Chapter 9. Biofuels

This chapter describes the market situation and highlights the latest set of quantitative medium-term projections for world and national biofuel markets for the ten-year period 2018-27. Given current policy developments and trends in diesel and gasoline demand, global ethanol production is expected to expand from 120 bln L in 2017 to 131 bln L by 2027, while global biodiesel production is projected to increase from 36 bln L in 2017 to 39 bln L by 2027. Advanced biofuels based on residues are not expected to take off over the projection period due to lack of investment in research and development. Trade in biofuels is projected to remain limited. Global biodiesel and ethanol prices are expected to decrease respectively by 14% and 8% in real terms over the next decade; however, the evolution of ethanol and biodiesel markets will continue to be shaped by policies and demand for transport fuel, which implies considerable uncertainty on these projections.

Market situation

Crude oil prices increased by 25% in nominal terms in 2017, but remained weak at USD 54.7 per barrel on average over the course of the year. The evolution of biofuel and biofuel feedstock prices was contrasting. Maize and ethanol prices declined by 5% and 2.3% respectively, while vegetable oil and biodiesel prices increased by 1.8% and 8% respectively. The biofuel-to-biofuel feedstock price ratios increased slightly but remained below their average values over the previous decade.

Policy decisions were globally favourable to biofuels in 2017 with developments such as mandate increases and differential taxation systems or subsidies enacted or announced in several countries. Demand for biofuels was sustained by bioenergy obligatory blending and by important demand for transportation fuels due to continued low energy prices. Unfavourable price ratios of biofuels to conventional fuels resulted in limited demand for non-mandated use of biofuels.

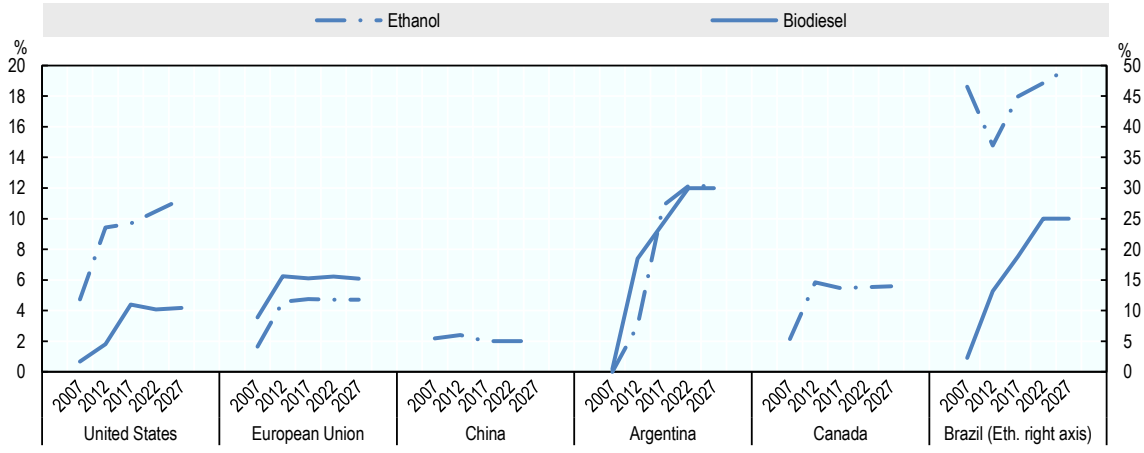
Projection highlights

International crude oil prices are expected to increase by 40% in nominal terms over the baseline period. This should lower demand for gasoline and diesel fuels, especially in developed countries. Biofuel prices, similar to biofuel feedstock prices, should trend slightly upward but at a slower pace than energy prices. Influenced by developments on the vegetable oil markets, biodiesel prices are expected to increase at a slower pace than ethanol prices in nominal terms. Global biodiesel and ethanol prices should decrease respectively by 18% and 4% in real terms over the next decade. The evolution of ethanol and biodiesel markets over the baseline period is expected to continue to be driven by policies. Biofuel policies are subject to uncertainty. Projections presented for biofuel markets in this *Outlook* assume a continuation of current policies over the next ten years, although some general policy targets will not be met owing to the absence of the necessary policy instruments to achieve them.

For the United States, all mandates are assumed to remain at their announced levels for 2018 except the cellulosic mandate. The latter is assumed to more than double over the projection period, but to reach only 4.5% of the level specified in the 2007 Energy Independence and Security Act (EISA) by 2027. The ethanol blend wall[1] is set to increase to 11.3% by 2027. This *Outlook* thus assumes a limited development of mid-blends of ethanol. In addition, biodiesel use is assumed to remain above the biodiesel mandate in the early years of the outlook period to meet part of the advanced mandate[2] (Figure 9.1).

The use of biofuels in the European Union is assumed to be governed by the 2009 Renewable Energy (RED) and Fuel Quality Directives and the 2015 ILUC Directive, as well as by national legislations. The proportion of total transportation energy accounted for by biofuels, including double counting for waste- and residue-based biofuels, is expected to reach 5.9% by 2020 and to decrease to 5.8% by 2027. The remainder of the 10% RED target should be met from other renewable energy sources. This *Outlook* does not take into account the European Parliament's proposal agreed to on 17 January 2018 to reach 12% renewable energy in transport by 2030. This proposal also places other restrictions on the use of biofuels based on food and feed feedstocks described below.

Figure 9.1. Evolution of ethanol blending in gasoline fuels and of biodiesel blending in diesel fuels



Note: Shares are expressed in volume.
Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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It is assumed that the Brazilian taxation system will remain favourable to hydrous ethanol rather than to gasohol,[3] which corresponds to the mandatory mix of 27% ethanol with gasoline. The Brazilian ethanol demand is expected to increase by 5.4 bln L over the outlook period, and the country's biodiesel mandate should reach 10% by 2020, leading to an increase in biodiesel production of more than 40% over the next ten years. The RenovaBio programme was signed in January 2018 and should be implemented in the course of 2019. The programme targets a fuel ethanol share in the fuels matrix of 55% by 2030, compared to the 50% share assumed in this *Outlook*. In Argentina, it is assumed that the 10% blending mandate for biodiesel and 12% mandate for ethanol will be fulfilled by 2020. The primary focus of Argentinean biodiesel production will probably be domestic, although some biodiesel trade is expected in the early years of the projection period, principally to the European Union as trade barriers will limit US import demand.

In September 2017, the Chinese government announced a new nationwide ethanol mandate that expands the mandatory use of E10 fuel from 11 trial provinces to the entire country by 2020. Mechanisms for implementation have not been announced yet and thus the announcement is not taken into account in this *Outlook*. Box 1.1 provides a description of the potential impact of such a move. Thailand is expected to expand its domestic ethanol production by 1.2 bln L by 2027, becoming a significant player on biofuel markets. The Thai Government plan to increase use of biofuels entails a differential taxation and subsidy system that are favourable to higher blends of ethanol in gasoline.

The Indian government should continue to support the production of ethanol from molasses. It is assumed, however, that the observed blending share of ethanol in gasoline will remain lower than the 5% mandate and will decline over the projection period. The Indonesian government has a 20% biodiesel blending mandate; however this *Outlook* assumes this mandate will not be fulfilled as the development of biodiesel is related to the potential attribution of subsidies to biodiesel producers who depend on vegetable oil exports.

Given these policy assumptions as well as the IEA assumptions concerning future diesel and gasoline demand across the world, global ethanol production should expand from 120 bln L in 2017 to 131 bln L by 2027, while global biodiesel production should increase from 36 bln L in 2017 to 39 bln L by 2027. By 2027, 55% of global ethanol production should be based on maize and 26% on sugarcane. In 2027, about 20% of global biodiesel production should be based on waste vegetable oils. Advanced biofuels based on residues are not expected to take off over the projection period due to lack of investment in research and development.

Trade disputes related to biofuels have had a major impact on the recent evolution of biofuel trade. Following a 2018 WTO ruling, Argentina and Indonesia can again export biodiesel with lower duties to the European Union. However, anti-dumping duties have recently been set up in the United States against these countries' biodiesel, and which may once again be challenged at the WTO. As such, this *Outlook* assumes biofuel trade will remain limited. Potential ethanol exporters are the United States, as the blend wall limits further increases in domestic demand, and Brazil. Brazilian ethanol exports are, however, not expected to increase as US ethanol will likely remain cheaper over the outlook period. On the biodiesel side, Argentina will likely be the major player, but with limited import demand.

Main assumptions

Since the early 2000s, the development of global biofuel markets has been driven by policies encouraging their production and use. Policies were initially motivated by a combination of factors, including the view that biofuel use would improve energy security and reduce greenhouse gas emissions (GHG). Government support for the biofuel industry takes the form of blending mandates, exemptions from taxes applied to corresponding petroleum fuels, and investment support. Biofuel markets are also affected by policies that apply sustainability criteria, fuel quality standards, and import tariffs on ethanol and biodiesel. The projections presented in this *Outlook* are based on a set of assumptions concerning the evolution of biofuel policies around the world in the medium term.

In the United States, the EISA defined in 2007 the Renewable Fuel Standard programme (RFS2).[4] Under this programme, EISA established four quantitative annual mandates up to 2022: the total and advanced mandates that require fuels to achieve at least a 20% and a 50% GHG reduction respectively, as well as the biodiesel and the cellulosic mandates that are nested within the advanced mandate. The Environmental Protection Agency (EPA) establishes on an annual basis the minimum quantities for each of the four classes of biofuels required.

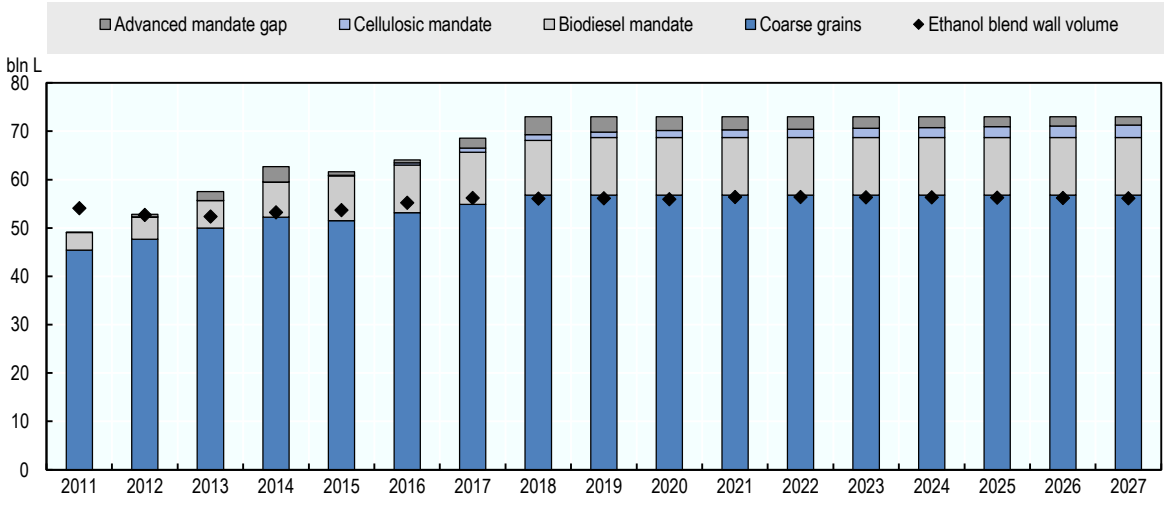
The EPA final rulemaking for 2018 and the biodiesel volume requirement for 2019 were issued in November 2018. Similar to the 2017 final rulemaking, an important part of the initial levels proposed in EISA for the total, the advanced and the cellulosic mandates was waived based on the fact that production capacity for cellulosic ethanol has not developed; the conventional gap,[5] often referred to as an implied coarse grains mandate constant, was maintained at 56.8 bln L. The final standards recently announced were kept at high level; which means that in view of the stagnating or decreasing prospects of gasoline and diesel demand, the availability of higher ethanol blends at the pump will need to be developed somehow over the short- to medium-term. At present, even if the maximum blend of ethanol for conventional petrol vehicles is set in the United States at

15% for vehicles produced in 2001 or later, E10[6] is still the most commonly available gasohol in the United States due to the blend wall constraints.

This *Outlook* assumes that all categories of mandates will remain at their recently announced levels in volume terms despite the decreasing use of transportation fuel. The exception is the cellulosic mandate, which is assumed to more than double over the projection period, even if reaching only 4.5% by 2027 of the level specified in EISA. It is assumed that the cellulosic mandate will be filled, mostly with renewable compressed natural gas and renewable liquefied natural gas. The ethanol blend wall is set to expand moderately beyond 10% to reach 11.3% by 2027.

Figure 9.2 shows the assumed evolution of mandates in the United States and the blend wall ethanol volume, i.e. the ethanol volume that can be consumed in the United States according to the expected evolution in gasoline use and blend wall constraint. In 2018, the conventional gap should be slightly above the volume of ethanol that can be blended according to the blend wall issue. Biodiesel use is thus projected to remain at levels close to 9.5 bln L in the early years of the outlook period, above the biodiesel mandate, in order to meet part of the advanced mandate, while imports of sugarcane-based ethanol should remain limited. In the latter years of the projection period, the advanced mandate gap is expected to narrow. The biodiesel blender tax credit is not assumed to be reinstated over the outlook period, and antidumping duties on Argentinean and Indonesian biodiesel are assumed to limit US biodiesel import demand.

Figure 9.2. Assumptions concerning the US biofuel mandates



Note: The advanced mandate gap, the gap between the advanced mandate and the sum of the biodiesel and cellulosic mandated volumes, can be met by biofuels being able to achieve a 50% greenhouse gas reduction such as cellulosic biofuels, sugarcane based ethanol or biodiesel.
Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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The 2030 Framework for Climate and Energy Policies for the European Union,[7] which targets a 40% cut in GHG emissions by 2030 compared to 1990 and a renewable energy share of 27% by 2030, does not propose concrete targets for the transport sector after 2020. At present, the policy framework concerning biofuels is determined by the 2009 Renewable Energy Directive[8] which states that renewable fuels (including non-liquids)

should increase to 10% of total transport fuel use by 2020 on an energy-equivalent basis, and by the Fuel Quality Directive which requires fuel producers to reduce the GHG intensity of transport fuels by 2020. Both directives were amended in September 2015 by a new Directive referred to as the Indirect Land Use Changes (ILUC) Directive,[9] and which introduced a 7% cap on renewable energy in the transport sector coming from food and feed crops.

This *Outlook* assumes a continuation of current policies at the European and Member country levels. In accounting for the fact that each unit of advanced biofuel consumed – including those produced from used cooking oil and tallow – counts double for the purpose of the RED, the projection assumes that the portion coming from biofuels expressed in energy share will reach 5.9% by 2020 and to decrease to 5.8% by 2027. The remainder of the 10% RED target should be met from other renewable energy sources. The portion of renewable energy in the transport sector coming from food and feed crops in the European Union should remain well below the current 7% cap at 4% on average over the projection period.

The evolution of biofuel policies in the European Union is likely to evolve in the near term. The European Parliament proposed on 17 January 2018 to reach 12% renewable energy in transport fuel by 2030. This proposal states that the consumption of biofuels based on food and feed feedstock cannot increase above the 2017 levels[10] and defines a 7% cap for food and feed biofuels at the Member States level. Palm oil-based biodiesel would be prohibited after 2021 and the share of advanced biofuels, including waste-based biofuels, should reach 1.5% by 2021 and 10% by 2030. The current *Outlook* does not take this proposal into account.

In Canada, the federal Renewable Fuels Regulations mandates 5% renewable content in gasoline and 2% in diesel fuel. This regulation could be replaced some time in 2019 by the Canadian Clean Fuels Standard (CFS), the regulatory framework of which was presented in December 2017. The CFS would apply to liquid, gaseous and solid fuels combusted for the purpose of creating energy, in addition to the transportation sector. It would use a lifecycle approach to set carbon intensity requirements. The objective is to achieve 30 Mt of annual reductions in GHG emissions by 2030, contributing to Canada's effort to achieve an overall GHG mitigation target of 30% emission reduction below 2005 levels by 2030.

In Brazil, flex-fuel vehicles can either run on gasohol or on E100 (hydrous ethanol). Over the projection period, it is assumed that the anhydrous ethanol mandatory blending requirement for gasohol will remain at 27% and that the differentiated taxation system will continue to be favourable to hydrous ethanol rather than blended gasohol in key Brazilian states. The 10% biodiesel mandate is assumed to be met by 2020. The RenovaBio program, a follow-up of Brazil's commitment under the 2015 Paris Climate Agreement to reduce greenhouse gas emissions by 37% in 2025 and 43% in 2030 compared to 2005, was officially signed in January 2018 with a not-yet defined implementation plan. The programme defines a minimum blending target for anhydrous fuel ethanol that should reach 30% by 2022 and 40% by 2030 as expressed in volume terms. The fuel ethanol share in the fuels matrix should reach 55% by 2030 according to RenovaBio, compared to the 50% share met in this baseline. This latter objective is not included in this *Outlook*.

Argentina's 10% biodiesel and 12% ethanol mandates are expected to be filled by 2020. Tax exemptions should continue to boost the development of the Argentinean biodiesel industry. However, trade barriers set by the United States on Argentinean biodiesel will

likely imply limited export demand for Argentinean biodiesel. In 2017, Colombia ethanol blending share was about 7.5%. While total ethanol demand is expected to increase, the ethanol volume share in gasoline is assumed to reach 8% by 2020 and to remain stable thereafter. Such an outcome is in part due to the limited availability of feedstuffs, in particular sugarcane.

Another major uncertainty on biofuel markets arises from China. In September 2017, the Chinese government announced a new nationwide ethanol E10 mandate by 2020. Mechanisms for implementation and enforcement have not been announced yet and thus this announcement is not taken into account in this *Outlook*. Box 9.1 provides a description of the potential impact of such a move. This *Outlook* assumes that Chinese use of ethanol is to expand by about 1 bln L. Chinese ethanol is expected to be produced domestically from maize – thus helping to lower domestic stocks – and from cassava.

Biodiesel production is also heavily dependent on policies in palm oil producing countries, especially Indonesia. After a decline in production in 2016, the Indonesian government made a strong commitment to reach a 10% biodiesel mandate; the currently rate is around 7%. This *Outlook* foresees that biodiesel demand will expand rapidly, and by 2027 the biodiesel volume share in diesel-type fuels could reach 8%, well below the newly announced target of 20% by 2030. Such a development relies entirely on the capacity of the government to collect the adequate levels of exports taxes and levies applied to palm oil exports.

The government in India is not foreseen to enforce the 10% ethanol mandate. The current volume share of ethanol in gasoline is around 3% and, as ethanol expansion should not keep pace with the strong expected growth in gasoline demand, this share should decrease over the projection period to 2.4%. In Thailand, the government has set targets for ethanol and biodiesel use of 4.1 bln L and 5.1 bln L by 2036. However, due to low oil prices and the potential limited availability of feedstuffs, such target could be reduced to only 2.6 bln L for both, ethanol and biodiesel. This *Outlook* assumes targets of 3.1 bln L for ethanol and 1.8 bln L for biodiesel by 2027. The development of ethanol production should be driven by subsidies and different levels of taxes that lower the prices of high ethanol blends.

Elsewhere in the world, development of the comparatively minor biofuels markets depends on a mix of effective policy support and price trends, leading to mixed prospects across countries.

Box 9.1. Biofuel policy announcement in China

The evolution of biofuel markets over the past decade has been strongly related to the policy environment. This *Outlook* highlights that developing countries are likely to play a more important role on biofuel markets in the coming years. There are several reasons for this. Transportation fuels demand is likely to continue to grow in those countries whereas it should either stagnate or decrease in developed countries. Biofuels being mostly blended in transportation fuels, even a stable biofuel mandate would translate into higher biofuel demand. Trade uncertainty is rising on biofuel markets. Major biofuel producers in developing countries (Brazil, Argentina, Indonesia) had developed their biofuel industries not only for domestic use but also given prospects on key markets in developed countries (United States and European Union). The European Union and the United states have used trade duties to prevent imports of biofuels. Developing countries have responded by an encouragement of domestic biofuel use, in particular through increases in mandates.

Importantly, in September 2017 the Chinese government proposed a new nationwide ethanol mandate that expands the mandatory use of E10 fuel from 11 trial provinces to the entire country by 2020. The underlying rationale for that announcement has not been clearly stated but could be related to abundant grains stocks and to environmental concerns.

Mechanisms for implementation and enforcement have not been announced yet. If fully implemented these policies could have important impacts on biofuel and agricultural markets, reinforcing the potential importance of developing countries in the medium-term projections.

Table 9.1. Potential impacts of an implementation of E10 in China

Comparison of different hypothesis

		Base-line	H1: 100% of AEU produced in China[1]	% change	H2: 90% of AEU imported from the United States[1]	% change	H3: 90% of AEU imported from Brazil[1]	% change
Ethanol markets in 2027 in bln L								
China	Ethanol production	11.1	29.1	163%	12	8%	12	8%
	Ethanol fuel use	4.4	22.4	414%	22.4	414%	22.4	414%
	Ethanol net trade	0.1	0.1	0%	-17	-15585%	-17	-15585%
	Volume share of ethanol in gasoline-type fuels	2%	10%	400%	10%	400%	10%	400%
United States	Ethanol production[2]	60.3			77.5	28%		
	Ethanol net trade	2.7			19.9	626%		
Brazil	Ethanol production[1]	32.8					48.2	47%
	Ethanol net trade	1					16.4	1576%
Agricultural markets in 2027 in Mt								
China	Maize production	241.5	256.3	6%	241.5	0%	241.5	0%
	Maize stocks[3]	71.3	57.1	-20%	69.9	-2%	69.9	-2%
	Maize biofuel use	17.9	46.9	163%	19.3	8%	19.3	8%
United States	Maize production	390.2			431.6	11%		
	Maize biofuel use	145.3			186.7	29%		
Brazil	Sugarcane production	789.5					961.9	22%
	Sugarcane biofuel use	365.4					537.8	47%

Note: This table does not correspond to a scenario run, but to simple calculations based on the baseline.
1. AEU: Additional Ethanol Use in China because of the E10 policy.
2. The share of the various feedstocks in ethanol production is kept constant in the different hypothesis.
3. Maize stocks in China are assumed to be depleted to produce ethanol. In H1, 50% of AEU is produced out of maize stocks. In H2 and H3, 10% of AEU is produced out of maize stocks.
Source: OECD-FAO Secretariats.

Table 9.1 provides an overview of the scale of potential impacts that have been calculated based on the *Outlook* baseline. In China, different hypothesis have been explored: additional ethanol could be mostly produced domestically from grains (with maize remaining the major feedstock and cassava the second major feedstock) (H1) or could be mostly imported from the United States (H2) or Brazil (H3).

The implementation of E10 in China over the next decade would correspond to an additional ethanol use (AEU in the table) of 18 bln L in 2027 when compared to the baseline. In terms of scale, ethanol use in China would then be comparable to ethanol use expected in the baseline for Brazil in 2027. Chinese fuel use of ethanol would quadruple, and Chinese ethanol use in 2027

would be 165% higher than the baseline value.

In H1, the AEU would be entirely met with ethanol produced in China.[1] The impacts on the Chinese maize markets could be substantial as an additional 29 Mt of maize would need to be used to meet the E10 mandate. In the calculations, H1 corresponds to a decrease of maize stocks by 20% when compared to the baseline and to an increase of Chinese maize production by 6% when compared to the baseline for 2027.

In the *Outlook*, Chinese maize stocks should reach 71 Mt by 2027. The scale of the additional volume of maize that needs to be devoted to ethanol in China (around 30 Mt p.a. in a context of rising gasoline demand) if E10 is fully implemented would mean that maize stocks would be quickly depleted. If no maize stocks were available and AEU was to be met by Chinese ethanol, Chinese maize production would need to be 12% higher than in the baseline in 2027.

In H2, 90% of AEU is imported from the United states. This hypothesis corresponds to a decrease by 2% of Chinese maize stocks in 2027 and to an increase of 41Mt of maize use for ethanol production in the United States in 2027. If grown entirely in the United States, the volume of domestic maize production in the United States would need to be 11% stronger than in the baseline in 2027. In H3, 90% of AEU is imported from Brazil. This hypothesis corresponds to a decrease by 2% of Chinese maize stocks in 2027 and to an increase of 168 Mt of sugarcane use for ethanol production in Brazil in 2027. If entirely grown in Brazil, the volume of domestic sugarcane production would need to be 22% stronger than in the baseline in 2027.

In conclusion, all three hypotheses presented in the table are hypothetical. However they provide a good illustration of the potential scale of impacts of an E10 implementation in China at the country-level. The AEU would be likely to be met by a mix of domestically produced and imported ethanol. What is clear however is that the depletion of Chinese maize stocks could meet part of the AEU for few years but certainly not for an extended period of time.

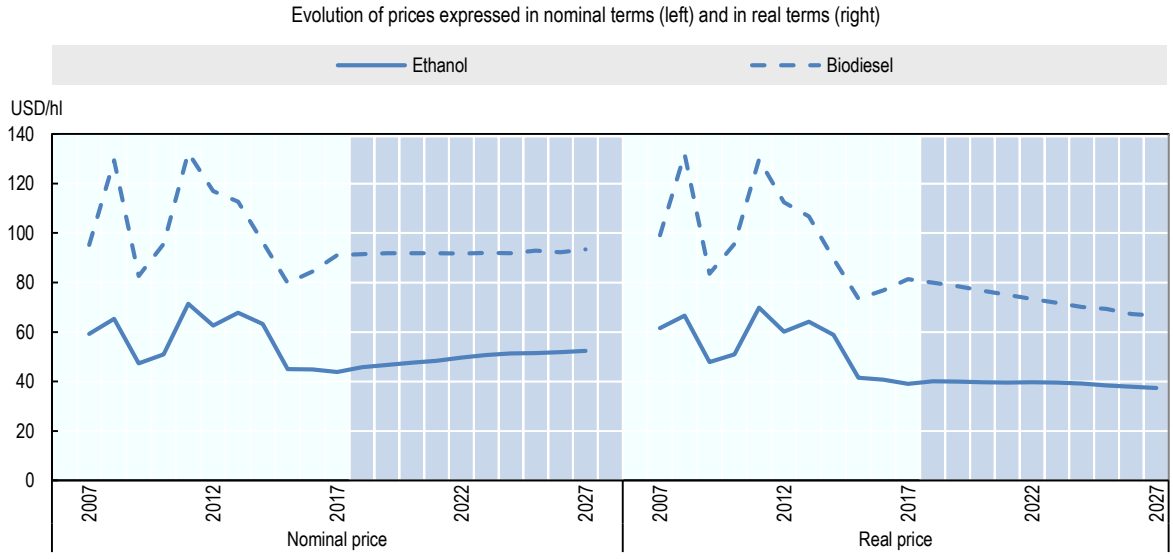
1. The calculations assumed that current ethanol feedstocks used in China (maize, cassava, wheat and other coarse grains) would continue to be used in the same proportion.
Source: Own calculation based on OECD/FAO (2018).

Prices

International crude oil prices are expected to increase by 40% in nominal terms over the baseline period. This should lower demand for gasoline and diesel fuels in developed countries and hence mandated demand for biofuels. Demand for biofuels should remain sustained in major developing countries given expected developments in the transportation fleet and domestic policies in place. Biofuel prices, similar to biofuel feedstock prices, should trend slightly upward but at a slower pace than energy prices.

Influenced by developments on the vegetable oil markets, biodiesel prices are expected to increase at a slower pace (+3%) than ethanol prices (+20%) in nominal terms. Expressed in real terms, biodiesel prices should decrease by 18% over the projection period, while ethanol prices should decline by 4%.

Figure 9.3. The evolution of biofuel prices is related to the evolution of biofuel feedstock prices



Note: Ethanol: wholesale price, US, Omaha; Biodiesel: Producer price, Germany, net of biodiesel tariff and energy tax.
Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Ethanol

Production

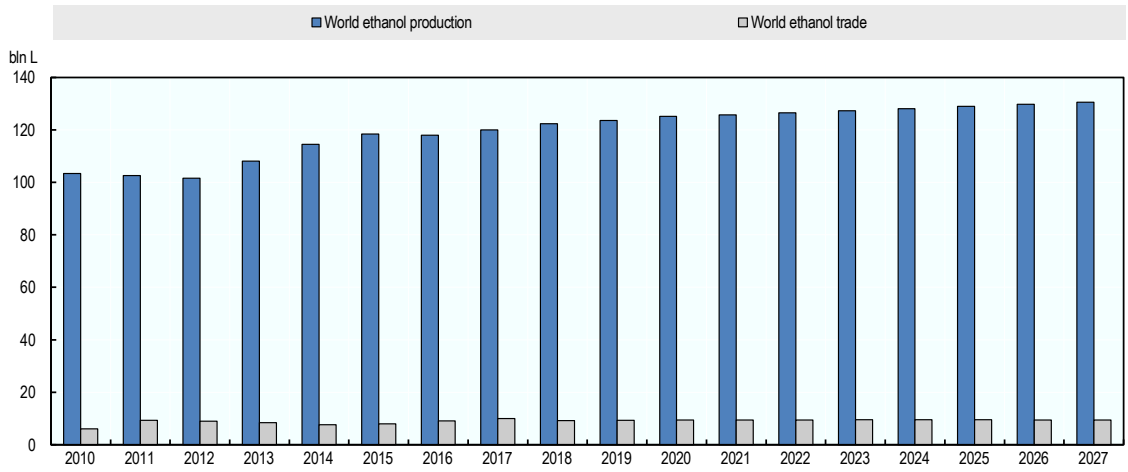
Global ethanol production is projected to increase by 14% during the outlook period from about 120 bln L in 2017 to nearly 131 bln L by 2027 (Figure 9.4). Fifty per cent of this increase is expected to originate from Brazil, to fill domestic demand. The other large contributors to the expansion in ethanol production are Thailand, China, India and the Philippines with respectively a 12%, 10%, 9% and 5% share in the global increase. The United States is expected to remain the major ethanol producer, followed by Brazil, China and the European Union. The evolution of ethanol production in developed and developing countries contrasts with increases in the developing world and stagnation or decreases in developed countries.

Coarse grains and sugarcane will continue to be the dominant ethanol feedstock. Ethanol production is expected to use 15% and 18% of global maize and sugarcane production respectively in 2027. Biomass-based ethanol is projected to account for about 0.3% of world ethanol production by 2027.

In the United States, ethanol production derived mainly from maize should remain around 61.6 bln L in the early years of the projection period, due mainly to domestic demand linked to the conventional gap and to the higher blend wall and also to a lower extent to international demand from Japan, Canada and the European Union. In the latter years of the outlook period, US ethanol production should decrease to 60.4 Bln L with lower domestic and international needs related to decreasing gasoline demand in developed countries.

Ethanol markets in Brazil are expected to be driven by the assumptions concerning blending requirements for gasohol and the differential taxation system which is favourable to hydrous ethanol. Brazilian ethanol production is thus projected to increase from 27.2 bln L in 2017 to 32.7 bln L in 2027.

Figure 9.4. Development of the world ethanol market



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Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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China should consolidate its role as the third leading ethanol producer, with production reaching 11 bln L by 2027. The expected 1.1 bln L production increase over the projection period should be used to meet domestic use. Chinese ethanol is expected to be produced domestically from maize using domestic stocks and from cassava. These projections do not take into account the E10 announcement made by Chinese authorities in September 2017.

In the European Union, ethanol production for fuel use mainly based on wheat, coarse grains and sugar beet is projected to decrease from 7.3 bln L in 2020 to 7.1 bln L by 2027 given assumptions of decreasing gasoline use. Sugar beet based ethanol production should stabilise around 1.4 bln L. In fact, ethanol production from sugar beet in the European Union should be less profitable than ethanol production from other cereal feedstocks due to higher production costs.

Thailand ethanol production is foreseen to increase at about 6% p.a. While production has historically been based mainly on molasses and cassava, sugarcane could increase its share given the limited availability of the other two feedstuffs to meet the rapid growing domestic demand. By 2027, Thai ethanol production should reach 3.2 Bln L. India is expected to increase ethanol production by 0.8 bln L during the outlook period, with around 95% of the total production coming from molasses.

Use

Global ethanol use is projected to expand by about12 bln L during the outlook period; 80% of this increase will take place in developing countries with Brazil, China, India and Thailand playing a key role. Ethanol use in Brazil should expand by 5.4 bln L

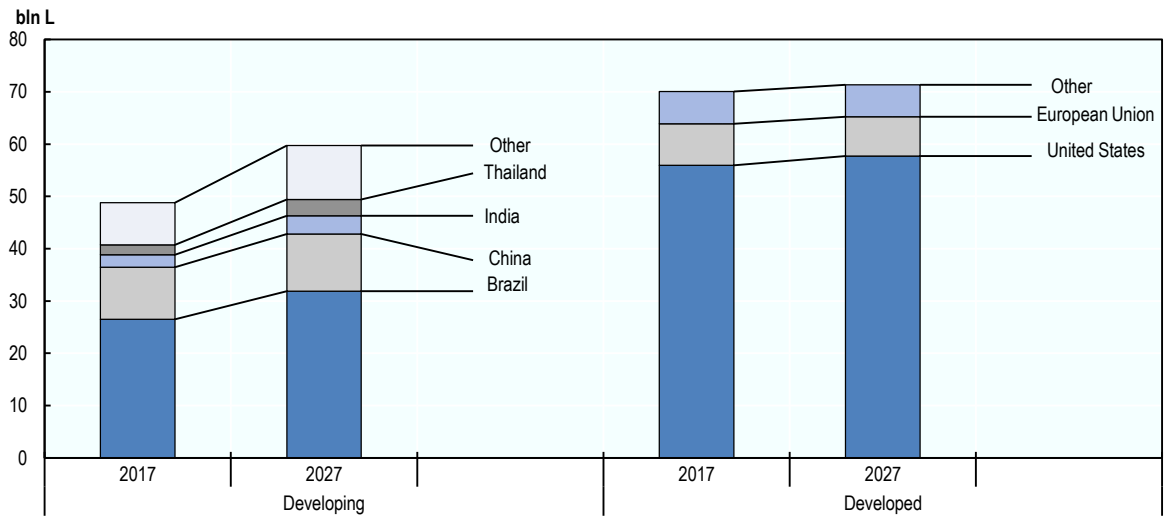
representing 42% of the global increase. The Brazilian taxation system will remain favourable to hydrous ethanol rather than gasohol, which corresponds to the mandatory mix of 27% ethanol with gasoline. In China, ethanol use is expected to expand by 1 bln L. Because of mandates in place in some provinces, the volume share of ethanol in gasoline-type fuels will be around 2% over the projection period. Box 7.1 provides an overview of the scale of a move to an E10 country-wide policy.

In the last decade, Thailand increased its ethanol fuel use by 1 bln L. This trend is foreseen to continue and it is expected that by 2027 ethanol fuel demand will reach 2.8 bln L. The ethanol volume share in gasoline fuels should increase from 14% in 2017 to 16% by 2027. The expansion of Thai ethanol fuel demand is driven by the subsidies to gasohol with high blends of ethanol, as well as obligatory blending for ethanol. After dropping in 2017, Indian ethanol demand is foreseen to recover increasing 4.5% p.a. for the projection period, adding a total of 0.7 bln L by 2027 with respect to the base period. The volume share of ethanol in gasoline fuels in India is to remain around 2% over the projection period.

Ethanol use in the United States is linked to mandates in place and limited by a marginally expanding blend wall as well as declining petrol use prospects. The share of ethanol (expressed in volume) in gasoline-type fuels should increase to 11.3% by 2027 (Figure 9.5), but ethanol fuel use should decrease to 56 bln L, down from its maximum volume of 56.5 bln L in 2021.

In the European Union, ethanol fuel use is expected to expand in the first part of the projection period to decrease to 5.1 bln L by 2027. This is due to decreasing gasoline use despite a stable average volume share of ethanol in gasoline up to 2020 at 4.8% decreasing to 4.7% by 2027.

Figure 9.5. Evolution of the regional distributions of world ethanol use



Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Trade

Global ethanol trade is expected to remain marginal, decreasing from 8% of global production in 2017 to 7% by 2027. It should decrease to 9.4 bln L by 2027. Ethanol net import needs from the European Union should decrease from 0.6 bln L in 2017 to 0.45 bln L by 2027. Other countries such as Japan and Canada should diminish their import needs because of their decreasing use of transportation fuels.

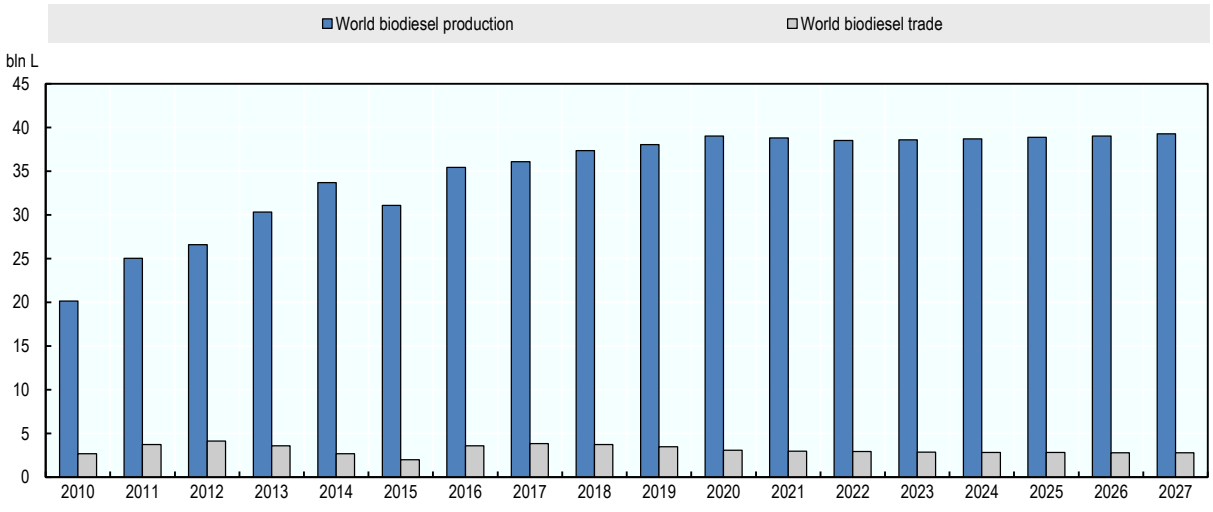
The United States is expected to remain a net exporter of maize-based ethanol and a modest importer of sugarcane-based ethanol. The need for sugarcane-based ethanol imports is related to the Low Carbon Fuel Standard in place in California and to the limited filling of the advanced mandate. US ethanol exports should decrease over the projection period because of a combination of strong domestic demand and weak international demand. Brazilian ethanol exports are not expected to expand over the projection period given that the Brazilian ethanol industry will mostly fill sustained domestic demand and that domestic ethanol prices are expected to remain slightly above international ones.

Biodiesel

Production

Global biodiesel production is expected to reach 39.3 bln L by 2027 corresponding to a 9% increase from the 2017 level (Figure 9.6). Policy rather than market forces will continue to influence production patterns. The European Union is expected to remain by far the major producer of biodiesel. Production should reach 12.9 Bln L by 2027, down from 13.5 bln L in 2017 and 14 bln L in 2020 when the RED target is supposed to be met. This evolution is in particular related to lower diesel use prospects.

Figure 9.6. Development of the world biodiesel market



Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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Vegetable oil continues as the feedstock of choice in biodiesel production. Biodiesel production based on waste oil and tallow will continue to play an important role in the European Union and the United States.

In the United States, the second major biodiesel producer, biodiesel production should increase from 6.9 bln L in 2017 to a record 7.2 bln L in 2019 and then decrease to 6.7 bln L by 2027. It will be used to meet the biodiesel mandate as well as part of the advanced mandate gap. It is expected that, despite anti-subsidy duties imposed on Argentine and Indonesian biodiesel, biodiesel imports will be necessary to fulfil the US advanced mandate gap, especially in the early years of the projection period.

Brazil should reinforce its position as the third major biodiesel producer and contribute to more than 50% of the global biodiesel production expansion, in particular because of its 10% domestic mandate. By 2027, Brazil biodiesel production should reach 5.6 bln L. Even if domestic blending is set to rise to 12% in 2020, Argentine biodiesel production is projected to decrease over the next decade from 3.7 bln L in 2017 to 3.3 bln L in 2027 due to lower import demand. Other significant players are Brazil, Indonesia and Thailand.

After a decline in 2015 due to a shift in policies, Indonesian biodiesel production recovered in 2016, driven mainly by growing domestic demand. However in 2017 due to lower exports, production declined although is expected that it will recover in 2018. The *Outlook* foresees that exports will increase slightly over the projection period, notwithstanding they will become a less relevant driver for Indonesian biodiesel production. Indonesian biodiesel production should reach 4.2 bln L by 2027. The main uncertainty surrounding this increase in biodiesel production is the viability to continue collecting the export levy on Crude Palm Oil (CPO) exports, which serves to finance the subsidy to biodiesel producers. Malaysia and the Philippines will continue expanding their biodiesel production. Malaysia domestic demand is expected to accelerate, therefore the exports shares of the domestic production will decline from 32% in the base period to 27.6% in 2027. The Philippines' production is expected to remain focussed on supplying the domestic market.

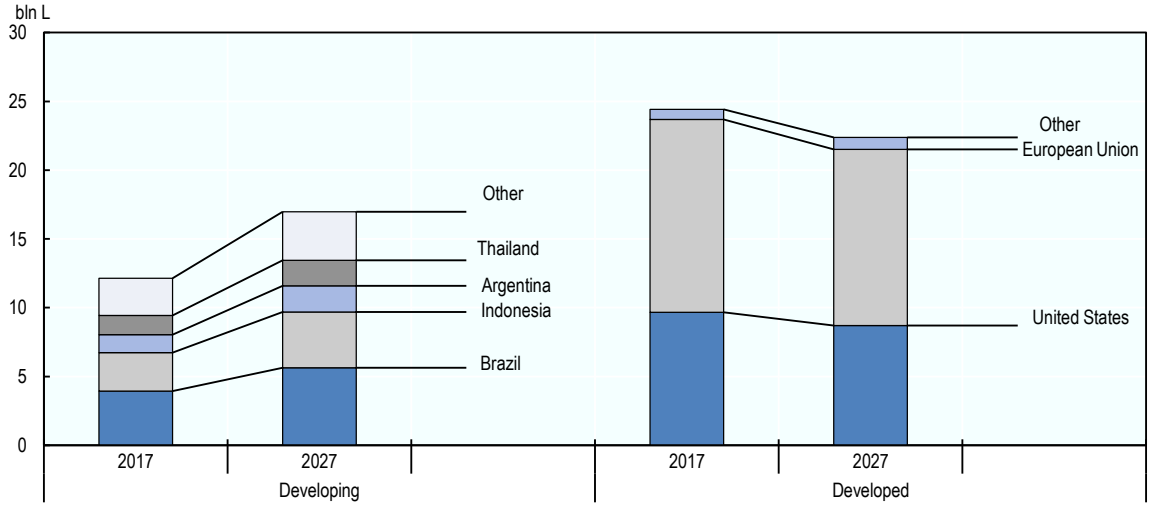
Use

Biodiesel use should decrease in developed countries and expand steadily in developing countries (Figure 9.7). Biodiesel use in Indonesia is foreseen to reach 4.1 bln L in 2027. In Brazil and Argentina it is expected to rise up to 5.6 bln L and 1.9 bln L respectively by 2027 given increases in domestic mandates. Because of biodiesel blending requirements, Colombia, India, Malaysia, Paraguay, Thailand, and Philippines will also see expanding biodiesel use; most countries are starting from very low levels of consumption and their biodiesel volume share in diesel fuels will remain between 1% and 3%, with the exception of Colombia where the blend is expected to remain around 6.5%.

In the European Union, biodiesel use is projected to average around 14 bln L in the period

leading to 2020 when the RED target is met. By 2027, European biodiesel use is expected to decrease to 12.8 bln L due to an expected strong decrease in diesel use. The average share of biodiesel in diesel-type fuels should reach its highest level in 2020 with almost 6.3% and then decrease to 6.1% by 2027.

Figure 9.7. Evolution of the regional distributions of world biodiesel use



Source: OECD/FAO (2018), "OECD-FAO Agricultural Outlook", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-outl-data-en.

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In the United States, the mandate for biodiesel is assumed to maintain the 7.9 bln L level specified for 2018 and 2019 in the 2018 RFS rulemakings over the outlook period. US biodiesel consumption volume share in diesel-type fuels is projected to decrease from 4.4% in 2017 to 4.1% by 2027. In the early years of the projection period, biodiesel use will remain well above the biodiesel mandate (9.5 bln L on average over the 2017-2020 period) as biodiesel should capture a share of the advanced mandate in a period when additional ethanol use is limited by the blend wall. Biodiesel use should then decrease by about 8%, in a context of declining diesel consumption.

Trade

Biodiesel trade is subject to uncertainties concerning the future of current trade disputes. In this *Outlook*, biodiesel trade is projected to retract by 25% or 1 bln L over the next ten years as most countries with biodiesel mandate or target will fill them domestically and import demand from developed countries and especially the United States and the European Union should diminish.

Argentina should remain the lead biodiesel net exporter followed by Malaysia, Indonesia and Canada. Argentine exports are expected to retract by 43% over the projection period. Indonesia's exports are expected to decline further in the following three years recovering thereafter, however by 2027 the exports would remain below their 2016 levels. Malaysia's exports are projected to increase around 2.7% p.a. reaching 0.225 bln L by 2027, becoming the fifth largest exporter of biodiesel

Main issues and uncertainties

Developments on biofuel markets are strongly related to biofuel policy packages, the macroeconomic environment, and the level of crude oil prices. In the medium term, the policy environment remains uncertain. This *Outlook* expects that most of the biofuels produced will be based on agricultural feedstock. It is thus likely that biofuel production

will have direct and indirect effects on the environment, on land use, and to a certain extent on agricultural markets in the medium term.

Revisions to biofuel policies are expected in the near future. Recent policy announcements appear to be favourable to biofuels with a focus on the potential contribution of renewable fuels to greenhouse gas mitigation in the transportation sector. It is not yet clear whether those announcements will mean stronger investments in research and development for advanced biofuels produced from ligno-cellulosic biomass, waste or non-food feedstock.

Notes

1 The blend wall refers to technical constraints that act as an impediment to increased ethanol use in gasoline.

2 The advanced mandate requires fuels to achieve at least a 50% GHG reduction.

3 Gasohol is a mixture of gasoline and anhydrous ethanol.

4. www.epa.gov/OTAQ/fuels/renewablefuels/.

5 The conventional gap is the difference between the total and advanced mandates as defined by the Renewable Fuel Standard (RFS2).

6 E10 refers to gasohol (i.e. the mix of gasoline and ethanol) with 10% volume of ethanol blended into petrol.

7 http://ec.europa.eu/clima/policies/2030/index_en.htm.

8 http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0016:0062:EN:PDF.

9 Directive (EU) 2015/1513.

10 Except for countries whose share of food and feed based renewables in transportation fuels is below 2%.