OECD-FAO Agricultural Outlook 2012

Chapter 3

Biofuels

Biofuels were added to the *Outlook* in 2008 as an emerging sector that would increasingly affect agricultural markets. This has certainly turned out to be the case with currently some 65% of EU vegetable oil, 50% of Brazilian sugarcane, and about 40% of US corn production being used as feedstock for biofuel production. Today, it would be inconceivable to prepare an agricultural projection without taking biofuels into account. The biofuels chapter has been expanded this year to provide a more detailed description of the very complex US biofuel policy and an analysis of the policy options facing the US Environmental Protection Agency over the medium term.

Market situation

World ethanol prices (Figure 3.1) increased strongly in 2011 well above the levels of the 2007/08 highs in a context of strong energy prices, although the commodity prices of ethanol feedstock, mainly sugar and maize, decreased from their peaks in 2010. The two major factors behind this increase were the stagnating ethanol supply in the United States and a drop in Brazilian sugarcane production. Additionally, ethanol production was also significantly below expectations in developing countries having implemented mandates or ambitious targets for the use of biofuels.

World biodiesel prices (Figure 3.1) also increased in 2011. Contrary to the global ethanol market, production did not stagnate in 2011; the four major biodiesel producing regions (the European Union, the United States, Argentina, and Brazil) increased their supply compared to 2010. This increase was moderated by a decreasing biodiesel production in Malaysia (from about 1 Bnl in 2010 to almost nothing in 2011).

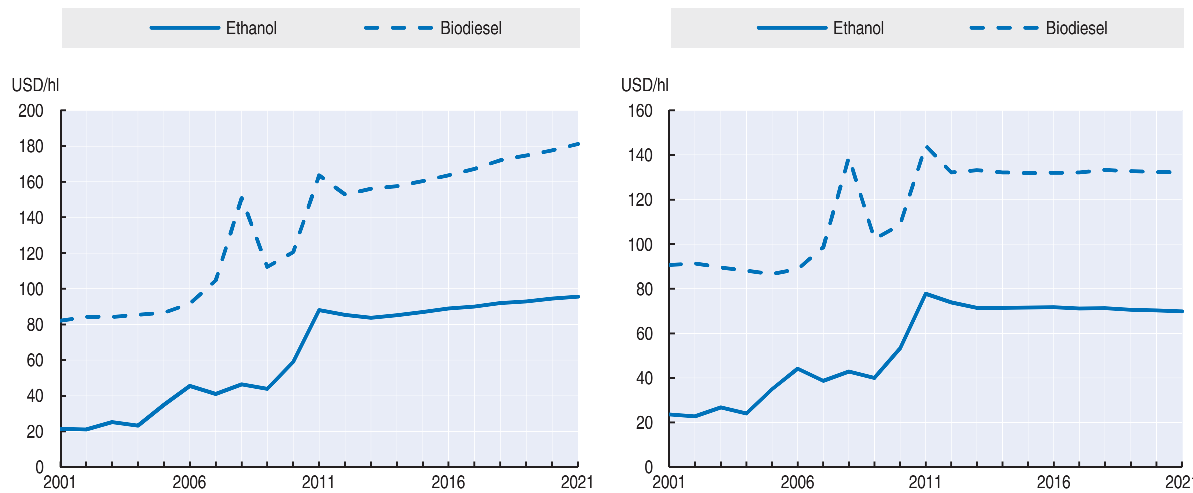
Projection highlights

- Over the projection period, ethanol and biodiesel prices are expected to remain supported by high crude oil prices and by the implementation and continuation of policies promoting biofuel use. Changes in the implementation of biofuel policies can strongly affect biofuel markets.
- Global ethanol and biodiesel production are projected to expand but at a slower pace than in the past. Ethanol markets are dominated by the United States, Brazil and to a smaller extent the European Union. Biodiesel markets will likely remain dominated by the European Union and followed by the United States, Argentina and Brazil.
- Biofuel production in many developing countries is projected to remain below expressed targets as the cultivation of non-edible crops to produce biofuels remains, in most cases, on a project or small-scale level and high prices of agricultural commodities do not encourage their use as biofuel feedstock.

- Biofuel trade is anticipated to grow significantly, driven by differential policies among major producing and consuming countries. The United States, Brazil and the European Union policies all "score" fuels differently for meeting their respective policies. This differentiation is likely to lead to additional renewable fuel trade as product is moved to its highest value market, resulting in potential cross trade of ethanol and biodiesel.

Figure 3.1. **Strong ethanol and biodiesel prices over the outlook period**

Evolution of prices expressed in nominal terms (left) and in real terms (right)



Notes: Ethanol: Brazil, Sao Paulo (ex-distillery), Biodiesel: Producer price Germany net of biodiesel tariff.

Source: OECD and FAO Secretariats.

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Market trends and prospects

Prices

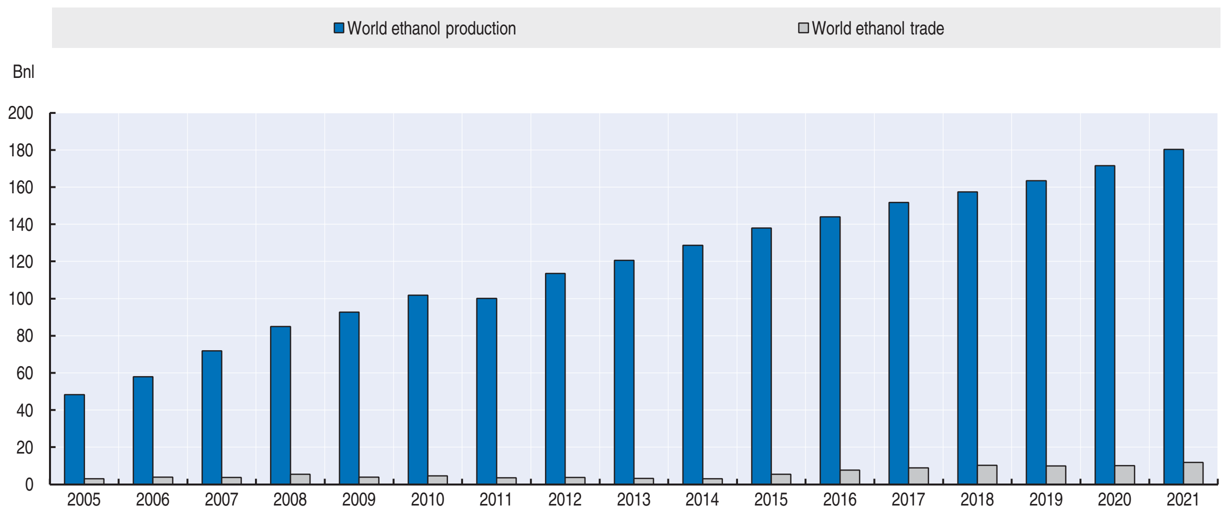
World ethanol prices[1] increased strongly in 2011, well above the levels of the previous 2007/08 highs. In 2012, a slight drop is projected but the price is expected to stay constant in real terms after 2013 following the price paths of the two major feedstocks maize and sugar (Figure 3.1). However, ethanol prices are not expected to increase as much as the crude oil price is assumed to over the projection period to reflect recent trends of the ethanol to crude oil price ratio.

World biodiesel prices[2] have increased in 2011 as well in a context of rising vegetable oil prices and high crude oil prices. This increase was smaller than for the world ethanol price because biodiesel production did not stagnate in 2011. Comparable to ethanol prices, biodiesel prices are projected to decrease slightly until 2013 and stay constant in real terms thereafter; this is in line with major biofuel feedstock prices.

Production and use of biofuels

Global ethanol production is projected to almost double over the projection period when compared to the 2009-11 base period and to reach some 180 Bnl by 2021 (Figure 3.2). The three major producers are expected to remain the United States, Brazil and the European Union. Production and use in the United States and the European Union are mainly driven by the policies in place, namely the US Renewable Fuel Standard (RFS2) final rule and the EU Renewable Energy Directive (RED). The growing use of ethanol in Brazil is linked to the development of the flex-fuel vehicle industry and the import demand of the United States to fill the advanced biofuel mandate. In the developing world, China should remain the main producer and user of ethanol with a production of 8 Bnl in 2011, projected to increase to 10 Bnl by 2021 (most of it is projected to be used for non-fuel applications), followed by India (4.2 Bnl in 2021).

Figure 3.2. **Development of the world ethanol market**



Source: OECD and FAO Secretariats.

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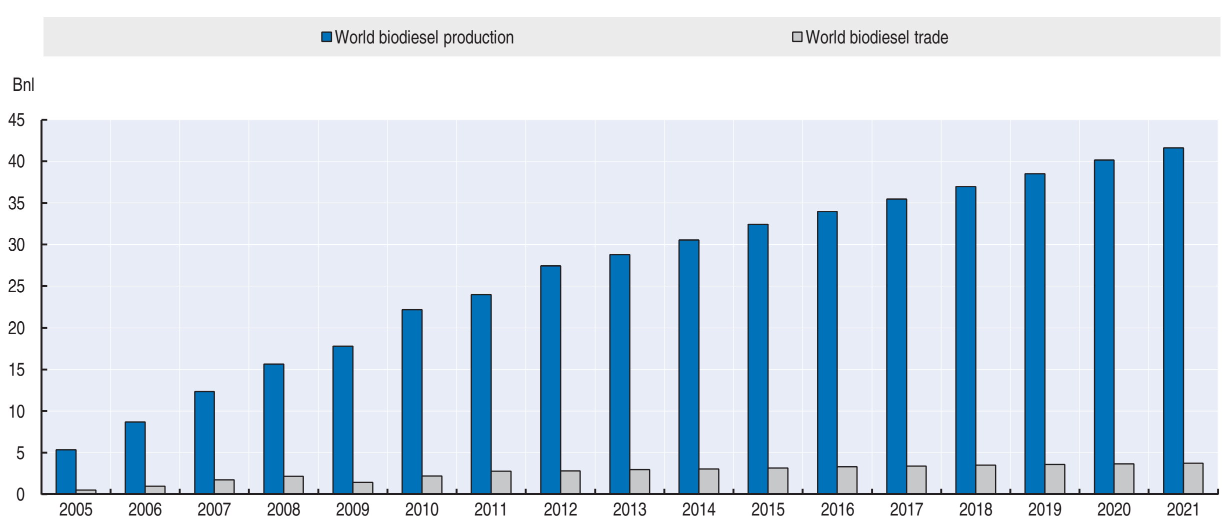
Global biodiesel production is expected to increase to above 42 Bnl by 2021 (Figure 3.3). The European Union is expected to be by far the largest producer and user of biodiesel. Other significant players are Argentina, the United States, Brazil, as well as Thailand and Indonesia.

Figure 3.3. **Development of the world biodiesel market**



Source: OECD and FAO Secretariats.

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To put in perspective the use of biofuel in total transport fuel use, Table 3.1 presents the projections for total transport and biofuel use both in energy and volume terms for a certain number of countries.

Table 3.1. **Transport fuel use in major biofuel producing countries**

		2009-2011			2021		
		Total	*Of which:* biofuel	Share of biofuel %	Total	*Of which:* biofuel	Share of biofuel %
Energy basis (1000toe)	Argentina						
	Gasoline type	3.5	0.1	2.7	4.1	0.1	3.4
	Diesel type	9	0.3	3.2	11	0.4	4.0
	Australia						
	Gasoline type	15	0.2	1.3	947	0.3	1.5
	Diesel type	16	0.5	3.1	18	0.5	3.1
	Brazil						
	Gasoline type	23	11.0	47.0	29	18.9	64.2
	Diesel type	40	1.6	4.0	54	2.4	4.6
	Canada						
	Gasoline type	30	0.8	2.6	32	1.1	3.4
	Diesel type	26	0.1	0.7	28	0.4	1.6
	China						
	Gasoline type	61	1.1	1.8	104	1.4	1.3
	EU						
	Gasoline type	103	2.8	2.7	103	8.6	8.3
	Diesel type	189	9.4	5.1	200	16.7	8.5
	USA						
	Gasoline type	409	21.9	5.4	412	45.0	10.9
	Diesel type	215	1.9	0.9	249	3.8	1.5
Volume basis (bnl)	Argentina						
	Gasoline type	4.7	0.2	4.0	5.4	0.3	5.0
	Diesel type	11	0.4	4.0	13	0.6	5.0
	Australia						
	Gasoline type	20	0.4	1.9	23	0.5	0.0
	Diesel type	19	0.6	3.9	22	0.7	3.8
	Brazil						
	Gasoline type	31	21.7	57.0	39	37.4	72.9
	Diesel type	48	2.1	5.0	64	3.2	5.7
	Canada						
	Gasoline type	40	1.6	3.8	42	2.1	5.0
	Diesel type	31	0.2	0.8	33	0.6	2.0
	China						
	Gasoline type	81	2.2	2.7	137	2.7	2.0
	EU						
	Gasoline type	137	5.5	4.0	136	16.9	12.0
	Diesel type	225	12.5	6.3	239	22.0	10.4
	USA						
	Gasoline type	541	43.4	7.8	545	89.1	15.5
	Diesel type	257	2.5	1.1	298	5.0	1.9

Source: OECD and FAO Secretariats.

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Developed countries

With a global production share of about 50% in 2011, the United States is currently the biggest ethanol producer. The development of US biofuel markets has taken off since the enactment of the Energy Independence and Security Act of 2007 (EISA).[3] The implementation of this policy is made by the Environmental Protection Agency (EPA) through annual rules setting the levels for different fuel types. The Annex of the biofuel chapter provides a detailed description of US biofuel policies and, in particular, of the nested structure of quantitative minimums in place. An analysis of different implementation options is provided in the last section of the chapter. Current technological developments seem to suggest that the cellulosic biofuel mandate as it is currently regulated by the EPA is unlikely to be met by 2022.

It was assumed in the baseline that the production of cellulosic ethanol would rise steadily over the course of the outlook period to reach 16 Bnl by 2021, *i.e.* only about 30% of the cellulosic biofuel mandate.[4] EPA announcements for 2012 are incorporated in the baseline projections. For 2013 and remaining years of the projection period, the assumptions were made that the conventional ethanol gap would stay at the quantities in the legislation and that the other advanced gap could not shrink from year to year following the shortfall in cellulosic biofuels, *i.e.* that the total and advanced mandates would be reduced in parallel.[5]

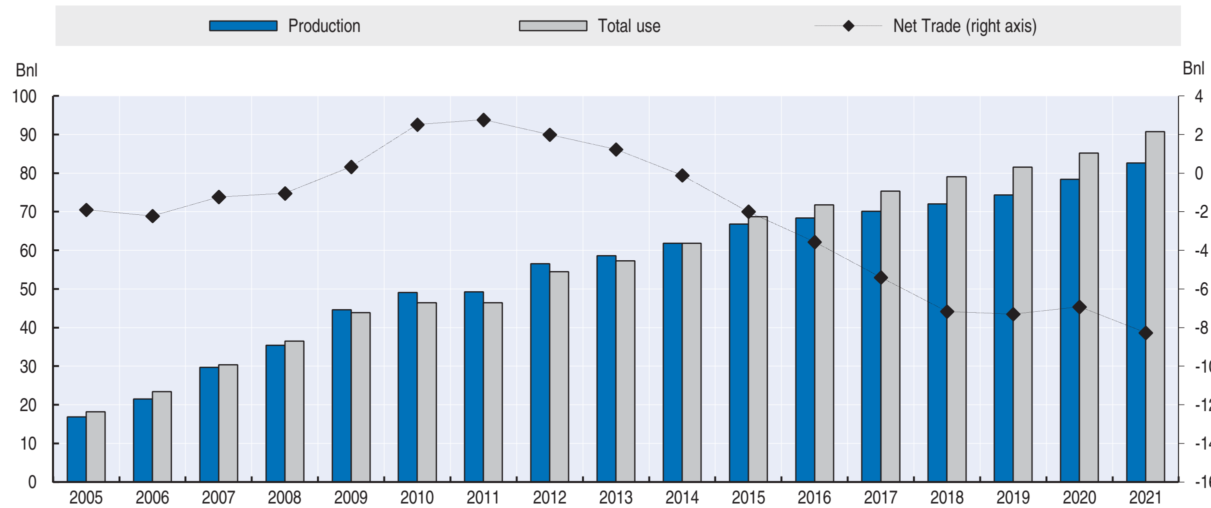
This adjusted total US biofuel mandate would amount to 96 Bnl in 2021. As the total biofuel mandate is projected to be binding throughout the projection period, ethanol use in the US is projected to follow the path of this mandate when subtracting the biodiesel mandate and reaches almost 90 Bnl (Figure 3.4). However, because of the high crude oil price, conventional ethanol production mostly based on coarse grains would be above the conventional gap.[6] Concerning the blend wall,[7] the EPA provided a decision in January 2011 to expand the ethanol blending percentage in regular gasoline from 10% to 15% expressed in a volume share for cars built in 2001 or later. At present, gasoline retailers are not ready to propose different types of gasoline to their customers because of logistics, warranties on motors as well as liability issues. It is assumed in the baseline projection that this issue will be resolved allowing cars built before 2001 to gradually disappear from the roads so that the full use of the 15% blend fuel would be reached at the end of the projection period. The assumed effective blend wall would be reached by 2017.[8] To meet the mandates, a slight expansion of the fleet of flex fuel vehicles is expected towards the end of the projection period.

The mandate for biodiesel defined in the RFS2 is extended from 3.8 Bnl to 4.8 Bnl to be used by 2012, driving the initial growth in US biodiesel use. Biodiesel production from tallow or other animal fat is expected to represent an important share of US biodiesel production. Because of relatively high ethanol Renewable Identification Numbers (RIN) prices, biodiesel production is expected to surpass the biodiesel mandate to reach 5 Bnl in 2021.

The RED[9] of the European Union requires that renewable fuels should increase to 10% of total transport fuel use by 2020. The RED allows for substitution with other renewable sources including electric cars. In that context, when adding together the energy content of ethanol and biodiesel, the *Outlook* assumes that only a 9.5%[10] share of renewable fuels can be reached by 2021.

In that context, fuel ethanol production mainly from wheat, coarse grains and sugar beet is projected to reach 16 Bnl in 2021 and ethanol fuel consumption amounts to an

Figure 3.4. **Projected development of the US ethanol market**



Source: OECD and FAO Secretariats.

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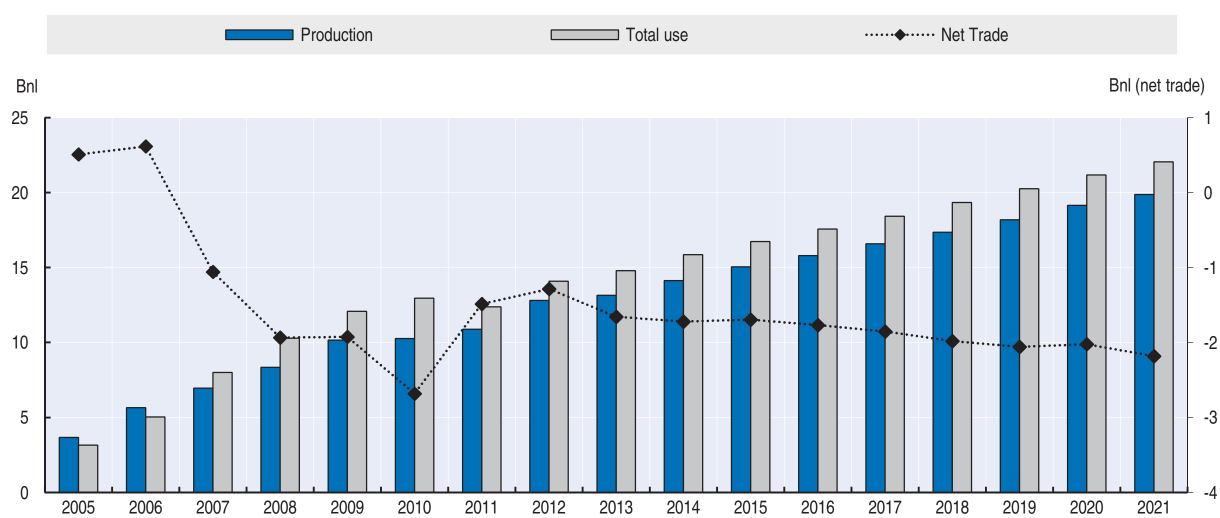
average share of 8.3% in gasoline type transport fuels. Second generation ethanol is not assumed to play a major role throughout the projection period. Stimulated by mandates and tax reductions in European Member States, total biodiesel use is projected to reach 22 Bnl by 2021 (Figure 3.5) representing an average share of biodiesel in diesel type fuels of 8.5%. Domestic biodiesel production should increase to keep pace with demand. Second generation biodiesel production is assumed to reach about 4 Bnl in 2021.

Figure 3.5. **Projected development of the European biodiesel market**



Source: OECD and FAO Secretariats.

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Canadian mandates require an ethanol share of 5% in gasoline type fuel use and a biodiesel share of 2% in diesel type fuel and heating oil use, both expressed in volume terms. Both mandates are projected to be filled; ethanol and biodiesel uses should grow in line with gasoline and diesel consumption. In Australia, the ethanol and biodiesel shares respectively in gasoline and diesel type fuel use are expected to remain almost unchanged over the projection period mostly driven by policies in place in two states (New South Wales and Queensland).

Developing countries

Within the last few years, several developing countries have implemented ambitious biofuel targets or even mandates. Their motivations are based mainly on two aspects: achieving a high level of energy supply security and/or independence and increasing domestic value added. However, the fuel production from promising feedstock such as jatropha or cassava are currently still on a project or small-scale level, far below the envisaged production levels. Rising biofuel feedstock prices provide strong incentives for exportation of agricultural raw products. This hampers the development of a domestic biofuel industry significantly; additionally, limited resources restrict the ability of governments to implement policies by supporting domestic production and use of biofuels through financial incentives. Subsequently the fill-rates of mandates and targets in several developing countries remain low.

Countries which already have a high potential for sugarcane and molasses production, such as India, Thailand, Colombia and the Philippines, or vegetable oil production such as Malaysia, Indonesia and Thailand, are expected to produce and use more ethanol and biodiesel over the projection period. However, it is very likely that, except for Brazil and Argentina, biofuel use in developing countries remains significantly below the targets/ mandates and an export oriented biofuel industry does not develop anywhere.

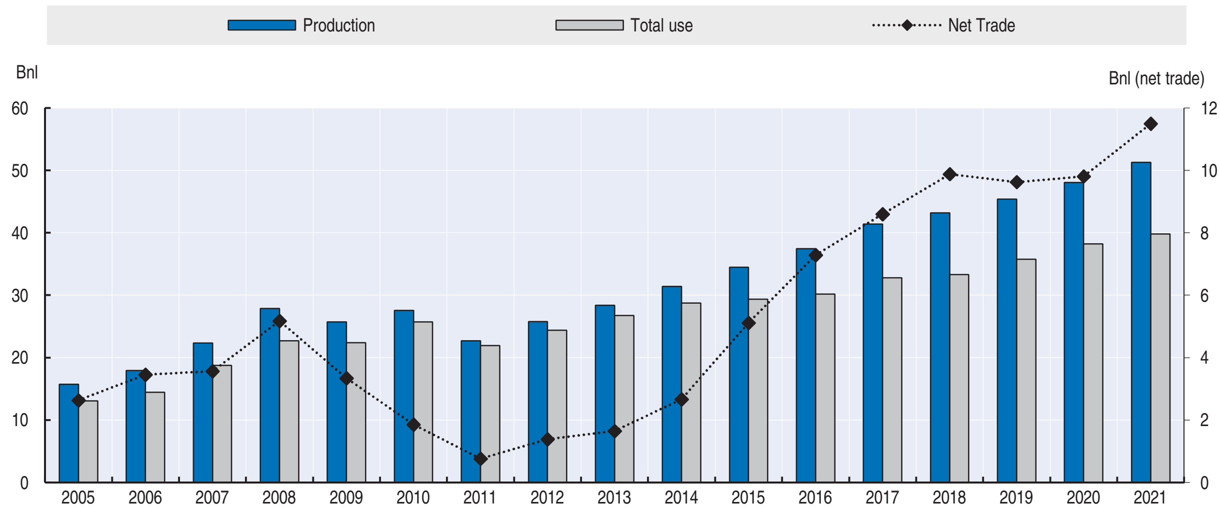
Brazil is projected to be the second largest ethanol producer. Brazilian ethanol derived from sugarcane should reach 51 Bnl and represent 28% of global ethanol production in 2021. One characteristic of the Brazilian ethanol industry is that it is very flexible. The sugarcane industry can quickly switch between sugar and ethanol production. Domestic ethanol demand is driven by the relative price ratios between ethanol and gasoline and between sugar and ethanol. It shifts with the growth of the flex-fuel vehicles fleet as well as the percentage of ethanol blended into gasoline. Brazilian ethanol domestic use is expected to increase over the projection period to reach 40 Bnl in 2021 (Figure 3.6). This growth is mainly driven by the growing fleet of flexi-fuel vehicles.[11]

Argentina has a biodiesel domestic use target (7% in volume share). However, most of its biodiesel production is planned to be exported due to the incentives offered by the differential export tax system. It will be the largest biodiesel producer in the developing world (4.2 Bnl in 2021). Driven by a domestic biodiesel consumption mandate, biodiesel production in Brazil should reach 3.2 Bnl.

Trade in ethanol and biodiesel

Global ethanol trade is set to increase strongly. While international trade represented on average about 4% of global production in the previous decade, the outlook projects it to increase to about 7% by 2021 (4.5 Bnl to 12 Bnl). Most of this increase is due to ethanol trade between Brazil and the United States. In 2021, the United States is expected to import about 16 Bnl of sugarcane based ethanol from Brazil which is assumed to be the cheapest alternative to fill the advanced biofuel mandate.[12] At the same time Brazil is projected to import 7.5 Bnl corn based ethanol from the United States to satisfy the flexfuel demand. Despite some tariffs, the European Union should increase imports by 2 Bnl of ethanol over

Figure 3.6. **Projected development of the Brazilian ethanol market**



Source: OECD and FAO Secretariats.

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the projection period while some countries like Thailand, Pakistan or South Africa increase their export supply only marginally. Recently, the two major palm oil producers, Indonesia and Malaysia have developed flexible refining capacities that enable them to quickly switch to biodiesel production for export once the relative prices become favourable. Yet given the expected price ratio in the coming decade, biodiesel trade is projected to increase only slightly with Argentina remaining the major exporter due to its differential export tax system.

Feedstocks used to produce biofuels

Coarse grains are projected to remain the dominating ethanol feedstock but the share of coarse grains based ethanol production in global ethanol production is projected to 44% by 2021. By then, 14% of global coarse grain production should be used to produce ethanol by 2021. The sugarcane based ethanol share in global ethanol production should increase from 23% in 2009-11 to 28% in 2021. By 2021, 34% of global sugarcane production is expected to be used for ethanol production. While the share of ethanol produced from wheat and molasses should decrease, cellulosic ethanol is projected to take a global share of almost 9.5% – almost all stemming from production in the United States.

The share of biodiesel produced from vegetable oil in global biodiesel production is expected to decrease by 10% over the projection period down to 70%. Sixteen per cent of global vegetable oil production should be used to produce biodiesel by 2021. Second generation biodiesel production is projected to increase slightly over the projection period, mainly coming from the European Union.

Main issues and uncertainties

Global issues

The development of biofuel markets over the past few years has been strongly related to the level of crude oil prices, biofuel policy packages in place, and the macroeconomic environment. This *Outlook* is marked by the assumption of strong energy prices which favour the development of biofuels. A scenario on the effect of a lower crude oil price is presented in the Overview. It shows that if the crude oil price was lower by 25% on average over the projection period, the world ethanol price would be on average 12% lower and the world biodiesel price would be 5% lower on average.

The first generation of biofuels produced from agricultural feedstocks could be progressively replaced in the future by advanced biofuels produced from lignocellulosic biomass, waste material or other non-food feedstocks. The pace of this transition will depend on profitability expectations determining industry investment decisions and private R&D research and development efforts as well as on the biofuel policy framework which determines public spending and provides guidelines for the private sector. This *Outlook* remains very cautious on the medium-term potential of second generation biofuels. No specific assumptions have been made on the development of other advanced biofuels including drop-in fuels[13] such as bio-butanol. The conversion of some ethanol facilities in Brazil and the United States into bio-butanol facilities is currently in the pipeline, although potential associated environmental and safety problems still need to be resolved. Important investments are currently being made on these advanced biofuels, especially in the defence sector. Advancements should be monitored as they could displace many of the projected paths presented in this *Outlook*.

The sustainability criteria embedded in the US and European biofuel policies are expected to increasingly affect biofuel markets. In the coming years, biofuel producers will have to comply with GHG emission targets. This could limit the availability of imported biofuels or biofuel feedstock. Given the steadily increasing amount of agricultural commodities used as biofuel feedstocks it is expected that regulations set forth by biofuel policies will shape not only biofuel markets but all agricultural commodity markets.

The rest of this section presents a quantitative analysis of the uncertainties around the implementation of US biofuel policies. It is complemented by a description of US biofuel policies presented in the Annex of the chapter.

Implementation of US biofuel policies

Baseline assumptions concerning the implementation of US biofuel policies can be challenged as implementation possibilities open to the EPA are numerous. Until now, the yearly decisions taken by EPA did not have important impacts on agricultural and biofuel markets because the level of the cellulosic ethanol shortfall was small. But by 2021, the end of this *Outlook*, the amounts will be much larger and EPA's decision will likely have impacts on agricultural markets. This section identifies the effect of three alternative implementation options (as described in Annex 3.A1):

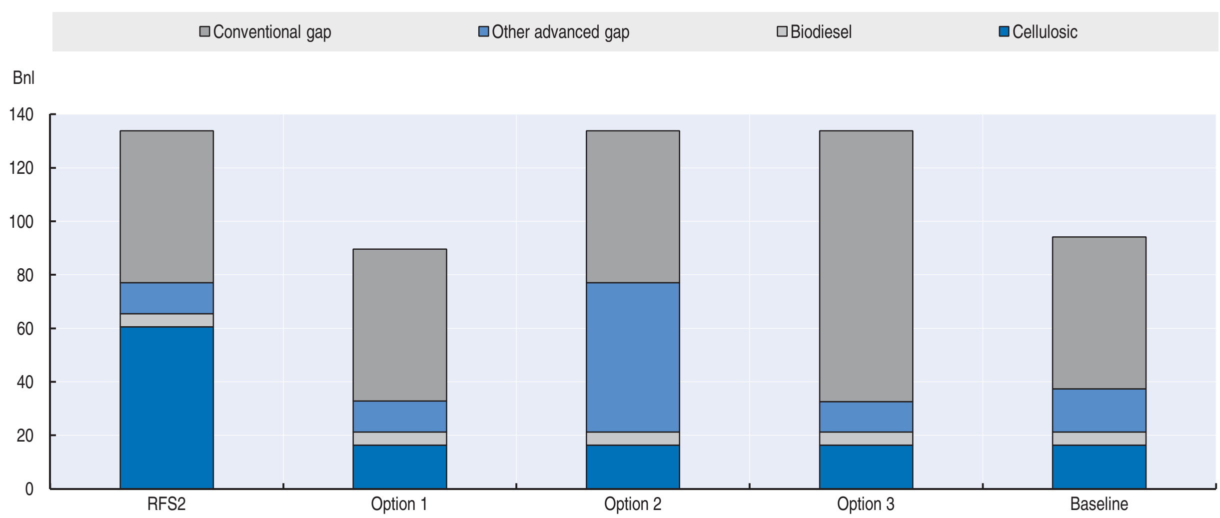
- *Option 1:* Lower the total and advanced mandates by the shortfall in the cellulosic mandate; EPA has not so far chosen this option which could seem to be the "simplistic" one.
- *Option 2:* Maintain both the advanced and total mandates, *i.e.* increase the other advanced gap. This is the option that has been chosen by the EPA. This scenario provides some insights regarding the sustainability of such an implementation option, especially when focusing on the interactions between US and Brazilian ethanol markets.
- *Option 3:* Maintain the total mandate and lower the advanced mandate by the shortfall in cellulosic production, *i.e.* increase the conventional gap. Maize based ethanol production is expected to exceed the conventional ethanol gap in baseline projections especially in

the latter years of the projection period when the conventional gap cannot exceed 56.8 Bnl. This scenario highlights the effects on international markets of the nested structure of US biofuel mandates.

The assumptions regarding the implementation of US biofuel policy in the baseline and in the three envisaged scenarios for 2021 are summarised in Figure 3.7. Scenarios were conducted after the completion of the revision of the US biofuel module of the AGLINK-COSIMO model, which captures the complex interplay of the different mandates, a simplified market of Renewable Identification Numbers (RINs) as well as the possibility to transfer these RINS between two years (*i.e.* roll-over). Scenario results are presented in Table 3.A2.1.

The decision taken by EPA will not be reflected fully by any of the scenario options. Those scenarios have been produced to illustrate the policy space, not to promote any particular policy option. This analysis focuses in different sub-sections on the impacts of the scenarios in comparison to baseline projections on ethanol markets (United States, Brazilian, European and global), on biodiesel markets and on agricultural markets. The last section provides key conclusions.

Figure 3.7. **Structure of US biofuel mandates in the law (RFS2), the baseline and the 3 options for 2021**



Source: OECD and FAO Secretariats.

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Impacts on US ethanol market

This section illustrates the key impacts in terms of supply, use, net trade and prices of the three implementation options on the US ethanol market. Results are summarised in Figure 3.A2.1. The three scenario options underline the fact that the US ethanol market – on the supply side as well as on the demand side – can adjust relatively easily to policy changes and to world price variations. On the demand side, the blend wall issue[14] is a major constraint for further expansion in ethanol use. An increase in the size of the flex-fuel vehicles is expected to be the most plausible outcome if the total mandate was to remain at the level defined in EISA towards the end of the projection period.

Option 1

With this implementation option, the total and advanced mandates are lowered by the shortfall in meeting the cellulosic ethanol mandate which keeps the conventional ethanol and other advanced fuel gaps unchanged from original levels. In 2021 the need for ethanol imports from Brazil to meet the other advanced gap is 30% lower than in the baseline, which leads to a 2% decrease of the world ethanol price. United States conventional ethanol production is projected to still exceed the conventional gap, but to be reduced by 1% in 2021 when compared to the baseline, in line with the reduction of the ethanol producer price. Option 1 leads to lower percentages of ethanol blended into regular gasoline: the blend wall is not achieved in any year of the projection period and consequently there is no need to expand the fleet of flex-fuel vehicles.

Option 2

In this case, EPA would maintain both the advanced and total mandate. This would result in the widening of the other advanced gap and in an important increase of advanced ethanol imports, *i.e.* imports of sugarcane based ethanol from Brazil. Those would reach 51 Bnl in 2021, compared to 16 Bnl in the baseline. This additional demand for advanced biofuels on world markets triggers a 17% higher world ethanol price in 2021 when compared to the baseline which is transmitted in part to the US ethanol producer price. In 2021, conventional ethanol production is expected to exceed baseline levels by 10%; this additional production would be largely exported to Brazil (see next section). On the demand side, Option 2 leads to ethanol use being 40% higher in 2021 than in the baseline. Ethanol blended into regular gasoline is expected to reach the assumed blend wall limit from 2014 onwards. Additional ethanol use should come from the development of the fleet of flex fuel vehicles which leads to a lower ratio between ethanol consumer price and gasoline consumer price induced by higher RIN prices.

Option 3

This option would mean that the other advanced gap would be kept fixed by reducing the advanced mandate by the same amount as the shortfall in cellulosic fuels while maintaining the total mandate. The conventional ethanol gap would exceed the baseline level by more than 70% in 2021, reaching 97 Bnl. Conventional ethanol production would not be able to reach the mandate despite being 40% above the baseline in 2021[15] – the ethanol producer price exceeds baseline levels by 40% – and US ethanol exports outside North America would be close to zero. To meet the global mandate, the United States would have to import ethanol. The world ethanol price in 2021 is projected to be 6% above the baseline level. This disparity in the movement of the Brazilian and US ethanol price is caused by the passage of the US price from the export floor (world price minus transport cost) to the import ceiling (world price plus transport cost plus a small *ad valorem* tariff) basis.[16] On the demand side, Option 3 leads to a situation very similar to Option 2 because the total mandate that has to be consumed is the same: ethanol blended into regular gasoline is expected to reach the assumed blend wall limit from 2014 onwards and additional ethanol use should come from the development of the flex fuel vehicle fleet. However, a stronger increase in biodiesel production leads to an ethanol consumption increase of only 38% compared to 40% in Option 2.

Interactions between the US and Brazilian ethanol markets

The different EPA implementation options analysed in this section have major implications for US import demand of ethanol able to qualify for the advanced biofuel mandate. Currently, the only ethanol type qualifying and being produced on a large scale is from sugarcane. In the outlook period, Brazil is the sole country that has the capacity and the flexibility to respond to strong additional demand from non domestic markets.[17] This means that the three implementation options have direct effects on Brazilian ethanol and sugar sectors.

Figure 3.A2.2 illustrates the most important interactions between the US and Brazilian ethanol markets. US ethanol imports directly impact Brazilian ethanol exports. In Brazil, the expansion/contraction of ethanol exports are due to several inter-related factors on the domestic market: expansion/contraction of domestic ethanol production and thus of sugarcane and sugar production, but also shifts in domestic ethanol demand through the adjustment of the car fleet as well as possibilities of ethanol re-imports from the United States.

Option 1

In the case of Option 1, US ethanol import demand is reduced. It is interesting to note that Option 1 has hardly any effects on the Brazilian and the world sugar markets when compared to baseline levels. Although ethanol exports to the United States are 30% lower in 2021, ethanol production in Brazil is only reduced by 3%, reducing sugarcane area by 2% while domestic consumption with a rising flex-fuel fleet increases by 3%. However, the lower sugarcane production does not have a visible impact on sugar production given the flexibility of the Brazilian sugar industry.

Option 2

Option 2 is associated with the strongest increase in US ethanol import demand when compared to baseline levels in 2021. This additional demand of about 35 Bnl induces larger Brazilian ethanol production by only about 10 Bnl. The rest will become available because of lower Brazilian consumption and higher imports from the United States.

Impact on Brazilian sugar markets: To produce more ethanol, the Brazilian sugarcane area is extended by 9% when compared to the baseline and the share of sugarcane used for biofuel production is increasing at the expense of sugar production. On the domestic Brazilian sugar market, lower sugar production implies higher domestic sugar prices, a lower sugar demand and a significant decrease of sugar exports. As a consequence, world sugar prices in Option 2 are 6% above baseline levels in 2021.

Impact on Brazilian ethanol use: Brazilian ethanol demand in a context of higher prices is expected to decrease considerably when compared to baseline levels in 2021. This decrease can be decomposed into two components:

- Low blend demand is reduced to the minimum blending requirement (18% of total fuel consumption on an energy equivalent basis).
- Ethanol used by flex-fuel vehicles is reduced to 21% of total fuel consumption – the 2011 level – compared to 41% in the baseline.

Ethanol imports from the United States: To meet domestic demand – even if it is much lower than in the baseline – in a context of tremendous increase[18] of Brazilian ethanol exports, Brazil needs to import some ethanol. Imports are projected to reach 18 Bnl, to a large extent originating from the United States where, in turn, the maize based ethanol production is stimulated by high ethanol prices. So Option 2 would create a large policy driven two-way trade in ethanol.

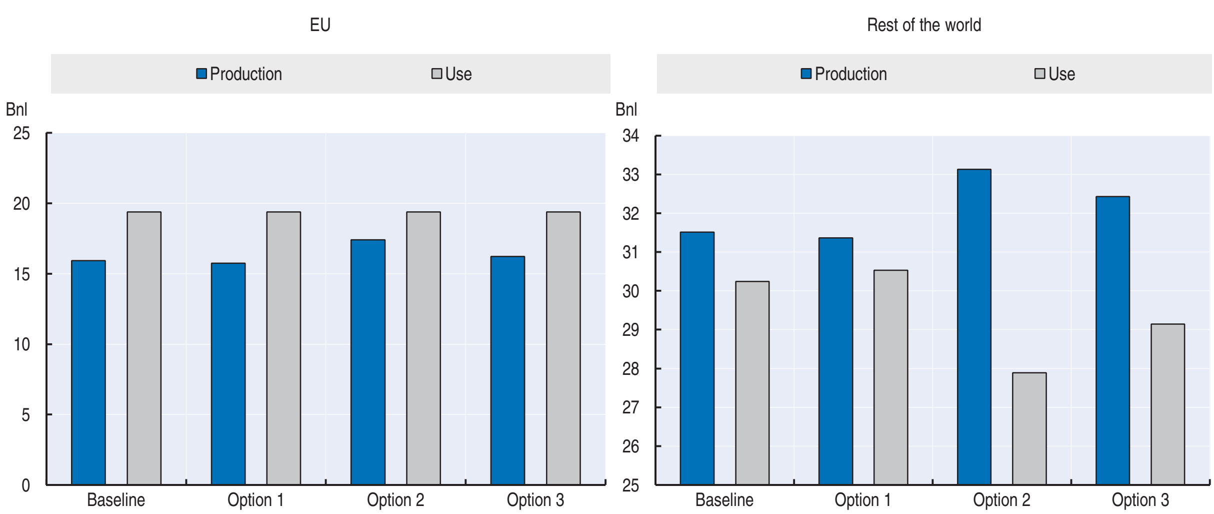
Option 3

The same argumentation can be built for Option 3. However, impacts on Brazilian ethanol and sugar markets are lower as US import demand is only 11% higher than in the baseline case in 2021. With much higher requirement for other conventional ethanol, the price of ethanol in the United States increases to levels eliminating the possibilities of exporting any ethanol outside North America. Brazil replaces this amount (close to 7 Bnl in the baseline) by domestic production and increases exports to the United States.

Implications on global ethanol production

The impacts of the scenarios on the European Union are only visible on the supply side, because consumption is bound by the EU mandate. In Option 2, with high world ethanol prices and a lot of competition on the world market, EU ethanol production is increasing by 9% (Figure 3.8). In the rest of the world, the supply and demand responses follow the world price incentives. In Option 2, China, India, Thailand and Canada make more than 50% of the production increase and even more in Option 3, where Canada shows the strongest supply increase given the tight connection to the US ethanol market. Consumption changes mainly take place in China, Thailand and Ukraine.

Figure 3.8. **Global ethanol market effects**



Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932639495

Implications on biodiesel markets

Given the implicitly strong increases in RIN prices for ethanol in Options 2 and 3, biodiesel is likely to become more competitive against ethanol to meet the advanced mandate. In Option 2, US biodiesel production and use are increasing by about 50% to

7.5 Bnl when compared to the baseline. They increase even more in Option 3 where they reach 8 Bnl. Effects on global biodiesel markets are quite low, as the US biodiesel net trade position does not change considerably in the scenarios when compared to the baseline. In that context, the world biodiesel price does only increase slightly.

Implications on other agricultural sectors

The increasing production of ethanol from sugarcane and from coarse grains in Options 2[19] and 3 is sufficient to generate significant impacts on the other sectors, which is not the case for Option 1. Therefore, only Options 2 and 3 are reflected in this section. The impacts are summarised in Figure 3.A2.3.

Impacts on biofuel feedstock sectors

The starting point is obviously an increase in the demand for coarse grains and for sugarcane by the ethanol producers by 11% and 20% respectively in Option 2 and by 35% and 3%, respectively, under Option 3. This leads to an increase in the world price of coarse grains and sugar of 5% and 6%, respectively, in Option 2 and of 16% and 4% in Option 3. Many factors are mitigating the price impact and in particular the strong reduction in consumption of ethanol by flex fuel cars in Brazil and an increase in coarse grains and sugarcane production by 1% and 6% in Option 2 and by 2.5% and 0.5% in Option 3.

Overall, the larger amount of coarse grains consumed by ethanol producers (20 Mt and 64 Mt respectively in Option 2 and 3) is accounted for in the model by a larger production, increase in distiller's dry grain (DDG) production (5 Mt and 20 Mt) and by a reduction in the amount consumed by human either directly or indirectly through non-ruminant meats. Basically, the reduction in human consumption represents less than 50% of the additional demand by ethanol producers in Option 2 and Option 3. In the case of sugarcane, 80% of the additional amount used by ethanol producers is accounted for by larger production and 20% by lower sugar consumption in Option 2. In Option 3, these percentages are 41 and 59, respectively.

Impact on other sectors

The increase in the world coarse grains price affects many other sectors. First, through demand and supply substitution, it leads to a higher price of wheat and oilseeds by 2% in Option 2 and by 5% and 4% in the case of Option 3. The higher oilseed price reduces crush demand leading to lower supply of protein meal and vegetable oil. This combined with substitution on the feed demand side lead to a significant increase in the price of protein meal by 2% and 5% in Options 2 and 3 respectively.

The increasing price of feed generates a reduction in supply and production of non-ruminant meats. World pigmeat and poultry production falls respectively by 0.1% and 0.2 % in Option 2 and by 0.2% and 0.7% in Option 3. This leads to higher price and lower consumption of these meats. Taking the Pacific market as an example, the price of pork is 2% higher in Option 2 and 7% higher in Option 3. The US price of poultry increases by about the same percentage.

Considering the smaller share of feed in the variable cost of producing beef and the longer production cycle, the impact on the beef sector is different. In fact, the increasing demand for beef generated by the higher price of pork and poultry crosses the lower supply generated by the higher feed prices at a point leading to higher price and to a small increase in world production by 0.1% and 0.3% in Options 2 and 3.

The impact on the fish sector is also different since capture and raised molluscs, the largest share of supply, are not directly influenced by feed prices. On the other hand, demand for fish as food is entirely influenced by the movement in meat prices. Another important point is that China, which counts for 61% of world aquaculture production, is not strongly tied to the movement in the world price of coarse grains. Chinese coarse grain price is only 3% higher in Option 3 compared to a 16% increase for the world price. The combination of all these elements and world capture being mostly controlled by production quotas, leads to a small impact on production. For aquaculture production, the increasing price caused by the larger demand generated by higher meat prices compensates for the increasing feed cost.

Key conclusions of the scenarios

Option 1 (the total and advanced mandates are lowered by the shortfall in the cellulosic mandate), does not differ much from the baseline except from the fact that low blend ethanol use in the United States would not reach the blend wall in any years and that the United States would be less dependent on advanced ethanol imports.

Option 2 analysed in this section corresponds to maintenance of the actual policy of the EPA: both the advanced and total mandates are kept at the EISA level. The main conclusions of Option 2 compared to baseline projections are the following:

- Important policy driven two-way ethanol trade emerges between Brazil and the United States.
- Spill-over effects are expected in the coarse grains market as ethanol trade is completely free between the United States and Brazil, but the impact on the world price of coarse grains is not expected to be large.
- The largest adjustment will come from a severe reduction in consumption of ethanol by flex fuel cars in Brazil, *i.e.* the improvement in the US energy independence would be partly achieved through a reduction in Brazil's energy independence.
- The potential increase in sugarcane production is sufficient to prevent a large increase in the sugar price.

If, on the contrary, the EPA decides to reduce as well the advanced mandate without changing the total mandate as is the case in Option 3, then the impact on the coarse grains markets will be much larger. This is due to the fact that the US ethanol price will be much higher because it will go from an export floor price basis to an import ceiling. Not surprisingly, this will put even more upward pressure on the price of coarse grains. The main conclusions of this scenario are the following:

- US ethanol exports outside North America disappear and imports from Brazil driven by price advantage increase significantly.
- World coarse grains price is almost 16% higher in 2021, compared to the baseline.
- About half of the coarse grains or sugarcane used to produce the additional ethanol is derived from lower human consumption, taking into account additional production and the greater availability and use of DDGs.

- Quantities of food consumed around the world are somehow similar but at higher prices. Option 3 would put even more pressure on countries where food expenditure already accounts for a large share of income.
- The reduction in feed demand comes entirely from the non-ruminant meat sectors.

Finally, the impacts of the decisions to be taken by the EPA concerning the implementation of the US biofuel policy in the coming years are not fully reflected by the scenario options presented. However, it is clear from this analysis that the impacts will vary according to the decisions taken, that they are likely to be important, and that they will affect not only the biofuel sector in the United States but more broadly the global biofuel and agricultural markets. The implementation decision will have an impact on world ethanol and agricultural commodity prices. It will require some adjustment in terms of ethanol production and consumption patterns, as well as in terms of ethanol feedstocks use around the world.

Notes

1. Brazil, Sao Paolo (ex-distillery).
2. Producer price Germany net of biodiesel tariff.
3. Energy Independence and Security Act of 2007, Public Law 110–140 (2007) *www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf.*
4. Cellulosic ethanol production is an exogenous model component.
5. The total and advanced mandates are reduced by about 90% of the difference between the assumed applied and the legislated cellulosic biofuel mandate at the end of the projection period.
6. The conventional gap is the difference between the total mandate and the advanced mandate, see Annex 3.A1 for more explanations.
7. For more information on the blend wall, see Annex 3.A1.
8. In baseline assumptions, the blend wall is gradually extended from 10% to 15% over the projection period (accounting for the disappearance of older vehicles and for the resolution of logistic problems by blenders). These assumptions result in an assumed effective blend wall slightly lower than E15 in all years of the projection period except 2021. For example, it is assumed that the maximum ethanol blending percentage in regular gasoline would be of 13% in 2017.
9. *eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.*
10. This percentage takes into account the fact that the contribution of second generation biofuels will be counted twice toward the EU RED mitigation targets.
11. Currently, gasoline prices in Brazil are not allowed to exceed a certain cap value. The *Outlook* assumes that this cap will be adjusted upwards given rising energy prices so that the driving ethanol/gasoline price ratio remains slightly in favour of ethanol.
12. According to the RFS2, sugarcane based ethanol is classified to be an advanced biofuel, while maize based ethanol is not.
13. Drop-in fuels are defined as renewable fuels that can be blended with petroleum products, such a gasoline, and utilised in the current infrastructure of petroleum refining, storage, pipeline and distribution.
14. Vehicles produced in 2001 or later are allowed since 2011 to use blends up to 15% ethanol. Annex 3.A1 contains a specific section on the blend wall and associated constraints on US biofuel demand.
15. In Option 3, in 2021, 53% of US coarse grains production would be consumed by ethanol producers.
16. US imports in Option 2 occur even if Brazilian ethanol prices are high because of the classification of sugarcane based ethanol as advanced biofuel. The US ethanol price, which can be interpreted as the conventional ethanol price, is therefore tight to the marginal quantity of US ethanol exported.

In Option 3, exports completely disappear and Brazilian sugar-cane ethanol exports now compete inside the conventional gap.

17. Other producers in the world are also reacting to a smaller extent to the higher ethanol price and mitigate some of the shortfall on the world market created by the US policy.
18. In 2021, Brazilian exports that qualify for the US advanced mandate are projected to be more than 260% higher than in the baseline.
19. All impacts reported are with respect to the baseline for the last year of the *Outlook* period, *i.e.* 2021.

ANNEX 3.A1

US biofuel policy

Biofuel policies in the United States are entering a new phase as the long standing blenders credits on ethanol and biodiesel and the tariff on imported ethanol expired at the end of 2011 and mandated quantities of biofuels continue to expand.

The expiration of the ethanol blenders credit of USD 0.45 per gallon (USD 0.12 per litre) with an offsetting USD 0.54 per gallon (USD 0.14 per litre) import tariff and the USD 1.00 per gallon (USD 0.26 per litre) blenders credit on biodiesel ends a decade's long policy of subsidisation to mix the renewable fuels into general motor fuel use.[1] The unique producers' credit for cellulosic biofuels of USD 1.01 per gallon (USD 0.27 per litre) is set to expire at the end of 2012. While there are calls for renewal of the credits, and it has happened in the past (even retroactively), as of the writing of this text the credit paid for by US taxpayers has expired. What remains is a system of mandates on blenders for inclusion of four classes of renewable fuels, total, advanced, bio-based diesel and cellulosic biofuels, into broader petrol and distillate use.

US biofuel mandates

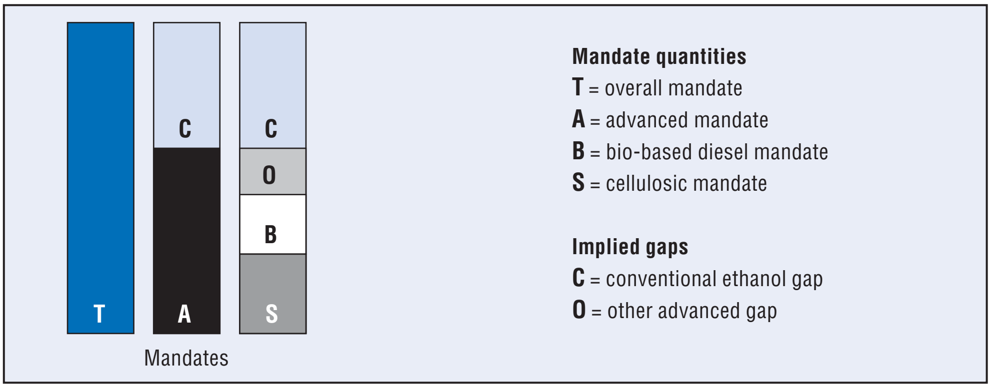
The mandates on blenders represent their share of the calendar year quantitative national mandates laid out in the Energy Independence and Security Act of 2007 (EISA).[2] The mandates are segmented into four classes presented in Figure 3.A1.1 based on the fuel's feedstock and its estimated greenhouse gas (GHG) reduction score relative to the 2005 base level as specified in EISA but are not independent of each other; they are a nested structure of quantitative minimums.

The overarching total mandate (T) requires fuels to achieve at least a 20% GHG reduction. Advanced fuels (A), as specifically defined in the legislation, are fuels which achieve a 50% greenhouse gas reduction score, ethanol derived from sugar is explicitly defined as an advanced fuel. Of that advanced mandate, a minimum quantity must come from bio-based diesel fuels (B), a distillate replacement with a 50% GHG reduction score, and cellulosic renewable fuels (S), either petrol or distillate replacement fuels, with a 60% green house gas reduction score.

The biodiesel and cellulosic minimums leave another advanced gap (O), the difference between the advanced mandate and the minimum that must come from cellulosic fuels and biodiesel, which can be met with fuels such as sugar based ethanol or excess biodiesel (B) and cellulosic fuel (S) consumption.

The conventional gap (C), the difference between the total mandate and the minimum that must come from advanced fuels, is then the portion of the total mandate that could

Figure 3.A1.1. **Mandated quantities and implied gaps**



Source: OECD and FAO Secretariats.

potentially come from conventional biofuels such as maize starch based ethanol and therefore only needs to meet the 20% GHG reduction criteria. It is worth noting here that there is no explicit mandate for maize based (specifically maize starch) ethanol in the system, only that it may compete with both other conventional biofuels[3] and advanced biofuels which may be consumed in excess of its mandate, in filling the conventional gap (C).

The mandates only restrict minimum quantities and are nested within each other, creating a hierarchy of biofuel types. Any overproduction in a sub-category can be used to fulfill the next broader mandate. Under varying conditions all, some or none of the four mandates may be binding at any given time.

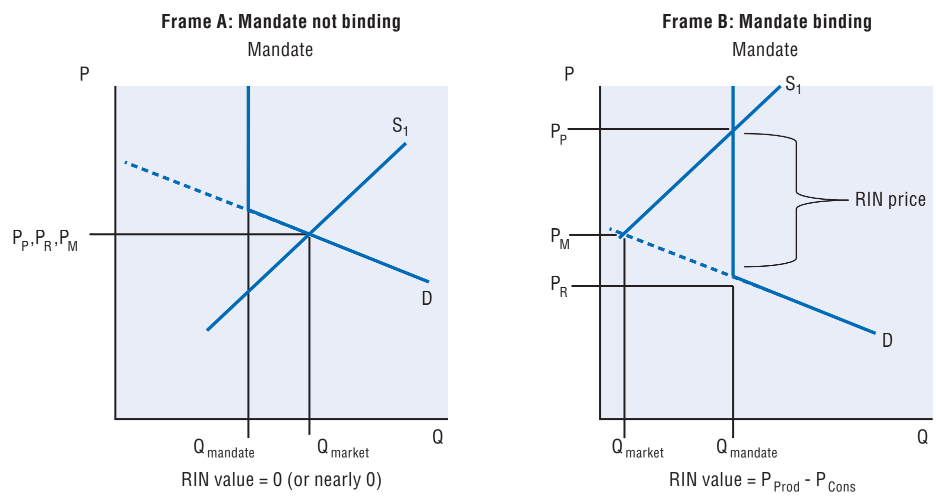
RIN markets and prices

Blenders are the obligated party in the system of mandates and show compliance in all four mandate categories, total, advanced, bio-based diesel and cellulosic biofuels, through the submission of Renewable Identification Numbers (RINs). A RIN is a 38-digit number which indicates the year, volume and highest mandate classification the renewable fuel is capable of meeting and is obtained from the US Environmental Protection Agency (EPA) by the biofuel producer upon production and registration of the fuel. Conveyed along with the fuel, for example maize starch based ethanol, is the associated RIN (in this case a conventional RIN) where the blender can detach and use the RIN for compliance or sell the RIN to another blender to help satisfy their obligation. The RIN price may be very low if the market demands quantities in excess of the mandate, such as when oil prices are high relative to biofuel prices, or the RIN may be very costly if the mandate quantity is well in excess of true market demand.

When the market (P_M) demands more than the mandated quantity (frame A in Figure 3.A1.2) the price paid for the renewable fuel from producer (P_P), blended and sold into the retail supply chain (P_R) will be equivalent when adjusted for taxes and margins. However, when the mandate is in excess of that the market would otherwise demand the wholesale price of the renewable fuel will rise relative to its value to consumers (frame B). In this context, blenders must pay a price to producers high enough to obtain the quantities they need to meet the mandate (P_P). The blenders cannot impose the cost directly on the ethanol share of the retail fuel or risk reducing demand for renewable, making the mandate even harder to achieve. They therefore must sell it at a lower price (P_R)

based on consumers preferences. Blenders must spread the cost of RINs out over the entire motor fuel sales, both petrol and distillates, maintaining relative renewable and conventional fuel prices; which in turn raises costs to motor fuel consumers. This difference between what the blenders pay (P_P) and what they impose on the retail market (P_R) is reflected in the RIN price. With four separate mandates there are potentially four separate RIN prices each of which reflects the per gallon cost born by motor fuel consumers of imposition of that mandate.

Figure 3.A1.2. **Determination of a binding mandate and RIN price evaluation**



Source: OECD and FAO Secretariats.

The hierarchical nature of the mandates will be reflected in the RIN prices. A biodiesel RIN can be priced no lower than an advanced RIN as any lower priced biodiesel RINs would be diverted to satisfy the advanced mandate equalising prices. If the biodiesel mandate is highly binding, biodiesel RIN prices would rise, but advanced RINs which, conversely, cannot be used for biodiesel compliance may lag behind.

Examples illustrating the nested nature of the biofuels mandates

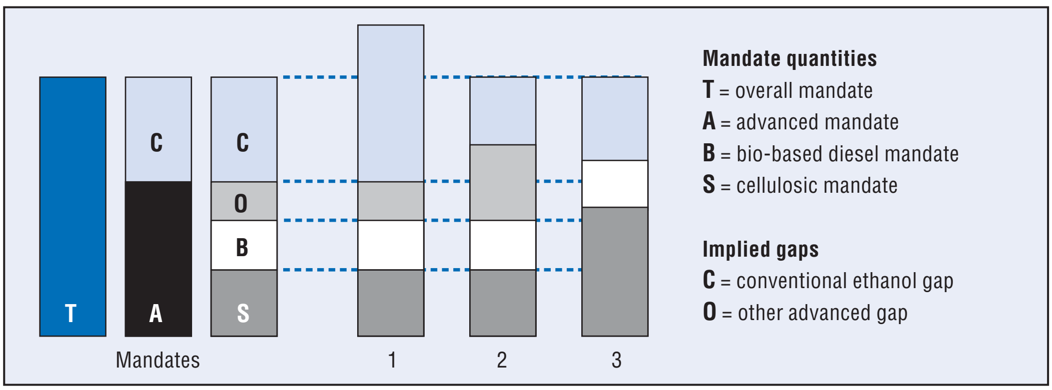
A number of examples not intended to be exhaustive, can highlight some of the possible outcomes and clarify the hierarchical nature of the mandates (Figure 3.A1.3).

Market outcome 1 shows the situation where, perhaps due to high petroleum prices and low agricultural commodity prices, maize ethanol consumption exceeds the conventional mandate gap (C) and therefore total ethanol RIN supplies exceed the total mandate. The total mandate would then be non-binding, conventional RIN prices would approach zero.

Market outcome 2 highlights the point that no specific mandate for conventional ethanol exists within EISA, but only a conventional biofuel gap. This case may be reflected in a situation where the total biofuel mandate may be binding, but imports of sugarcane ethanol, perhaps from high maize prices as a result of a short-crop, could enter and displace maize starch based ethanol in meeting the total mandate. In this instance the total mandate may be binding while the advance mandate is not and conventional and advanced RIN prices will be close in value.

Finally, market outcome 3 further highlights the hypothetical situation where there is a technological breakthrough in cellulosic ethanol production which reduces the cost of production, while the overall mandate remains binding, perhaps in the context of a low petroleum price. In this instance, cellulosic production may far exceed its mandate, but it cannot displace bio-based diesel production which has its own category specific mandate. Together, biodiesel and cellulosic ethanol may provide sufficient quantities to meet and exceed the advanced biofuel mandate and even displace some of the corn starch based ethanol being used to meet the total mandate. The biodiesel mandate and the total mandate may be binding but the cellulosic and advanced mandates would not be. In this situation, the prices for cellulosic and conventional RINs would be very close.

Figure 3.A1.3. **Nesting of mandates, examples of different market outcomes**



Source: OECD and FAO Secretariats.

Mandate flexibilities

Additional flexibility and complexity is added to the mandate system with provisions allowing blenders to "rollover" or run a "deficit" of RINs into the following year. Up to 20% of a given mandate may be met with RINs produced in the previous year. This allows for limited "stock holding" of obligations which can be drawn down in years where RIN prices rise. The blender can hold an additional stock of RINs as a hedge against rising biofuel and RIN costs or other compliance issues. This allows for some moderation of feedstock prices when a transient shock, such as below average crop yields, push RIN prices higher.

On an individual basis, blenders may fall short of the mandate in a particular year if in the following year they make up the "deficit" from the previous year and fully comply with the mandate in the current year. Running a deficit in the current year introduces considerable rigidity in the following year for blenders, as failure to comply with mandates can result in a fine of USD 37 500 per day plus any economic benefit derived from non-compliance.[4] Such flexibility in the mandate should mitigate swings in feedstock and biofuel prices from transient shocks in energy prices and crop production.

Mandate waivers and the implication of EPA implementation

The OECD-FAO baseline maintains current US biofuel policy with respect to mandates;[5] however, implementation of the policy by the Environmental Protection Agency (EPA) remains a significant source of uncertainty and could have significant effects on commodity markets.

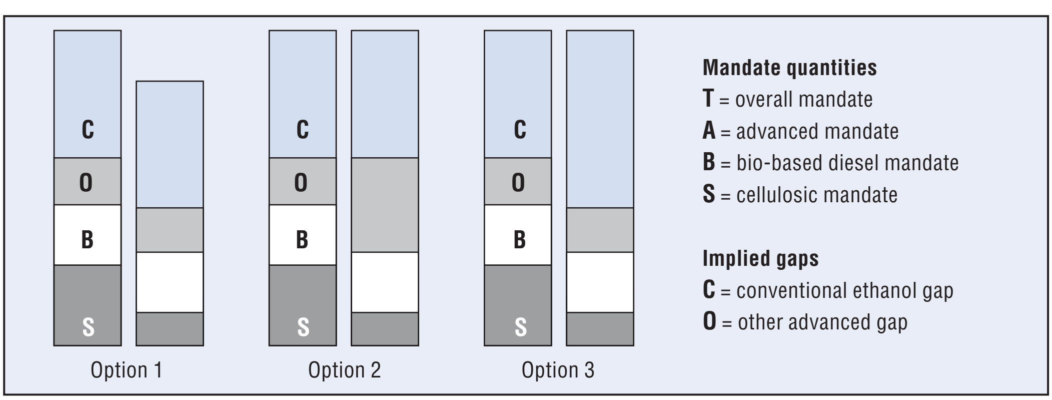
Each year, the EPA puts forth the minimum quantities for each of the four classes of biofuels required (total, advanced, bio-based diesel and cellulosic biofuels), taking into account what can be viably produced or imported. Thus far, the production capacity for cellulosic ethanol has lagged well behind the quantities mandated in 2010, 2011 and 2012. For 2012 the EISA legislation calls for 500 Mn gallons (1.893 Bnl), but has been reduced by the EPA to just 8.65 Mn gallons (32.7 Mnl) or just 1.7% of the targeted quantity. The cellulosic mandate also grows at an increasing rate for the remainder of the projection period. While this shortfall has its own implications for biofuel markets in terms of potential feedstock use and production, there is concern that meeting the cellulosic mandate faces considerable hurdles.[6, 7]

This leaves the EPA with an important decision each year regarding the other mandates. It is within their power to adjust each of the other mandate levels or leave them as legislated in EISA. The EPA may choose Option 1 in Figure 3.A1.4, in this case they lower the total and advanced mandate by the shortfall in cellulosic ethanol which keeps the conventional ethanol gap and other advanced fuel gap consistent with EISA. This policy maintains the maximum quantity of maize based ethanol that can be used to meet the mandate as well as the need for advanced fuels to meet the "other advanced gap". This choice is likely to lead to the lowest commodity and food prices while also resulting in the lowest GHG savings.

Alternatively the EPA could choose Option 2 in Figure 3.A1.4 and maintain both the advanced and total mandate which results in the widening of the other advanced gap and potentially drawing in additional imports such as sugarcane ethanol from Brazil. This option is likely to have a larger impact on commodity and food prices and mandate compliance costs than Option 1.

The EPA could alternatively choose to keep the other advanced gap fixed by reducing the advanced mandate by the same amount as the shortfall in cellulosic fuels while maintaining the total mandate. This would result in a growth in the conventional ethanol gap and a larger potential market for maize ethanol (Option 3 in Figure 3.A1.4). The EPA could also choose to do a partial adjustment on either the advanced mandate or total mandate or any combination of the two.

Figure 3.A1.4. **EPA mandate implementation options**



Source: OECD and FAO Secretariats.

Thus far, with the cellulosic mandate at relatively low levels, the EPA has chosen to keep the total and advanced mandate at their original levels (*i.e.* Option 2 in Figure 3.A1.4). This has led to the opening up of the "other advanced gap" of undefined advanced fuels needed to meet the mandate, such as imports of sugarcane ethanol from Brazil, a gap which will grow rapidly in the future if EPA maintains this option (Table 3.1).

Under legislated quantities, in 2020 the advanced gap would require 2.58 Bn gallons (9.76 Bnl) of other advanced fuel. Under our projected cellulosic biofuel production path, the continuation of current EPA implementation would result in the need for 10.731 Bn gallons (40.624 Bnl) of other advanced fuels in 2020. In developing the baseline for the *OECD-FAO Agricultural Outlook 2012-2021*, this was deemed an unlikely outcome; the most viable fuels to fill this gap, under current projections, would appear to be significant additional imports of sugarcane ethanol with possible additional production of biodiesel beyond its mandated minimum. This volume of imports would represent more than the total ethanol production for Brazil in 2011.

In the *OECD-FAO Outlook 2012-2021*, it was therefore decided to reduce both the total and advanced mandate by a proportion of the shortfall in cellulosic biofuels such that the other advanced gap did not shrink from year to year and the conventional ethanol gap was held to the quantities in the legislation. Changes in this assumption would have significant impact on commodity prices and consumer fuel costs as well as biofuel prices and trade. The production of cellulosic biofuels is an exogenous component in the model; all other categories of biofuels as defined in the nested structure of mandates are modeled endogenously.

The blend wall and constraints on biofuel demand

While the system of mandates in US policy specify quantities of biofuels which must be domestically consumed it provides no direction on *how* such fuels should be consumed. Petrol dominates US fuel consumption, representing 62% of consumption, with diesel fuels representing another 28%.[8] Short run technical constraints, referred to as "the blend wall" in the petrol market, act as an impediment to increased ethanol consumption. Biodiesel use could face similar constraints in the future.

Prior to 2011, conventional petrol vehicles in the United States were limited, by EPA rules, to a maximum blend of 10% ethanol by volume with a small number of flex fuel vehicles (FFV) able to take up to 85% blends.[9] The 10% constraint posed little problem when motor fuel use was near 568 Bnl annually and ethanol production well below the constraint of 57 Bnl. With rising quantitative mandates and stagnating aggregate motor fuel use as a result of the financial crisis and of higher mileage vehicles, the United States quickly was approaching saturation of the conventional vehicle market.[10] In 2011 the EPA announced that vehicles produced in 2001 or later would be allowed to use blends up to 15% ethanol[11] and preliminary rules and consumer guidelines were released in early 2012.[12] Data from a similar 11 year period from 1998 to 2009 showed the newer vehicles represented 70% of household automobile ownership but these vehicles represented over 77% of the miles driven.[13]

While this increases substantially the size of the ethanol market in conventional vehicles, many obstacles remain along the distribution chain. These constraints can have significant impact on the costs to consumers of the mandate system and the competition between renewable fuels, primarily ethanol and biodiesel, to fill the undefined advanced fuel quantities (O) within the EISA mandate. While EPA rules allow the dispensing of E15, retailers may be hesitant to offer it to consumers until the issue of liability is resolved. Earlier car warrantees may limit ethanol content to the previous 10% limit and would expose retailers to other consumer complaints. In addition, with a bifurcated market of newer and older vehicles, retailers must take action to minimise the mis-fuelling of vehicles by consumers who may be unaware of the restrictions. There may also simply be no "room" at the pump to add yet another handle dispensing an additional fuel type (different octane and ethanol inclusion rate combinations). Furthermore, the installation of additional underground tanks is very costly.

While even modest growth in E15 dispensing would allow for full absorption of maize ethanol that could be used to fulfill the conventional ethanol mandate gap (C), any significant growth in cellulosic ethanol production[14] or imports of sugarcane ethanol to meet the advanced mandate gap (O) could put pressure on the distribution system. This pressure will be reflected in increased RIN prices, ultimately born by consumers, and increase the incentives for blenders to expand the availability of E15 and E85 fuels and to price them competitively. This pressure also increases the motor fuel costs to consumers who may consume less in aggregate and thus make the ethanol blend-wall even more constraining. As an alternative, the constraint of the blend-wall also increases the potential for biodiesel consumption to exceed its own mandate to fulfill the larger advanced mandate if consumption of renewable diesel is less constrained.

It is assumed in baseline projections that the blend wall is gradually extended from 10% to 15% over the projection period and that the assumed effective blend wall would be reached by 2016.

Further reading

The discussion of US biofuel policy and its implementation are drawn from the following works where additional detail may be found.

Meyer, Seth and Wyatt Thompson. "EPA Mandate Waivers Create New Uncertainties in Biodiesel Markets", *Choices*, Vol. 26 (2), 2011.

Thompson, Wyatt, Seth Meyer and Patrick Westhoff. "Renewable Identification Numbers are the tracking Instrument and Bellwether of US Biofuel Mandates", *EuroChoices,* Vol. 8 (3), pp 43-50, 2009.

Notes

1. The vast majority of cars in the US have gasoline engines while the trucking fleet is dominated by diesel engine trucks.
2. Energy Independence and Security Act of 2007, Public Law 110–140 (2007) *www.gpo.gov/fdsys/pkg/PLAW-110publ140/pdf/PLAW-110publ140.pdf*.
3. Ethanol derived from corn starch is explicitly named as a conventional biofuel but it is not the only conventional biofuel. Other grains could be used to produce ethanol and if a 50% GHG reduction is not achieved the derived ethanol would be considered as a conventional biofuel.
4. EPA clams this authority under sections 205 and 211 of the Clean Air Act *www.epa.gov/air/caa/title2.html*.
5. Including the assumption that the cellulosic mandate will continue to be set by EPA at a reduced volume relative to that legislated in EISA.
6. *www.fas.org/sgp/crs/misc/R41106.pdf*.

7. The *Outlook* baseline for cellulosic biofuel production in the United States is exogenous and dependent on a fixed technology path.
8. Jet fuel consumption represents the remaining 10%, *www.eia.gov/forecasts/steo/report/us_oil.cfm*.
9. In October of 2010, the EPA granted a partial waiver for the use of E15 in model year 2007 and newer vehicles.
10. The mandates are quantitative and do not respond to aggregate motor fuel use. Factors which increase or decrease aggregate motor fuel use, change the effective share of biofuels required in consumption.
11. *http://edocket.access.gpo.gov/2011/2011-1646.htm*.
12. *www.gpo.gov/fdsys/pkg/FR-2011-07-25/pdf/2011-16459.pdf*.
13. National Travel Household Survey (*http://nhts.ornl.gov/download.shtml*) Author's query from data set using NTHS estimates of miles driven by age, self reported miles driven would increase the share of newer vehicle miles to over 81%. The results do not correct for potential differences in miles per gallon based on age of vehicle.
14. Cellulosic biodiesel also qualifies as a cellulosic fuel.

ANNEX 3.A2

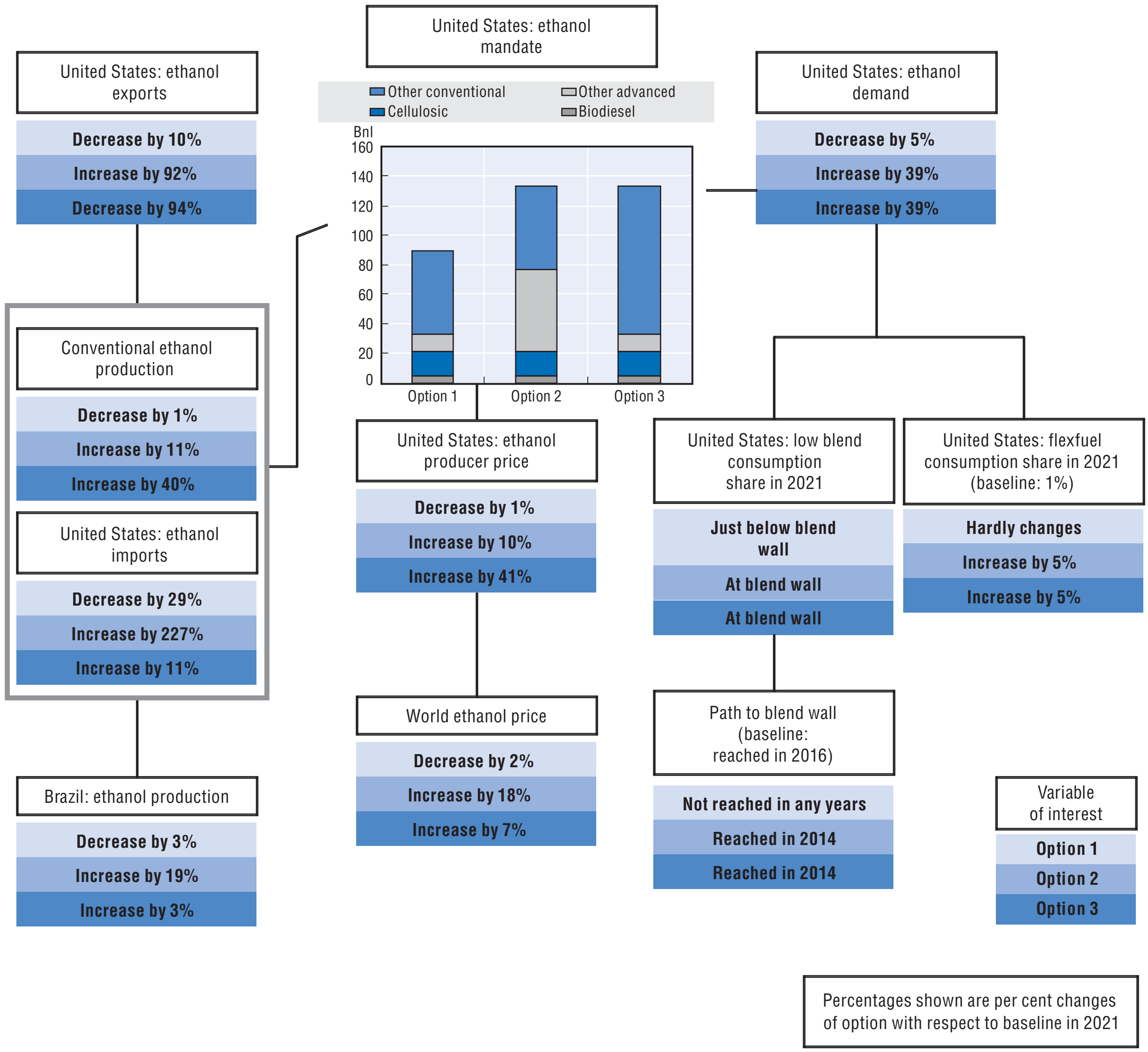
Uncertainties around the implementation options of US biofuel policies: Results of the scenarios

Table 3.A2.1. **Results of the three options scenarios**

		Baseline		Option 1	Option 2	Option 3
		Average 2009-2011	2021	2021	2021	2021
Ethanol production						
USA	MN L	47 617	82 610	81 860	89 553	108 960
Brazil	MN L	25 331	51 300	49 625	61 048	52 627
European Union	MN L	6 424	15 748	15 572	17 145	15 986
Canada	MN L	1 565	1 992	1 978	2 135	2 550
China	MN L	8 094	10 058	10 016	10 507	10 146
India	MN L	1 976	4 194	4 174	4 376	4 237
Rest of World	MN L	7 213	14 673	14 598	15 337	14 776
Ethanol use						
USA	MN L	45 582	90 757	86 217	126 462	125 778
Brazil	MN L	23 347	39 805	41 287	25 902	34 467
European Union	MN L	7 877	19 388	19 388	19 388	19 388
Canada	MN L	1 759	2 356	2 356	2 356	2 356
China	MN L	7 994	10 242	10 433	8 905	9 646
India	MN L	2 254	4 384	4 385	4 381	4 383
Rest of World	MN L	8 406	13 460	13 573	12 524	13 076
Energy share in Gasoline type fuels						
USA	%	5.4	10.9	10.4	15.3	15.2
Brazil	%	47.1	64.3	66.8	40.4	55.1
European Union	%	2.7	8.3	8.3	8.3	8.3
Canada	%	2.6	3.4	3.4	3.4	3.4
China	%	1.8	1.3	1.4	0.7	1.0
Ethanol trade						
USA	MN L	1 864	–8 268	–4 479	–37 030	–16 943
Brazil	MN L	1 984	11 495	8 338	35 146	18 160
European Union	MN L	–1 453	–3 640	–3 816	–2 243	–3 402
Canada	MN L	–195	–364	–378	–221	194
China	MN L	100	–183	–416	1 602	500
India	MN L	–278	–190	–211	–5	–146
Rest of World	MN L	–1 205	1 214	1 025	2 813	1 700
Biodiesel						
USA production	MN L	2 834	5 083	5 083	7 571	8 006
USA consumption	MN L	2 546	4 979	4 979	7 515	7 956
USA net trade	MN L	288	104	104	56	50
Prices						
World						
Ethanol	USD/hl	64	96	94	113	102
Biodiesel	USD/hl	132	181	181	184	185
Coarse grains	USD/t	228	246	245	259	286
Raw sugar	USD/t	533	483	482	516	503
Wheat	USD/t	267	279	279	286	294
Oilseeds	USD/t	503	550	549	562	572
Vegetable oils	USD/t	1 067	1 232	1 232	1 256	1 265
Beef and veal (USA)	USD/t	3 477	4 718	4 711	4 780	4 900
Pigmeat (USA)	USD/t	1 658	2 380	2 375	2 434	2 542
Poultry (USA)	USD/t	1 074	1 121	1 119	1 148	1 204
Fish	USD/t	2 500	3 445	3 441	3 484	3 532
USA						
Ethanol	USD/hl	61	77	76	85	108

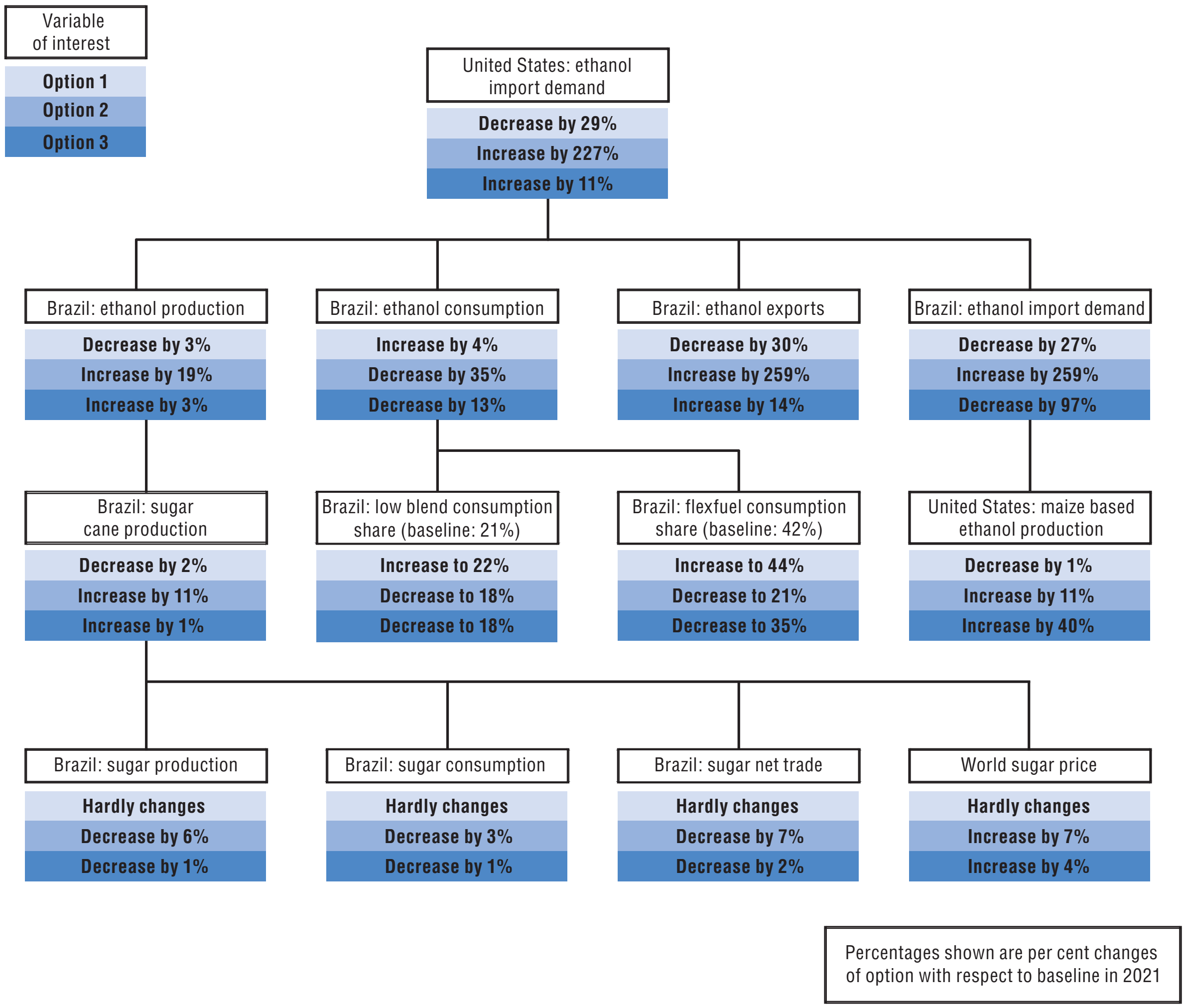
Note: For the definition of world prices, please refer to footnotes of Table 1.A.2. 30 and 31.
Source: OECD and FAO Secretariats.

Figure 3.A2.1. **Implications of the three options on the US ethanol market**



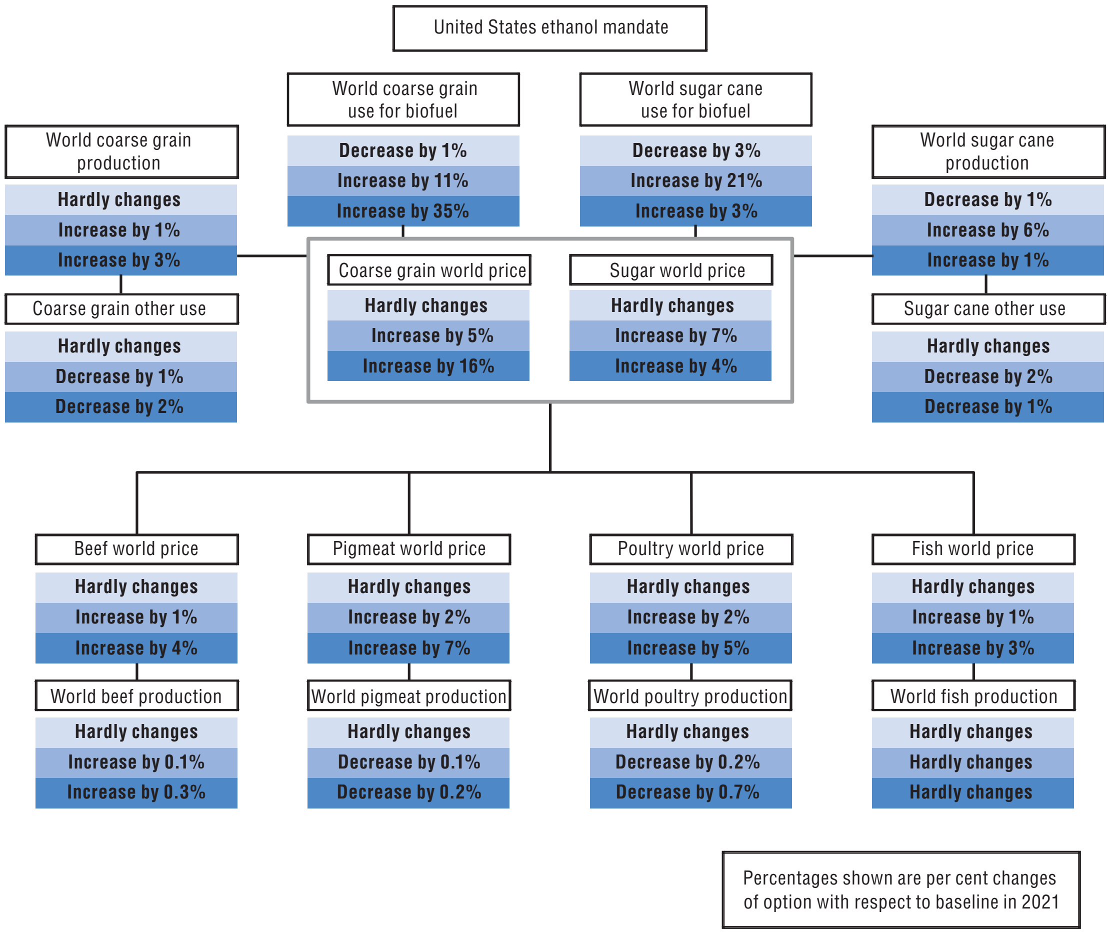
Source: OECD and FAO Secretariats.

Figure 3.A2.2. **Interactions between US and Brazilian ethanol markets**



Source: OECD-FAO Secretariats.

Figure 3.A2.3. **Impacts on the other agricultural sectors**



Source: OECD and FAO Secretariats.