of 20% to be eligible for a Renewable Identification Number (RIN), and setting higher reduction thresholds for three of the four fuel categories it defines, RFS2 promotes lower-carbon fuels and next-generation biofuels. It is the first national regulation adopted anywhere in the world that recognizes the potential for significant contributions to lifecycle GHG emissions from indirect land-use change (ILUC). (At the state level, California has already incorporated ILUC GHG emissions in carbon-intensity calculations under its Low Carbon Fuel Standard [LCFS].)

The combination of volumetric targets, corresponding GHG-reduction threshold requirements, and incorporation of GHG emissions from indirect land-use change is expected to reduce annual GHG emissions by 138 million metric tons (MMT) in 2022. Under the new requirements, renewables will displace 13.6 billion gallons of gasoline and diesel, with net economic and human health benefits of $8.5 to $21.5 billion in 2022. According to ICCT estimate, if the goal of producing 16 billion gallons of cellulosic ethanol is met by 2022, RFS2 may reduce the carbon intensity of regulated fuels by 6.5% relative to their carbon intensity in 2009.

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Key elements

Volumetric and GHG-reduction requirements

RFS2 sets volumetric requirements and GHG-reduction standards for four nonexclusive categories of renewable fuel.

(1) Total renewable fuel. This refers to transportation fuels derived from biomass defined as "renewable" by RFS2 (see the summary of land use restrictions below) that reduce GHG emissions by 20% relative to gasoline or diesel. For example, corn ethanol can qualify as renewable fuel if it meets the 20% GHG-reduction target. Thanks to an exemption, almost all corn ethanol produced in the U.S. qualifies as renewable. About 9.6 billion gallons of corn ethanol was produced in the U.S. in 2009.

(2) Biomass-based diesel. This refers to both ester-based diesel and non-ester diesel obtained from biomass such as oil seeds, algae, and lignocellulose. Biomass-based diesel is required to reduce GHG emissions by 50% as compared to diesel. Currently, biomass-based diesel comes mainly from soybean. U.S. production in 2009 was about 700 million gallons. If diesel is produced by co-processing biomass with petroleum feedstock, it is not recognized as biomass-based diesel but still can qualify as advanced biofuel if it meets a 50% reduction threshold.

(3) Advanced biofuel is renewable fuel other than ethanol derived from corn starch that meets a 50% GHG-reduction target. For example, sugarcane ethanol can qualify as advanced biofuel if it reduces GHG emissions by 50% as compared to gasoline. Cellulosic biofuel volumes (see below) are counted toward the volumetric requirements for advanced biofuels.

(4) Cellulosic biofuel refers to fuel derived from lignocellulosic feedstocks such as dedicated energy crops (e.g., yellow poplar, switchgrass), forest thinnings, agriculture residues, and biogenic portion of municipal solid waste. A cellulosic biofuel is required to meet a 60% GHG-reduction threshold relative to gasoline. The EPA has lowered the 2010 mandate for cellulosic biofuel to 6.5 million ethanol-equivalent gallons (from 100 million gallons), which is the amount that the Energy Information Agency estimates that will be on the market.[1]

Fig. 1 depicts one possible scenario for renewable fuel use under RFS2. Total production of renewable fuel required by 2022 is 36 billion gallons, of which 16 billion gallons must be cellulosic biofuel. The volumetric requirement for advanced biofuel, including cellulosic biofuel, is 21 billion gallons by 2022. Corn ethanol will be the major renewable fuel in the early part of the RFS2 program, but the volume requirement peaks at 15 billion gallons in 2015. The rule does not specify a standard for biomass-based diesel beyond 2012, but it will be at least one billion gallons.

Under the rule, GHG-reduction thresholds for advanced biofuel, biomass-based diesel, and cellulosic biofuel can be relaxed by as much as 10% if EPA determines that the thresholds are not feasible in a given year for fuels obtained from various feedstocks, processes, and technologies. Considering the immature biochemical and thermochemical technologies involved in producing cellulosic biofuels, it is likely that those standards will indeed be relaxed in the near term.

1 More precisely, the EIA estimates 5.04 million gallons of cellulosic biofuel on the market, including both ethanol and diesel, which contains 1.5 times the energy of ethanol—hence the use of "ethanol-equivalent" measurement for this category.

Threshold exemption

One notable aspect of the standard is that renewable fuels are indefinitely exempted from the 20% GHG-reduction threshold if they are produced in facilities built before December 2007. Corn-ethanol facilities built between 2007 and 2009 are exempted if they use natural gas or biomass, or a combination thereof. This exemption also applies to soybean biodiesel. The existing conversion processes would meet the 20% reduction threshold, so the provision will not worsen GHG emissions from soybean biodiesel.

Nearly all current U.S. production of renewable fuel, about 9.6 billion gallons, is thus effectively grandfathered under the new rule. Consequently, short term GHG reductions from renewable fuel will be minimal, because the majority of existing production facilities do not use advanced corn-ethanol processes. This observation is based on EPA's revised estimate of indirect land use change emissions for corn, approximately 44 g CO2. eq./MJ.

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model estimates that the average GHG intensity of corn ethanol produced from wet and dry mill ethanol plants is 44 g eq./MJ. Including GHG emissions from ILUC, its life cycle GHG intensity would be 88 g CO2 eq./MJ which is slightly less than the GHG intensity of gasoline (93.3 g CO2 eq./MJ).

Renewable Volume Obligation (RVO)

Obligated parties, i.e., gasoline and diesel refiners/importers, are required to meet a Renewable Volume Obligation (RVO) for each type of renewable fuel each year. The RVO for each obligated party is determined based on the volume of gasoline/diesel produced or imported by the party and the percentage standards (by volume) set for the four categories of renewable fuels in a given year. To track transactions and demonstrate compliance, an obligated party must use and accumulate enough RINs[2] to meet their RVOs. The fundamental aspect of the RIN system has not changed in RFS2 from RFS1. The one difference is that RFS2 has multiple RINs corresponding to various types of renewable fuel.

If an obligated party generates more RINs than required, RINs can be transferred to the following year to meet no more than 20% of its RVO for that year or can be sold to another party. Under certain conditions, an obligated party that cannot accumulate enough RINs can carry deficits to the following year.

Each obligated party should accumulate current year RINs that meet at least 80% of its RVO. An obligated party can meet a maximum of 20% of the RVO by acquiring excess RINs from the previous year. These can come from its own excess RINs, or RINs purchased from other obligated parties. Excess RINs from the previous year are voided if not used in the subsequent year.

Renewable biomass

Only renewable fuel obtained from renewable biomass can be used to generate RINs, and RFS2 defines "renewable biomass" so as to prevent the utilization of biomass obtained from land that will increase

2 RIN is a unique 38-digit number assigned to one gallon of renewable fuel. RINs will be used to demonstrate that compliance with volumetric targets for various renewable fuels is met. The RIN will have unique information attached to each gallon of renewable fuel indicating the company and facility where it was produced, its batch number and fuel category, production year, etc. Similar to RFS1, RFS2 requires the producer or importer to assign RINs to volumes of renewable fuel and transfer the RINs through the distribution system.

GHG emissions or may reduce biodiversity. Only planted crops[3] and crop residues from existing agricultural land[4], planted trees and tree residues[5], slash and pre-commercial thinnings from non-federal forestlands[6], algae, separated food and yard waste, and biomass obtained from certain areas at risk from wildfires can qualify as renewable biomass.

To verify that renewable biomass is used in generating RINs, obligated parties are required to follow certain certification and reporting protocols.

If a biofuel producer is not interested in obtaining RINs, there is no restriction on how and where biomass is produced, nor does the producer need to report it.

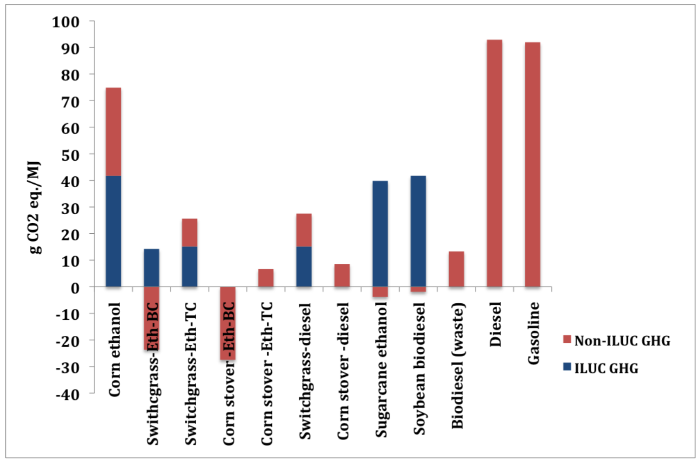

Fig. 2. Life cycle GHG estimates for various feedstocks and pathways. Eth = ethanol, BC = biochemical conversion, TC = thermochemical conversion. Estimates are based on 30-year time frame and zero percent discount rate. Corn ethanol data in above figure refers to average value for dry milling process using natural gas. Source: EPA 2010a.

Land use restrictions

The regulation defines renewable biomass so as to exclude production from federal forests, natural forests in non-federal land, trees in urban settings, orchards, and rangeland.

Life-cycle analysis and indirect land use change

Life-cycle analysis (LCA) is the foundation on which GH-reduction thresholds for renewable fuel are developed. The system boundary for LCA extends "from well to wheels," and includes GHG emissions from ILUC[7]. Typically, biofuels derived from food crops such as soy and corn have greater ILUC GHG emis-

3 Planted crops refer to annual, perennial, and microcrops obtained from agricultural land that is cultivated or cleared prior to December 2007 and is actively managed, fallow, or nonforested.

4 "Existing agricultural land" includes cropland, pasture, and land in the Conservation Reserve Program (CRP).

5 Planted trees and tree residues should come from tree plantations in non-federal land. Planted trees refer to trees grown by human intervention on parcels of land greater than one acre. A tree plantation refers to an area containing trees that was cleared any time prior to December 2007 and has been actively managed thereafter.

6 EPA defines forestland as underdeveloped land of at least one acre that has trees as predominant vegetative species, including land that previously had trees and will be regenerated as well as tree plantations. Non-forested land is land that is not forestland.

7 EPA used the Forestry and Agricultural Sector Optimization Model (FASOM) and the Food and Agricultural Policy and Research Institute (FAPRI) model to estimate the indirect GHG emissions from land-use change. FASOM is the partial equilibrium model of the U.S. forestry and agriculture sector. It provides estimates of impacts on the domestic agriculture sector, such as changes in crop acreage and livestock population as a result of increase in biofuel feedstock production. The FAPRI model analyzes the impacts of biofuel production on international agriculture and livestock production. Since the FAPRI model can only provide estimates of the acreage of international land use change, not the type of land converted, EPA relied on Winrock land-use data to estimate GHG emissions. Some notable modifications to the models for the final rule were the full incorporation of a forestry model in FASOM, revised co-product substitution rates, addition of corn oil as co-product, and the addition of a Brazilian agriculture model. EPA also used a 30-year timeframe and a zero

sions than those derived from dedicated energy crops such as switchgrass. Biofuels from agriculture residues, forest thinnings, and municipal solid waste do not induce indirect land use change.

EPA has identified several feedstocks and fuel pathways that can deliver renewable fuels with at least 20% GHG reduction threshold even after including ILUC GHG emissions (fig. 2).

The average value for corn ethanol obtained from dry milling process with natural gas as process energy lies on the borderline of the 20% reduction threshold. Not all corn ethanol in the U.S. is produced from dry milling with natural gas. Some of the plants use wet milling or dry milling with coal as process energy, which will produce ethanol with GHG reduction thresholds of less than 20%. EPA predicts that all new corn ethanol plants built by 2022 will use dry milling and either natural gas or biomass for process energy and can meet the 20% GHG reduction target.

Based on the EPA estimates, cellulosic biofuel produced using a biochemical process has the lowest GHG intensity, due to GHG emissions avoided through the use of lignin to produce electricity. The avoided GHG emissions more than compensate for ILUC GHG emissions. Cellulosic biofuel obtained from agriculture residues and waste also benefits from having no ILUC GHG emissions. Therefore, the emphasis in RFS2 on cellulosic biofuel is justified. As the production volume of cellulosic biofuel and advanced biofuel rises after 2015, there will be measurable reductions in GHG emissions from the transportation sector. The only uncertainty is whether technological hurdles will be overcome to allow faster commercialization of cellulosic biofuel.

Environmental and economic impacts

The Regulatory Impact Analysis (RIA) of RFS2 identifies several environmental and economic implications of large-scale biofuel production. One obvious impact is the reduction of GHG emissions. EPA estimates that RFS2 could reduce GHG emissions by 138 MMT per year in 2022 compared to the EIA's Annual Energy Outlook 2007 (AEO 2007) reference case. The ICCT estimates that RFS2 may reduce the combined carbon intensity of regulated fuels by 6.5% in 2022 compared to their 2009 carbon intensity. Other environmental and economic impacts are described below.

Air quality. RFS2 will increase emissions of hydrocarbons, sulfur dioxide, nitrogen oxides (NOx), acetaldehyde, and ethanol. RFS2 will reduce emissions of carbon monoxide (CO) benzene, and ammonia. These reductions come from decreases in exhaust CO emissions, gasoline use, and livestock population, respectively. RFS2 may increase ethanol and acetaldehyde emissions by 30%-40% in 2022 when compared to the RFS1 scenario.

Water quality and availability. RFS2 will increase loadings of nitrogen, phosphorous, and sediment relative to the AEO 2007 reference case since the projected volumes of renewable fuel use are larger under RFS2. For example, annual flows of nitrogen, phosphorous, and sediment into the Upper Mississippi River Basin may increase by 9 million kg, 0.5 million kg, and 10 million kg, respectively. Water quality can be affected by ethanol leaks from underground storage tanks and spills from above-ground tanks or distribution systems.

Since crop production and biorefineries require significant amounts of water, water availability and groundwater depletion can be an issue, depending on the locations of croplands and biorefineries. It requires more than 600 gallons of water to produce a gallon of ethanol, when irrigation is factored in.

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discount rate in the calculation of ILUC effects.

Costs. Increased renewable-fuel production mandated by RFS2 will increase the costs of agriculture crops. For example, the USDA's Forestry and Agricultural Sector Optimization Model (FASOM) estimates that the prices (measured in 2007 U.S. dollars) of corn and soybean will increase by $0.27 per bushel and $1.02 per bushel, respectively. With increases in commodity prices, U.S. exports of corn and soybean will decrease by 8% and 14%, respectively. Overall food costs will increase by $10 per capita.

Increased renewable fuel production will displace 13.6 billion gallons[8] of gasoline and diesel by 2022. It will decrease gasoline and diesel costs by 2.4 cents per gallon and 12.1 cents per gallon, respectively. Expenditure on petroleum imports will decline by $41.5 billion (2007 dollars) in 2022. Figure 3 shows production costs of various renewable fuels in 2010 and 2022.

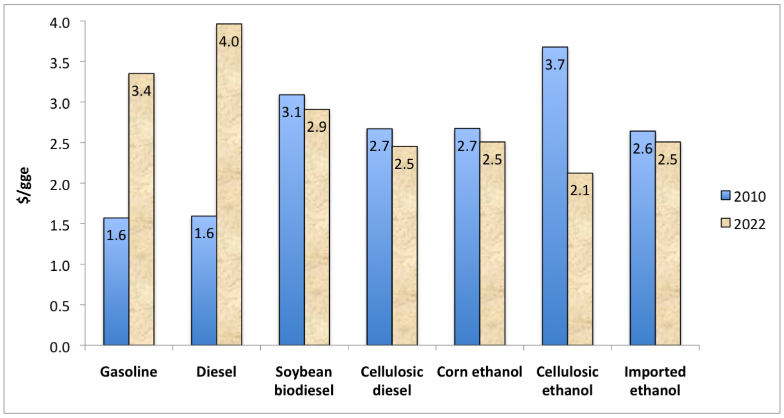

Fig. 3. Production costs of renewable fuels under RFS2. Gasoline and diesel costs are wholesale costs. Because the energy content of renewable and petroleum fuels differs, costs are expressed in 2007 U.S. dollars per gasoline gallon equivalent (gge). Crude oil prices in 2010 and 2022 are assumed to be $49 and $116.5 per barrel, respectively. Actual production costs of gasoline and diesel are lower than the wholesale costs. However, the overall trends remain the same. Source: EPA 2010b.

Considering fuel costs, monetized health and GHG impacts, and energy security, the total benefits of RFS2 would be $13 to $26 billion in 2022. Capital investments totaling $90.5 billion through 2022 are required to achieve the required renewable fuel production. Those investments are spread out over fifteen years (from the baseline year 2007), leaving net benefits of approximately $8.5 to $21.5 billion in 2022.

References

EPA, 2010a. Regulation of Fuels and Fuel Additives: Changes to Renewable Fuel Standard Program. 40 CFR Part 80 [EPA-HQ-OAR-2005-0161; FRL-XXXX-X], RIN 2060-A081. Assessment and Standards Division, Office of Transportation and Air Quality, EPA.

EPA, 2010b. Renewable Fuel Standard Program (RFS2) Regulatory Impact Analysis. Assessment and Standards Division, Office of Transportation and Air Quality, EPA.

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8 Compared to the AEO 2007 reference case, RFS2 increases renewable fuel production by 22.4 billion gallons a year in 2022. Since gasoline and diesel have higher energy content than ethanol (the energy content of gasoline is 1.56 times higher, for example), the total amount of gasoline and diesel displaced will be lower than 22.4 billion gallons.