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# Impact of promotion mechanisms for advanced and low-iLUC biofuels on markets

## Trade of ethanol between Brazil and the US

IEA Bioenergy

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## List of Acronyms

| | |
|---|---|
| CBOT | Chicago Board of Trade |
| CIF ARA | Cost, insurance and Freight, delivered to the Amsterdam, Rotterdam and Antwerp region |
| E10 | Gasoline with 10% ethanol |
| E15 | Gasoline with 15% ethanol |
| E85 | 85% ethanol and 15% gasoline |
| EC | European Commission |
| EISA | Energy Independence and Security Act (US) |
| EPA | Environmental Protection Agency (US) |
| EU | European Union |
| FFV | flexible fuel vehicles |
| FOB | freight on board |
| GHG | greenhouse gas |
| GJ | Giga Joule |
| GTIS | Global Trade Information Services |
| IEA | International Energy Agency |
| iLUC | indirect land use change |
| kTOE | kilo tonne oil equivalent |
| kton | 1000 metric tonnes |
| LCFS | Low Carbon Fuel Standard (California) |
| Mt | million metric tonnes |
| MW | MegaWatt |
| MWh | MegaWatt-hour |
| OPIS | Oil Price Information Service (US) |
| PJ | Peta Joule |
| RED | Renewable Energy Directive (2009/EC/28) |
| RFS | Renewable Fuels Standard (US) |
| RIN | Renewable Identification Numbers (US) |
| RVO | Renewable Volume Obligations (US) |
| TWh | TeraWatt-hour |
| US | United States |
| VEETC | Volumetric Ethanol Excise Tax Credit (US) |

# 1. Introduction

## 1.1. Background

With current discussions on indirect effects of biofuels (the 'indirect land use change or iLUC debate'), and the aim to broaden feedstocks to non-food biomass, policies are trying to put focus on biofuels from waste, residues and lignocellulose materials, so called 'advanced' biofuels with low iLUC impact. Next to the general biofuel incentives, these biofuels are getting extra support through specific promotion mechanisms. Examples are the double-counting mechanism for advanced biofuels in the EU, and the specific targets for advanced biofuels in the US.

While technologically challenging lignocellulosic ('2$^{nd}$ generation') biofuels are developing slower than expected, markets so far seem to have focused on cheaper options, using waste and residues or cheap feedstocks in more conventional biofuel technologies to take advantage of these extra incentives. Typical examples are used cooking oil or animal fats which are used for biodiesel production in the EU, or sugarcane ethanol to fulfil advanced biofuels targets in the US.

However well these policy measures intended to be, some of these may create unintended effects. These promotion mechanisms induce market movements and also trading of specific biomass and biofuel types. Other applications relying on these (residue) materials - traditionally very cheap feedstocks - may be impacted by this, both in terms of available volumes, and in terms of feedstock prices.

## 1.2. Scope of the overall study

In this study, some typical cases are presented where promotion mechanisms for advanced biofuels have had an impact on markets and trade, or may be anticipated to impact markets and trade in the future.

The study focuses on some concrete cases. The selected cases are:

1. **Used cooking oils and animal fats for biodiesel**: impact of the double-counting mechanism for advanced biofuels in the European Renewable Energy Directive on market prices and trade flows, analysed for the Netherlands and Italy.

2. **Sugarcane ethanol**: impact of the subtargets for specific advanced biofuels in the US Renewable Fuels Standard (RFS2), where sugarcane ethanol is classified as 'advanced biofuel'. This has had a clear impact on prices and trade patterns between Brazil and the US.

The other two are more prospective cases, where we can learn from a stimulated demand for straw or woody biomass in the past (for stationary bioenergy). With the introduction of advanced biofuel technologies (based on lignocellulosic feedstocks), these feedstocks may experience an additional demand for biofuels production (also stimulated by specific promotion mechanisms such as double counting):

3. **Crop residues (straw) for bioenergy**: straw may play an important role for advanced biofuels in the future. In countries such as Germany, Denmark or Poland, this is an emerging feedstock for energy and biofuels. There are already some experiences we

can take into account from the promotion of straw for stationary energy, e.g. in Denmark.

4. **International trade of US wood pellets for bioenergy in the EU**: Renewable Energy promotion in certain EU Member States is causing considerable trade flows from the US to the EU. There is clear that there are interactions with existing wood markets and forestry practises. In the future there may be additional effects when demand for cellulose-based biofuels enters these markets.

For each case, the specific relevant promotion mechanisms in place, volume and price evolutions of the specific feedstocks, emerging trade patterns and impact on other applications/markets are discussed. Impacts can be increased competition or additional pressure to ecosystems; however, it may also induce new possibilities and synergies for certain markets. Potential future impacts are also anticipated, e.g. on straw or woody biomass when advanced biofuel technologies get more mature. The case studies themselves are available as separate reports. All reports are available at:
http://bioenergytrade.org/publications.html#lowiluc

## 1.3. Scope of this report

This report contains the second case study on the role of sugarcane ethanol in the US Renewable Fuel Standard and the impact on ethanol trade flows between US and Brazil.

Brazil and the USA are the most important producers, consumers and traders of ethanol. Brazilian ethanol is produced primarily from sugarcane, while the US produces ethanol primarily from maize, but the resulting ethanol products are physically indistinguishable. Until 2010, ethanol trade between the two countries was one direction only (from Brazil to the US). In recent years, we have seen significant volumes of bilateral trade of (physically identical) ethanol between the US and Brazil driven by their different biofuel policies.

The following section is mainly derived from existing studies, in particular the report of Meyer (2013)[1], which discussed the phenomenon.

[1] S. Meyer, J. Schmidhuber, J. Barreiro-Hurlé (2013). Global Biofuel Trade: How uncoordinated biofuel policy fuels resource use and GHG emissions. FAO ICTSD, Issue Paper48. May 2013.

# 2. Promotion mechanisms for advanced biofuels in the US

## 2.1 US Renewable Fuel Standard

The main promotion system for biofuels in the US is the Renewable Fuel Standard (RFS).The RFS[2] is a requirement that a certain percentage of petroleum transportation fuels needs to be displaced by renewable fuels. RFS1 started with the Energy Policy Act of 2005. This was amended by the Energy Independence and Security Act (EISA) of 2007, the new renewable fuel standard being known as RFS2. The RFS2 further segmented biofuels in four classes, as displayed in Table 1, and mandated volumes were greatly expanded in comparison to the previous RFS1. The volumes are shown in Figure 1.

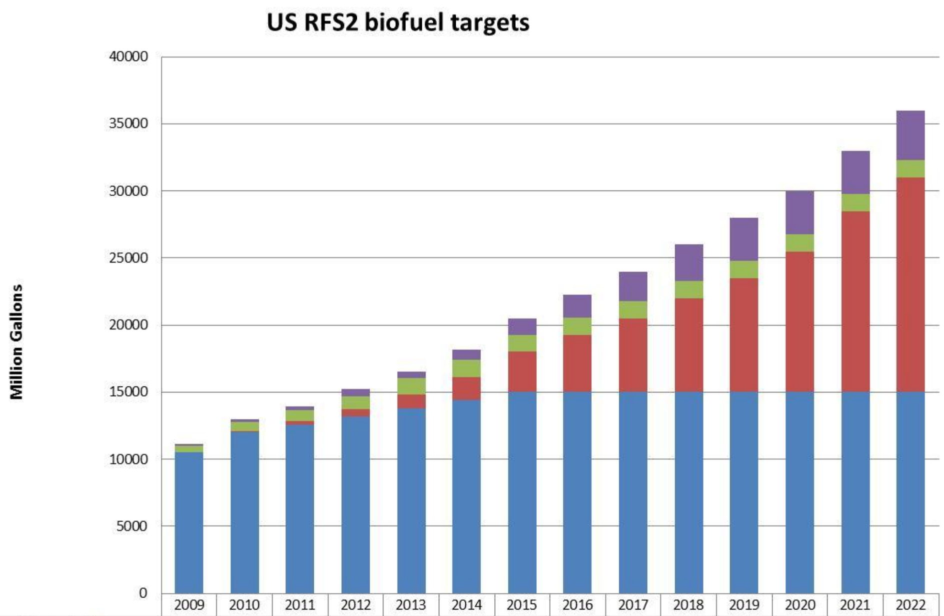
### 2.1.1 Four classes of biofuels

The four classes of mandates are delineated by fuel type, the reduction in life cycle GHG emissions relative to a base for gasoline or diesel transport fuels, feedstocks and manufacturing process. The mandates (renewable fuel (T), advanced biofuel (A), bio-based diesel (B) and cellulosic biofuel (S)) are not individual compartmentalized mandates, but quantitative minimums nested within the overall renewable fuel mandate.

**Table 1.** Summary of EISA provisions for renewable fuel classification (source: US-EPA)

| Mandate | Minimum GHG reduction | Feedstocks, fuels and processes |
|---|---|---|
| Cellulosic biofuel (S) | 60% | Derived from cellulose, hemi-cellulose or lignin from renewable biomass (from existing lands in production): dedicated crops, crop residues, planted trees and residues, algae, yard waste and food waste |
| Bio-based diesel (B) | 50% | Distillate replacements produced from: vegetable oil, animal fats, waste grease, animal waste and by-products, excluding co-processing with petroleum |
| Advanced fuels (A) | 50% | All of above and sugar, starch other than maize, bio-based diesel from co-processing with petroleum, butanol, biogas |
| Renewable fuels (T) | 20% | All of above and ethanol from maize starch |

[2] The RFS1 and RFS2 are amendments to the Clean Air Act, which is the authority under which the RFS1 and RFS2 operate.




| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| other advanced biofuels | 100 | 200 | 300 | 500 | 470 | 720 | 1220 | 1720 | 2220 | 2720 | 3220 | 3220 | 3220 | 3720 |
| bio-based diesel (B) | 500 | 650 | 800 | 1000 | 1280 | 1280 | 1280 | 1280 | 1280 | 1280 | 1280 | 1280 | 1280 | 1280 |
| cellulosic biofuels (S) | 0 | 100 | 250 | 500 | 1000 | 1750 | 3000 | 4250 | 5500 | 7000 | 8500 | 10500 | 13500 | 16000 |
| implicit non-advanced biofuels (max) | 10500 | 12000 | 12600 | 13200 | 13800 | 14400 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 | 15000 |

(A = other advanced biofuels + bio-based diesel (B) + cellulosic biofuels (S); T = all four categories)

**Figure 1.** US RFS2 biofuel targets. Source of the data: EPA

The cellulosic biofuel (S) and bio-based diesel (B) mandates set minimum quantities of these two types of fuels to be consumed. The overarching advanced fuel (A) mandate is greater than (or equal to) the sum of the cellulosic and bio-based diesel mandates creating an undefined advanced gap for other advanced fuels used to meet the larger advanced fuel mandate. They explicitly include ethanol made from sugarcane and explicitly exclude maize starch ethanol. This advanced mandate is nested in a larger over-arching renewable fuels mandate (T). The nesting creates a renewable fuel gap for which maize starch ethanol qualifies. As they are minimums, over production in each category can be used to meet the larger, less restrictive mandate. That is to say advanced fuels, for example sugarcane based ethanol, blended in excess of the advanced mandate, could be used to satisfy the total renewable fuels mandate, crowding out maize starch ethanol, but the reverse is not true. This creates a hierarchy among the fuels based on the mandate classification while the physical product, in this case ethanol, is indistinguishable.

When looking at the actual targets two aspects catch the eye:

- *Cap on non-advanced biofuels* (i.e. corn ethanol). There is an implicit cap on non-advanced biofuels of 15 billion gallons from 2015. Mind that ethanol consumption in 2010 almost reached 13 billion gallons, so the growth margin for corn-based ethanol is very limited. Mind that US gasoline consumption is around 130-140 billion gallons per year, so about 9-10% of fuel sold as motor gasoline is ethanol, which is close to the E10 blend wall. This implies that growth margin for ethanol overall (including advanced ethanol) is limited, unless E15 or E85 are introduced on large scale.
- *High expectation for cellulosic biofuels.* The mandate foresees a spectacular growth of cellulosic biofuels from virtually nothing in 2009 up to 16 billion gallons in 2022.

### 2.1.2 RVO and RIN

**Renewable Volume Obligations (RVO)** and **Renewable Identification Numbers (RIN)** are the mechanisms the Environmental Protection Agency (EPA) uses to implement the RFS program. RVOs are the targets for each refiner or importer of petroleum-based gasoline or diesel fuel, while RINs allow for flexibility in how each of them may choose to comply. The RVOs are applied to each obligated party's actual supply of gasoline and diesel fuel to determine its specific renewable fuel obligation for that calendar year. Obligated parties must cover their RVOs by surrendering RINs within 60 days after the end of each calendar year. RINs are used for both record keeping and flexibility in meeting the separate RFS targets. Each RIN is a 38-character alphanumeric code assigned to each gallon of renewable fuel that is produced in or imported into the United States. The RIN identifies the highest of the four classifications the renewable fuel can qualify for, the volume and the vintage of production. The wholesale price of the biofuel reflects the embedded value of the RIN. The value of RINs, which derives from the RFS program, provides an economic incentive to use renewable fuels.

Once the renewable fuel is blended, RINs can be separated and used for compliance or sold to other blenders to meet their obligation in lieu of their own physical blending, much like a “book and claim” system. It is possible, and even likely, that each class of RIN will have a different price in the compliance market and so although fuels may be physically identical, at the wholesale level they can have different prices based on mandate compliance. This differentiation through RIN classification of the commodity by process or inputs versus physical characteristics opens the door for arbitrage where a physically identical product is cross shipped between countries or trade is reorganized based on different compliance systems. It is generally assumed that much of the implied ‘advanced gap’ of the RFS2 would have to be sourced from imported sugarcane ethanol or through additional use of bio-based diesel above its own mandate, as no other competitive fuels currently exist in the United States. The size of the undefined advanced gap is likely to influence the volume of US imports of ethanol from Brazil. (Meyer, 2013)

### 2.1.3 Adjustments to the biofuel mandates

There is an annual RFS review process where the Environmental Protection Agency (EPA) may propose waivers compared to the initial targets. The background of a decision to waive targets can be a severe risk of harm to the economy or environment of a state, region or the US, or “inadequate domestic supply”.

The EPA, faced with inadequate productive capacity to meet the cellulosic biofuel mandate as legislated for 2010-2013, was forced to reduce the cellulosic biofuel mandate significantly while choosing to leave the total and advanced mandate in place. The shortfall in cellulosic biofuels coupled with the EPA decision to maintain the other mandates means that the size of the implied undefined advanced gap has grown and even created an extra need for undefined advanced fuels. This prompted an increase of biobased diesel as well as sugarcane ethanol imports from Brazil, and plentiful supplies of maize starch ethanol in the US prompted increased ethanol exports.

Table 2 shows the original mandates, the updates from EPA, as well as the achieved biofuel volumes (in total generated RINs). Even the lowered mandates for cellulosic biofuels were not met. The other targets have been met, mostly by an increased use of biobased diesel, and imported sugarcane ethanol.

In its proposed rule for 2014, EPA lowered the level of the cellulosic biofuel mandate because of inadequate domestic supply, ánd reduced the overall renewables target. The main argument for the reduction of the overall target is that overall gasoline consumption in the United States is less than anticipated when Congress established the program by law in 2007.

**Table 2.** Waivers for biofuel mandates in 2010-2014 (in million gallons), and achieved biofuel volumes in the US market (total generated RINs). Source of the data: EPA

| | | **2010*** | **2011** | **2012** | **2013** | **2014**** |
|---|---|---|---|---|---|---|
| **Tot. renewable fuels** | Original mandate | 12950 | 13950 | 15200 | 16550 | 18150 |
| | Updated mandate | 12950 | 13950 | 15200 | 16550 | **15210** |
| | *achieved* | *7148* | *15535* | *15352* | *16647* | *n.a.* |
| **Advanced fuels** | Original mandate | 950 | 1350 | 2000 | 2750 | 3750 |
| | Updated mandate | 950 | 1350 | 2000 | 2750 | **2200** |
| | *achieved* | *352* | *1920* | *2364* | *3297* | *n.a.* |
| **Biobased diesel** | Original mandate | 650 | 800 | 1000 | 1280 | 1280 |
| | Updated mandate | 650 | 800 | 1000 | 1280 | 1280 |
| | *achieved* | *323* | *1692* | *1737* | *2739* | *n.a.* |
| **Cellulosic biofuel** | Original mandate | 100 | 250 | 500 | 1000 | 1750 |
| | Updated mandate | **6.5** | **6.6** | **8.65** | **60** | **17** |
| | *achieved* | *0* | *0* | *0.02* | *0.82* | *n.a.* |

** 2010 RINs only from July till December*
*** 2014 targets proposed by EPA;*
*Figures in bold deviate from the original figures; achieved = total generated RINs*

## 2.2 Low Carbon Fuel Standard (LCFS) in California

The California Air Resources Board (CARB) has implemented the Low Carbon Fuel Standard (LCFS) which rates individual fuels based on their GHG reduction score and sets a target for the reduction of GHG emissions. The policy requires the fuel to be consumed within California, but the RINs associated with the fuel can still be used to comply with the nationwide RFS2. Renewable fuels can therefore be counted both towards the LCFS and RFS2 as long as the fuel is consumed within the state.

Under RFS2 threshold levels, there is no incentive to further improve the GHG reduction once the renewable fuel pathway exceeds the desired mandate. Under the LCFS, in theory, each improvement in the pathway would be accompanied by a larger GHG reduction score which would increase the value of the fuel in California.

## 2.3 VEETC and ethanol import tariff

The Volumetric Ethanol Excise Tax Credit (VEETC) was created by the American Jobs Creation Act of 2004. VEETC expired on December 31, 2011.
The tax credits included in VEETC were (Gruenspecht, 2013):

- 45-cents per gallon credit for blending ethanol in gasoline;
- 10-cents per gallon credit for small producers of ethanol.

On top, there was a 54 cent per gallon tariff on ethanol imports, initiated in 1980. According to the US government, as it made no sense to give incentives as tax credits to ethanol produced abroad – and it was not possible to verify the origin of blended ethanol - the benefit was compensate by the tariff on ethanol imports. This mechanism of ethanol import tariffs also expired end 2011. The import tariff on ethanol was waived for Caribbean nations. Much of the ethanol from the Caribbean region between 2005 and 2009 had its origin in Brazil.

## 3. Brazilian biofuel policy

Brazil is the world's second largest producer of ethanol fuel (after the US) and the world's largest exporter (although the US seems to catch up in the past years). It uses cheap sugarcane as feedstock; the residual cane-waste (bagasse) is used to produce heat and power, which results in a very competitive price and also a low fossil energy input and high greenhouse gas savings. It is therefore qualified as 'advanced biofuel' in the United States, also because it is recognized that emissions due to land use change (LUC and iLUC) for sugarcane ethanol are low.

In Brazil, ethanol is used in two ways: (1) as octane enhancer in gasoline, in the form of 18 to 25% anhydrous ethanol (minimum mandated by law), (2) as pure ethanol in neat-ethanol engines or flexible fuel vehicles (FFV), in the form of hydrated ethanol. Consumers with FFVs are able to use blender pumps when purchasing fuel and select the ethanol inclusion rate between the policy minimum and pure ethanol based on relative prices of ethanol and gasoline.

Since the establishment of the National Alcohol Program (Proálcool) in 1975 ethanol was promoted in Brazil through heavy market intervention including fixed pricing, obligatory purchases and tax reductions on ethanol and dedicated ethanol cars. Minimum blends were established for ethanol-gasoline blending.

Meanwhile, ethanol prices have been liberalized along with gasoline and sugar markets, although ethanol still maintained a (state dependent) tax advantage relative to gasoline. It is still required by law that all gasoline should be blended at 18 to 25 percent ethanol inclusion rates. The governments sets the minimum percentage of ethanol blend according to the results of the sugarcane harvest and the amounts of ethanol produced from sugarcane, resulting in blend variations, even within the same year (e.g. in April 2011 the minimum blend rate was reduced to 18%). The shift in supplies available for domestic consumption can occur either through production shortfalls or from increased trade demand.

# 4. Volumes and prices of ethanol traded between Brazil and the US

## 4.1 Ethanol production volumes in the US and Brazil

The US and Brazil are the main ethanol producers in the world. In the Brazilian production, four stages can be distinguished: (1) start-up from 1975 until 1984; (2) stabilization between 1984 and 2001; (3) growth from 2003 until 2008; (4) stabilization after 2008. The US caught up with Brazilian production in 2005 and has seen a tremendous growth until 2010. After 2010 volumes have more or less stabilized because of the cap on corn-based ethanol in the RFS2, as well as the approaching “blend wall” of E10.

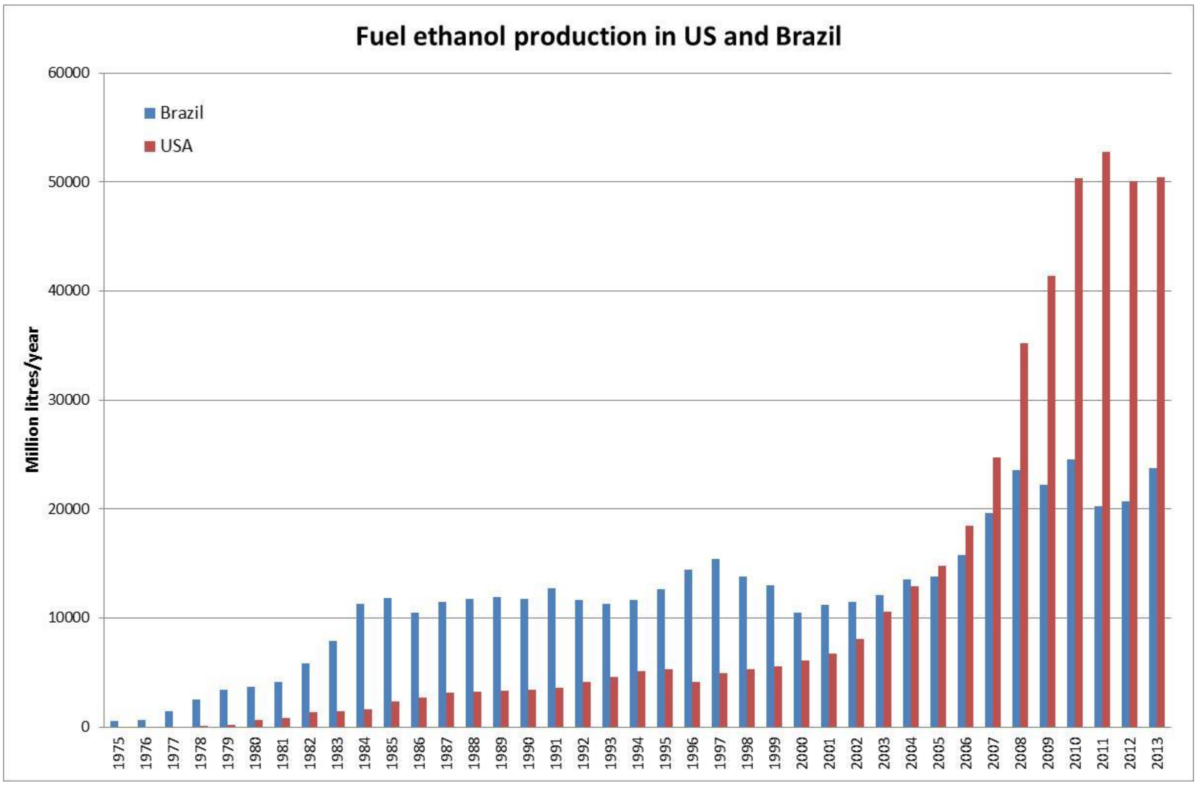



**Figure 2.** Fuel ethanol production volumes in Brazil and the US (data source: F.O.Licht’s & EIA)

## 4.2 Trade between the US and Brazil

In the past the US was a net importer of ethanol to fulfil the demand of its domestic ethanol market, most of it coming from Brazil and the Caribbean area (most of which is also Brazilian ethanol). However, since 2010 the US is a net exporter of ethanol, mainly to Canada, the EU, and in 2011 also a considerable amount to Brazil. Since 2011 we see the phenomenon that large volumes of sugarcane based ethanol are imported from Brazil, while also considerable amounts of corn based US ethanol are exported to Brazil.

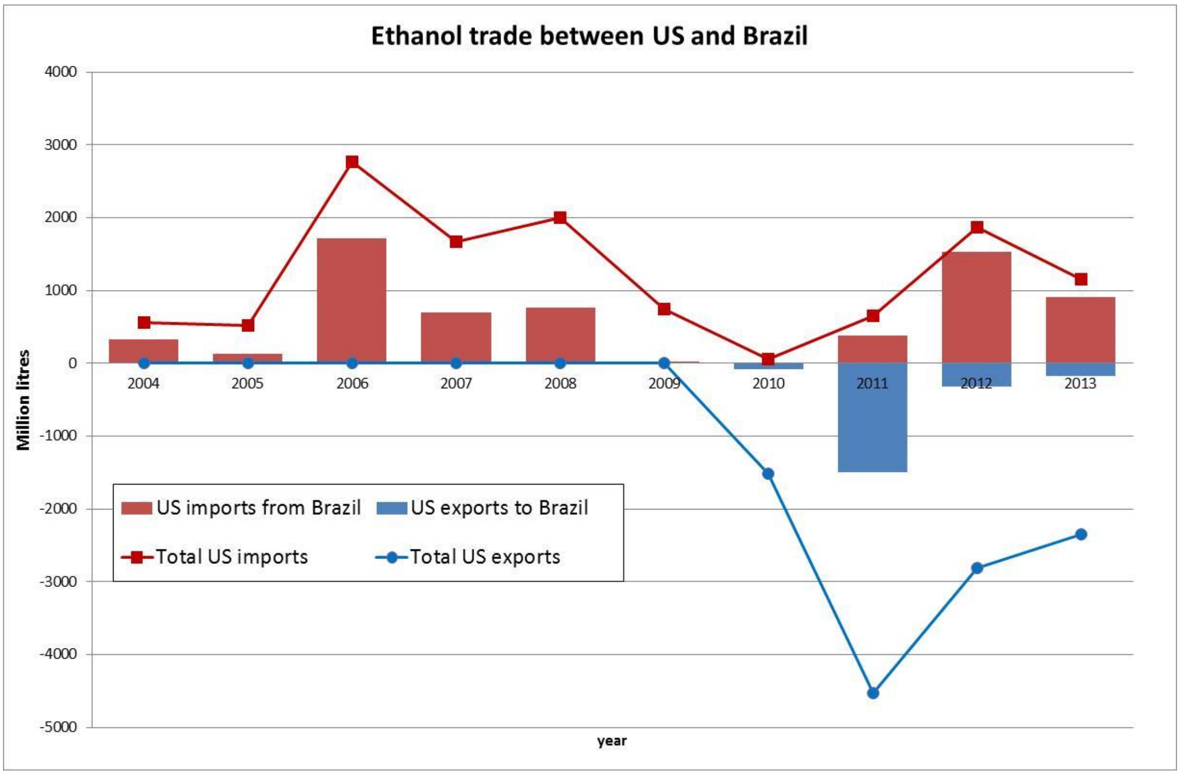



**Figure 4.** Ethanol imports and exports from the US, and trade with Brazil.
*Source of the data: EIA*

This new situation can also be seen on the following figure, displaying total ethanol imports and exports from Brazil. While in the 1990s Brazil relied heavily on imports to fulfil its domestic ethanol demand, this situation changed around 2000 and Brazil became the biggest ethanol exporter. Meanwhile, in the past years, exports have more or less stabilized between 2 and 3 billion litres, and in the past years there were even imports of ethanol to Brazil, most actually coming from the US. The question is if this was a one-time phenomenon, or that a trend of bilateral trade was triggered by policy.

There are various factors impacting this mutual trade between the US and Brazil:

- *Seasonal fluctuations*. Brazilian sugarcane harvest season is between March and November. Unlike corn, sugarcane cannot be stored because it goes bad after a couple of days, forcing mills to process the entire crop while harvesting.
- *Crop yields may vary year by year*. Typical examples are the low sugarcane yields in Brazil in 2011 and the draught in the US in 2012 leading to low corn yields. 2011 was a particular case with a low production in Brazil and the surplus in the US.
- *Crop prices* (maize, sugarcane) are related to world markets and may favor one or the other ethanol type.
- *Ethanol market in Brazil*: next to pure ethanol distribution, there is a mandated minimum ethanol blending in gasoline, 18-25%, so there is continuous demand for ethanol on the domestic market. The level may be adjusted according to harvest yields and actual ethanol production. In Brazil, the domestic market that is almost inflexible is the market for anhydrous ethanol (used of blending). In theory, because of FFVs, the market for hydrated ethanol is much more flexible.
- *RFS2 targets in the US*: the biofuel targets in the US make distinction between advanced and non-advanced biofuels, with separate targets (cap on corn based

ethanol, minimum target for advanced biofuels). The different biofuel types have different RIN prices.

- *Some changes in US policy*, e.g. the ethanol blending credit (0.45$/gallon), and the import tariff of 0.54$/gallon (0.14$/litre) for imported ethanol (waived for Caribbean), both expired end 2011.
- *EU market:* historically, trade flows (mostly exports from Brazil) were impacted by the European market. The amount exported from Brazil to Europe is relatively small, and the US took over this market in the past years.

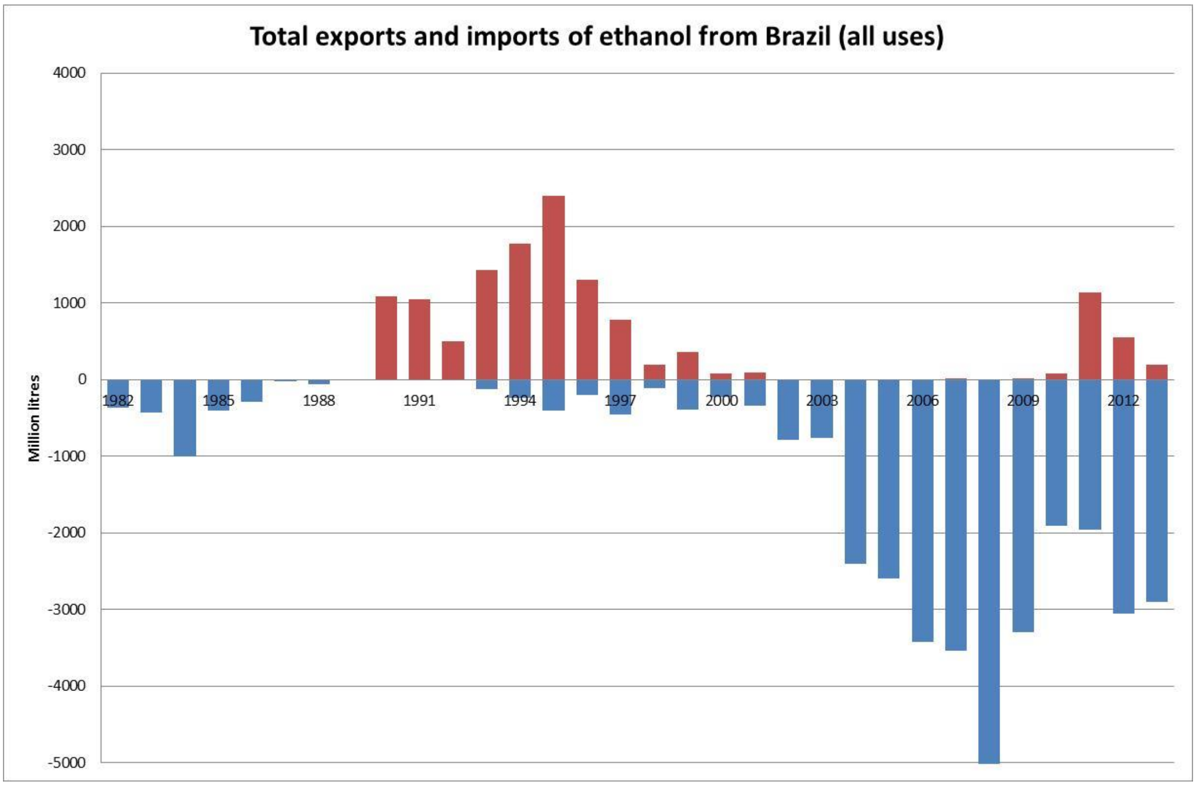



**Figure 3.** Total imports and exports of ethanol from Brazil.
*Source of the data: UNICA 2014, Macedo 2006*

## 4.3 Prices

The following figure shows the price evolutions of ethanol on the US domestic market (CBOT), and the ethanol exported from Brazil (FOB). Before 2009, Brazilian ethanol was considerably cheaper than US ethanol. Prices were comparable in 2009 and 2010 (leading to a disadvantage for Brazilian ethanol with the import tariff). In 2011 and 2012 prices for Brazilian ethanol were even higher than domestic US ethanol. The fact that Brazilian ethanol at that time was still imported to the US, despite that it was more expensive, is a clear sign that these trade flows were policy induced. In 2013, prices were comparable again, this time without import tariff, due to the recovery process in Brazil (e.g. more investments on sugarcane production).

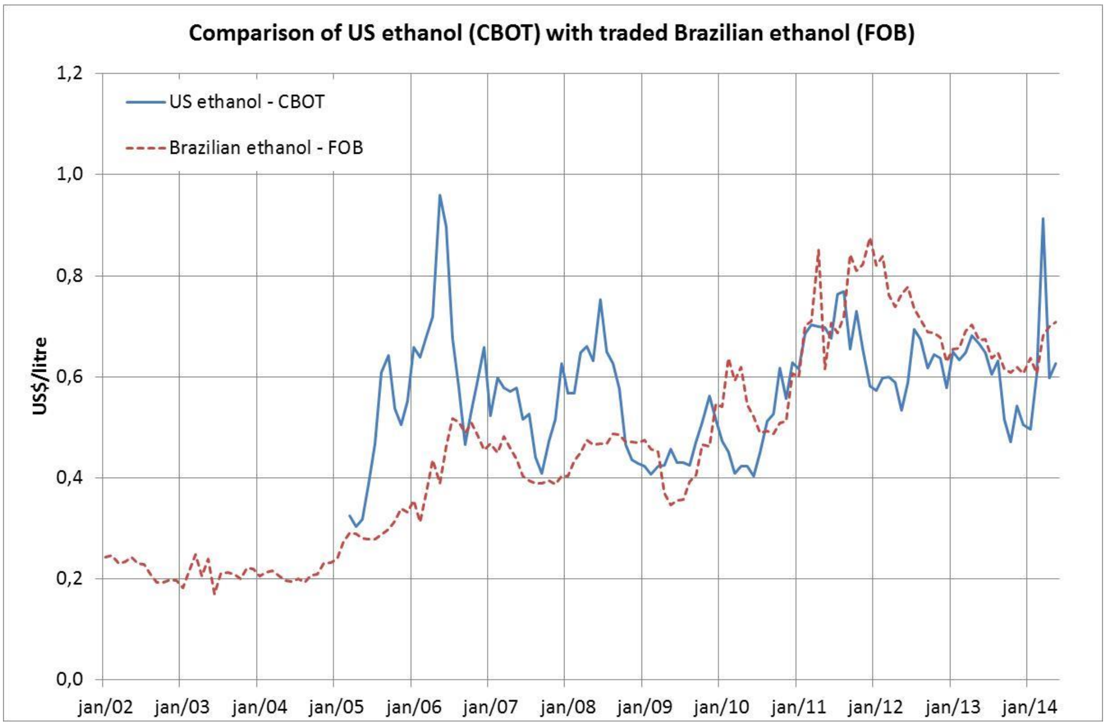



**Figure 4.** Evolution of US ethanol commodity prices (CBOT) and traded ethanol price from Brazil (FOB)
*Source of the data: US: TradingCharts.com (June 2014); Brazil: UNICA (June 2014)*

### 4.3.1 RIN (Renewable Identification Numbers)

The current mechanism in the US stimulates biofuels according to the RFS2, through Renewable Volume Obligations (RVO) and Renewable Identification Numbers (RIN), which are a kind of tradable certificates having a market price.

If RIN prices increase, blenders are encouraged to blend greater volumes of biofuels, based on their abilities to sell both the blended fuel and the separated RIN. If a biofuel is already economical to blend up to or above the level required by the RFS program, such as ethanol was from 2006 through much of 2012, one would expect the RIN price to be close to zero. When the biofuel is more costly than non-renewable fuels but is needed to meet RFS standards or must be blended in greater volumes to be economic, the RIN value should increase to a point at which firms will increase biofuel blending (see biodiesel RINs).

Before 2013, Renewable Identification Number (RIN) prices for corn ethanol, which can be used to meet only the overall target for biofuels under the Renewable Fuel Standard (RFS) program, had consistently ranged between $0.01 per gallon to $0.10 per gallon, and were substantially lower than biodiesel RIN prices, which can meet multiple targets. At the start of 2013, corn ethanol RIN prices began to increase sharply, reaching highs around $1.00 per gallon in early March and even higher in the summer of 2013. Since then, all RIN prices have stabilized again around 0.3 to 0.5 $/gallon. Ethanol RIN prices are now in the same order (or only slightly lower) than biodiesel and advanced fuel RIN prices.

The increase in the ethanol RIN price reflects the market's concern that the rising RFS-mandated volumes (released by EPA on 7 February 2013) and the E10 ethanol blend wall will contribute to future significant increases in the cost of blending biofuels to meet the RFS statutory volumes.

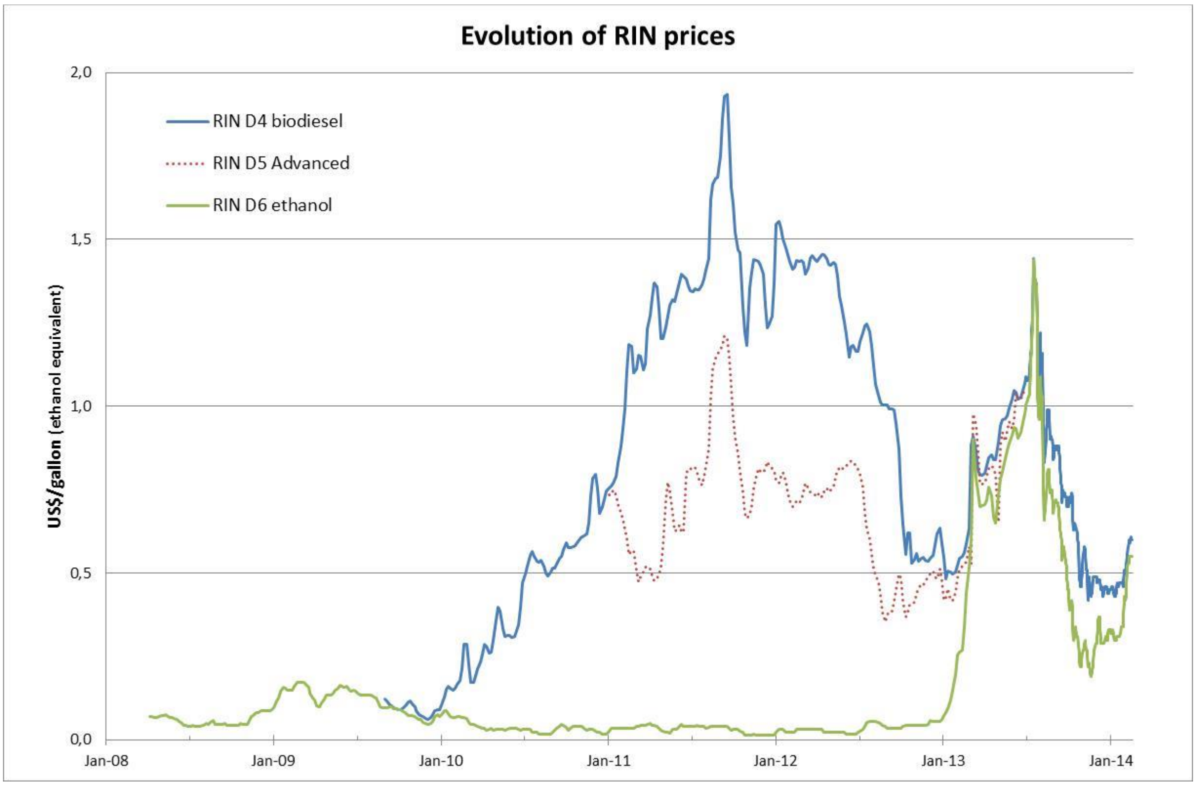



**Figure 5.** Evolution of RIN prices for corn ethanol (D6), biodiesel (D4) and advanced biofuels (D5)
*Source: OPIS, University of Illinois*

In the period 2011-2012 advanced biofuel RINs were pricing between 0.40 and 0.80 $/gallon, which was considerable higher than the RINs for corn ethanol. This created an extra incentive of 0.1 to 0.2 US$/litre, also for sugarcane ethanol which is qualified as advanced biofuel. From 2013, this RIN price difference more or less disappeared, although high fluctuations can be noticed.

# 5. Main conclusions

## 5.1 Critical issues and risks

***Incentives for technologically advanced biofuels in the RFS2 were insufficient for deploying these types of biofuels:*** Cellulosic biofuel targets in the RFS2 were very optimistic – at least in the short to medium term. From the start in 2010, cellulosic biofuel targets have been waived, down to less than 1% of original targets, and even those targets were not met on the market. In 2010-2013, the original 'advanced biofuel target' (of which cellulosic biofuels were part) remained as in the original RFS2, meaning that the gap needed to be filled by other advanced biofuels, i.e. biobased diesel and sugarcane ethanol. So the incentives for cellulosic biofuels do not seem to be sufficient, and have merely promoted more imports of Brazilian ethanol.

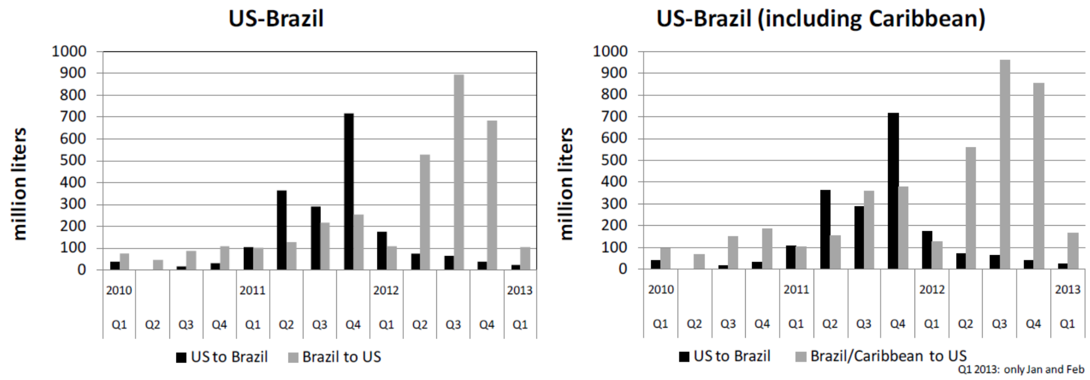
***E10 "blend wall" creating uncertainty in the fuel markets:*** Ethanol blending in gasoline in the US on average reaches between 9 to 10%, so in practice, the blend wall of 10% (E10) is reached. There are some efforts to further promote E85 (in flex-fuel vehicles), and also to extend the blend wall to E15 for released gasoline models (in principle this should be possible for a high share of the gasoline fleet). However, there are lots of concerns from vehicle manufacturers and fuel distributors, which also feed into the public. So the blend wall seems to be a practical barrier, which may impede further expansion of ethanol in the US fleet (corn based, sugarcane based, and in particular cellulose based ethanol due to higher production costs and market uncertainties). This creates uncertainty on how to fulfil the RFS mandates, with higher expected costs, and creates fluctuations in the price of RINs. This in its turn creates instability on biofuel markets.

***Volatility of RIN markets:*** RIN prices have proven to be very volatile (see Figure 5), which makes it difficult to reach a solid business case for new advanced biofuels (other than commercial ones like sugarcane ethanol or biobased diesel). The uncertainty of the blend wall is an extra barrier for cellulosic ethanol.

***Cap on corn ethanol creates exports:*** The RFS2 caps the amount of 'non-advanced biofuels' (i.e. corn ethanol). With production capacity higher than this cap, the US has now become a net exporter of ethanol, with the main partners being Canada, the EU, some Asian countries, but also Brazil in the past 3 years. So in practice, the US is importing sugarcane ethanol to fulfil its advanced biofuel targets, while it exports an excess of corn ethanol.

***Intra-trade between Brazil and the US:*** At a certain stage (in 2011), there was a high intra-trade between the US and Brazil: the US was importing sugarcane ethanol from Brazil to fulfil its advanced biofuel targets; meanwhile Brazil was falling short of ethanol because of lower sugarcane harvests. Two consequences resulted from this: Brazilian authorities reduced the general blending mandate from 25% to 18% in April 2011, and on the other hand Brazil started to import corn ethanol from the US. This created an intra-industry trade of physically identical but policy differentiated biofuels. This intra-trade of physically identical ethanol incurs additional transportation, adding costs and releasing additional GHG emissions, and therefore moderating some of the anticipated advantages of (advanced) biofuel use. Moreover, substituting Brazilian ethanol (in Brazil) with corn ethanol (having lower greenhouse gas performance) creates a carbon leakage in Brazil. When quantifying the combined effects, through the intra-trade of 2011, around 80-90% of the GHG advantage for sugarcane ethanol was lost, in 2012-2013, this effect amounted to around 20%

of the GHG advantage. So there is a clear '*carbon leakage*' effect in this phenomenon which needs to be taken into account.




*Source: Global Trade Information Services (GTIS)*

**Figure 6.** Quarterly bilateral ethanol trade between Brazil and the US in 2011-2013, with and without exports through the Caribbean countries
*Source: Meyer, 2013, based on GTIS data*

***Impact on Brazilian ethanol prices:*** The intra-trade drives up ethanol prices in Brazil (see also Figure 4), the extent of which depends critically on the size of domestic supplies relative to Brazil's own blending mandate and where domestic demand sits relative to that mandate. Exports typically represent 10% of Brazilian ethanol production. In 2011 and 2012, Brazilian ethanol (FOB) was more expensive than US corn ethanol – still imports were attractive because import tariffs have been removed and there were quite high RINs for advanced biofuels to compensate for higher costs. Meanwhile, the situation has more or less stabilized and US ethanol exports to Brazil have been largely reduced (while imports of Brazilian ethanol to the US are still important). Prices of Brazilian ethanol have stayed in the higher end and are now in the same range as US ethanol. The main reason is that US markets are now completely open for Brazilian imports since import tariffs has been removed, but also the advantage of higher RINs for advanced biofuels has more or less gone away since 2013.

## 5.2 Impact of promotion mechanisms

The main promotion mechanism for advanced biofuels in the US are the RFS mandates, implemented through Volume Obligations for fuel supplies and tradable certificates (RINs), which have a certain market value. There are specific separate targets for advanced biofuels, and subtargets for biobased diesel and cellulosic biofuels.

The growth of cellulosic biofuels has clearly stayed below expectations, and in the past 4 years, the subtarget for cellulosic biofuels was consistently reduced by EPA. The question is whether current promotion mechanisms are the right ones to stimulate further growth of technologically challenging cellulosic biofuels. Meanwhile, imports of Brazilian sugarcane ethanol (recognised as advanced biofuel by US authorities) have partly compensated for the underperformance of cellulosic biofuels.

There is a consistent import of Brazilian sugarcane ethanol to the US, being one of the cheapest ways to fulfil the advanced biofuels mandate, and with the current RFS system (and the abolishment of import tariffs on Brazilian ethanol) this seems to remain.

In normal seasons, Brazil is able to export about 2 to 3 Billion litres per year to the US. For these volumes, the domestic prices will not increase a lot. But Brazil will not be able to export much more than that, in short-term, at low prices.

In periods when Brazil is struggling with low sugarcane yields (as was the case in 2011), when in fact they only have sufficient volume to cover the domestic ethanol market, the import demand from the US market may lead to intra-trade (also shipping ethanol back from the US to Brazil) and lower blending mandates in Brazil. Ultimately, this has a large impact on greenhouse gas emissions (carbon leakage), and on prices.

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