OECD-FAO Agricultural Outlook 2011-2020

Chapter 3

Biofuels

Market situation

World ethanol prices[1] increased by more than 30% in 2010 in the context of a new commodity price spike of ethanol feedstocks, mainly sugar and maize, and firm energy prices. This situation contrasts with 2007/08 where ethanol price movements did not follow the pace of the commodity price increases and ethanol profit margins were reduced. The US became for the first time a net exporter of ethanol in 2010, while exports from Brazil were reduced significantly in a context of sky-high raw sugar prices and relatively more competitive corn-based ethanol when compared to the previous years.

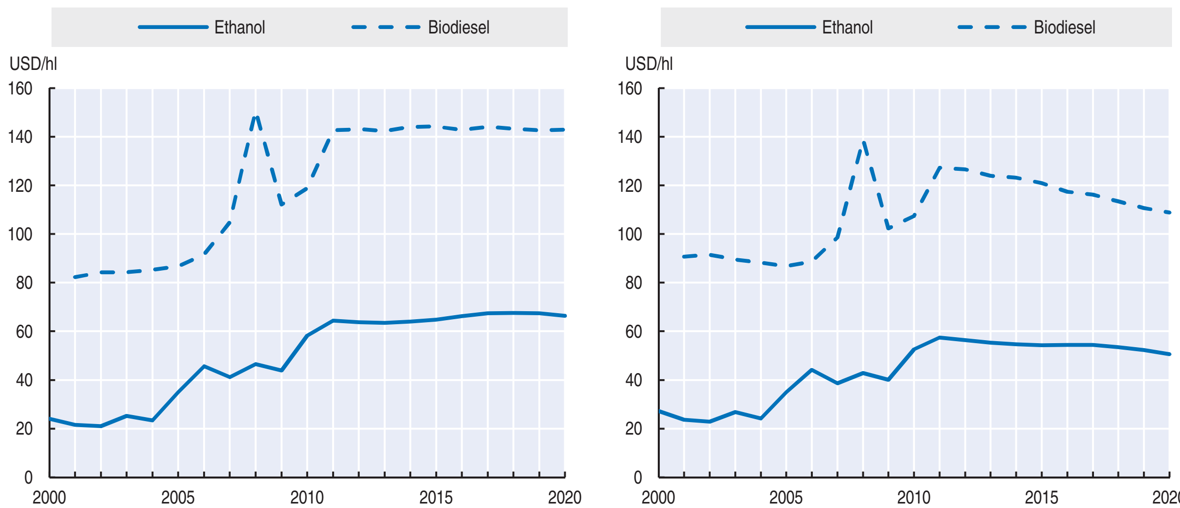
World biodiesel prices[2] have increased in 2010 in a context of rising rapeseed and other vegetable oil prices and high crude oil prices. This price increase is smaller in proportion than for ethanol due to the fact that biodiesel prices remained relatively firm in 2009 compared to crude oil and world vegetable oil prices.

Projection highlights

- World ethanol and biodiesel prices are expected to continue to rally in 2011. Over the Outlook period, ethanol and biodiesel prices are expected to remain firm as policies promoting biofuel use are being implemented and crude oil prices are expected to remain strong (Figure 3.1). Global ethanol (Figure 3.2) and biodiesel production (Figure 3.3) are projected to continue to expand rapidly over the next ten years.
- The US is expected to remain the largest ethanol producer and consumer. As raw sugar prices are projected to fall, sugar cane based ethanol should become more competitive than in 2010 and exports from Brazil should recover in the early years of the Outlook period. The European Union is expected to be by far the major producer and user of biodiesel. Some developing countries (Argentina, Malaysia and Thailand) could play a significant role in biodiesel exports.
- Biofuel production projections in many developing countries are quite uncertain following little or no production increases in recent years. The cultivation of new feedstocks, like jatropha or cassava, does not yet allow for large-scale biofuel production.

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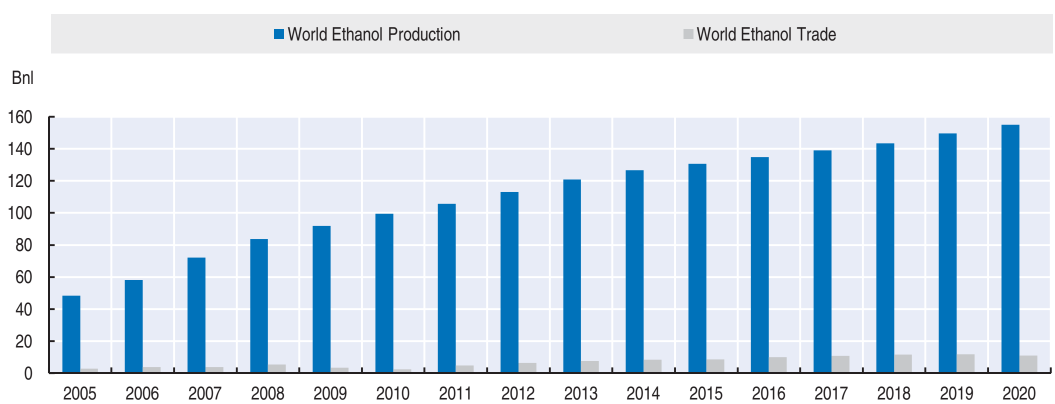
Figure 3.2. **Development of the world ethanol market**



Source: OECD and FAO Secretariats.

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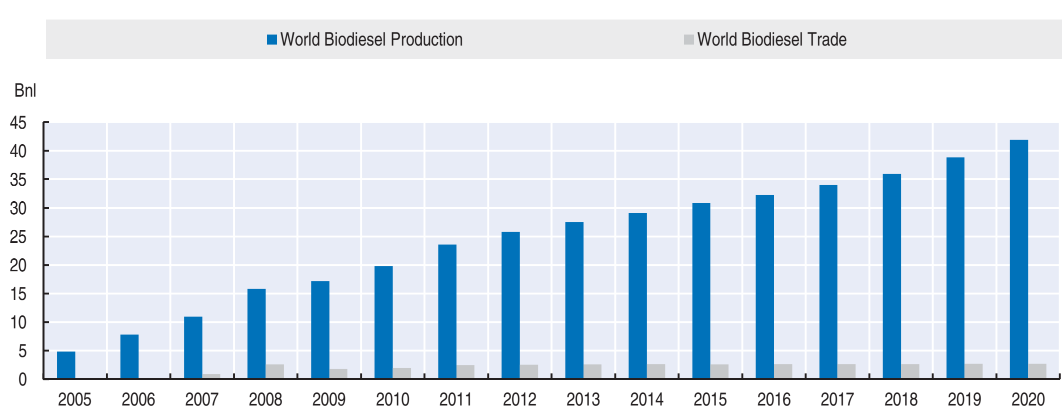
Figure 3.3. **Development of the world biodiesel market**



Source: OECD and FAO Secretariats.

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Market trends and prospects

Prices

Crude oil prices are assumed to continue to rally in 2011 and to remain constant in real terms over the remainder of the Outlook period. Expressed in nominal terms, they are projected to reach USD 107/barrel by 2020. World ethanol and biodiesel prices are expected to increase further in 2011. This increase is expected to be stronger for biodiesel, which should bring price ratios of biodiesel to vegetable oil and crude oil closer to their pre-2007 levels.

The expansion of biofuel production and use over the projection period should be mainly driven as in the past years by policy support in the forms of use mandates or other targets that impact use, tax relief for producers and consumers of biofuels, broader protection measures and fuel quality specifications as well as by investment capacities in leading producing countries.

In this context, ethanol and biodiesel prices are expected to remain firm over the Outlook period (Figure 3.1). They are projected to be on average 80% higher than over the previous decade in the case of ethanol and 45% in the case of biodiesel. They will reach, respectively, USD 66.4 per hl and USD 142.9 per hl by 2020. Prices should decrease slightly when expressed in real terms over the Outlook period but the ratios of biofuel prices to major biofuel feedstock prices are expected to remain relatively stable.[3] Biofuels are expected to become somewhat more competitive over the course of the projection period as their prices should increase less rapidly than crude oil prices.

Production and use of biofuels

Driven by policy mandates and renewable energy goals around the world, global ethanol and biodiesel productions are projected to continue their rapid increases over the projection period and to reach respectively some 155 bnl and 42 bnl by 2020. These projections are subject to important uncertainties which are described below in the main uncertainties section.

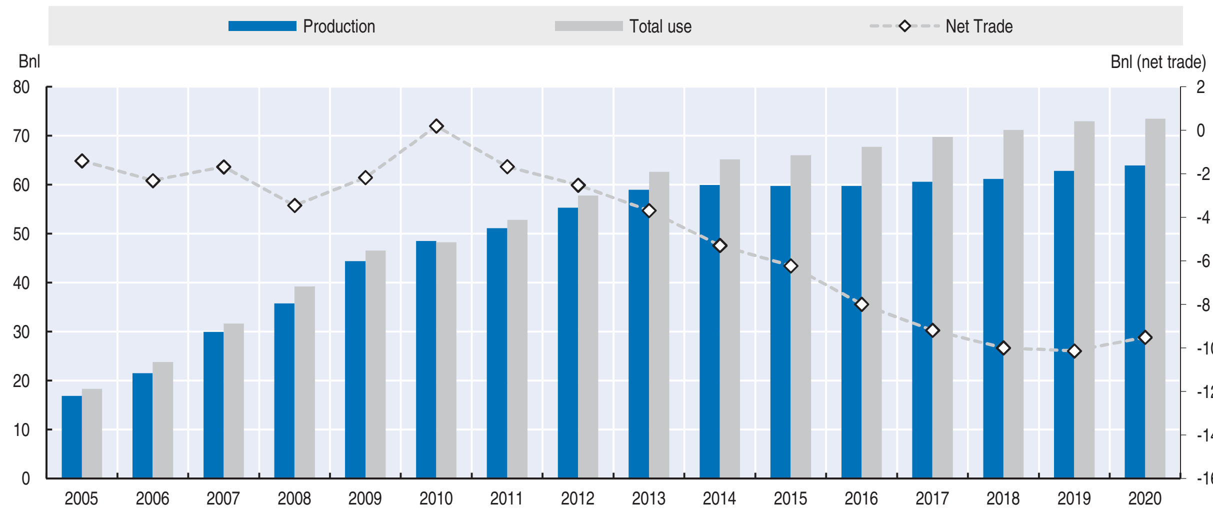
IEA (2010) provides a clear definition of first generation biofuels and second generation biofuels. Typical first generation biofuels are sugarcane ethanol, starch-based or "corn" ethanol and biodiesel. The feedstock for producing first generation biofuels either consists of sugar, starch and oil crops or animal fats, which in most cases can also be used as food and feed or consists of food residues. Second generation biofuels are those biofuels produced from cellulose, hemicellulose or lignin. Examples of 2nd-generation biofuels are cellulosic ethanol and Fischer-Tropsch fuels.

Developed countries

With the implementation of the Renewable Fuels Standard (RFS2) Final Rule,[4] the United States will remain the major player on the ethanol market. Despite current policy uncertainty, this *Outlook* assumes that the tax credit to blenders of ethanol and biodiesel as well as the tariff on imported fuel ethanol will remain in effect. In the US, ethanol use for fuel is expected to increase continuously over the projection period and to reach almost 71 bnl by 2020 (Figure 3.4), below the 2020 standards of 110 bnl.[5] It should represent an average share of 8.4% in gasoline types for transport fuel by 2020.[6]

Research and development on cellulosic ethanol does not yet allow for large scale production. Second generation ethanol production is thus only projected to expand in the latter years of the projection period to reach 4.3 bnl in 2020 and to remain far from meeting

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



Source: OECD and FAO Secretariats.

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the RFS2 cellulosic biofuel requirement of 40 bnl. Domestic production, mainly derived from corn, should account for most of the US ethanol consumption. RFS2 allows 56.8 bnl of first generation corn based ethanol by 2015, which is capped thereafter.

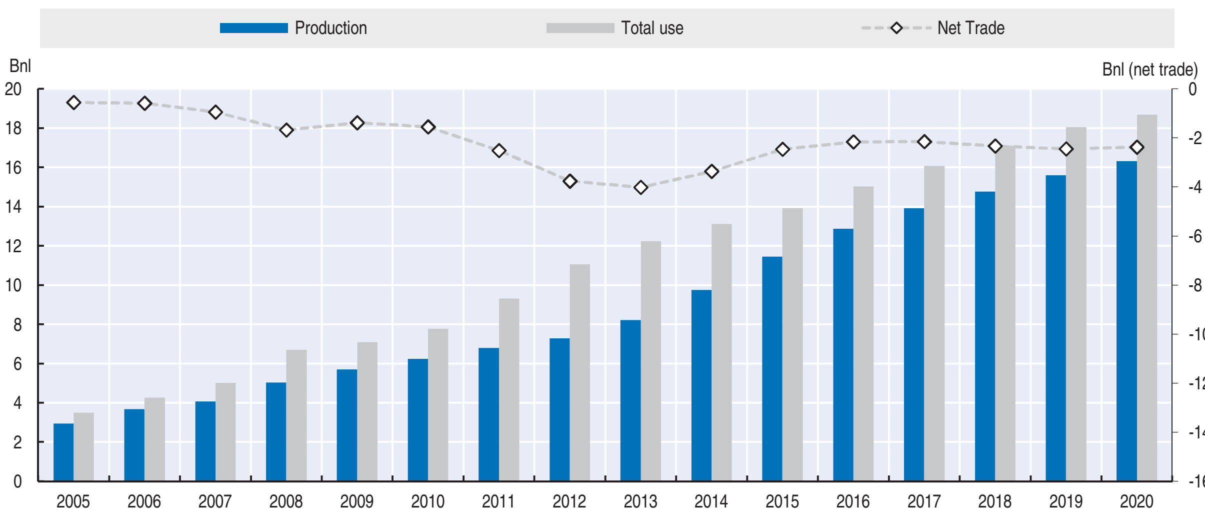
The US Environmental Protection Agency provided a decision in January 2011 on the expansion of the ethanol blending permission into regular gasoline from 10% to 15%[7] for cars built in 2001 or later. In practice, the impact of this decision should be minimal in the short term as retailers are not likely to propose different types of gasoline to their consumers as different pumps would be needed and warranty as well as liability issues still need to be resolved. In the medium term, this decision should reduce the impact of the blending wall because of the price competitiveness of ethanol. Over the Outlook period, the blending wall of 10% of ethanol blended into regular gasoline is expected to be achieved by 2012.

The biomass-based diesel requirement mandate defined in the RFS2 calls for 3.8 bnl of biodiesel to be used by 2012. This mandate is not defined after 2012, it is assumed to remain unchanged over the rest of the Outlook period. It drives the initial growth in US biodiesel use, which should in the latter years of the projection period continue to increase to reach 4.8 bnl by 2020. Biodiesel use will contribute to filling the non-cellulosic advanced biofuels mandate of 57 bnl in 2020. Biodiesel production from tallow or other animal fat, waste oils as well as from corn oil by-product of ethanol plants is expected to represent more than 60% of US biodiesel production.

The Renewable Energy Directive (RED) implemented by the European Union states that the share of renewable energy sources (including non-liquids) should increase to 10% of total transport fuel use by 2020. The RED allows for substitution with other renewable sources such as electric cars. The contribution of second generation biofuels will be counted twice[8] toward EU RED mitigation targets. This *Outlook* does not make assumptions on the development of the fleet of electric cars or of alternative renewable energy sources.

Total biodiesel use in the European Union is projected to increase by almost 85% over the projection period and to reach around 20 bnl by 2020 representing an average share of biodiesel in diesel type fuels of 6.5%, 70% higher than over the 2008-2010 period.[9] Domestic biodiesel production should increase to keep pace with demand (Figure 3.5). Imports are expected to remain pretty stable at about 2 bnl on average over the projection period. From 2018, second generation biodiesel production is assumed to accelerate, with an output of about 2.2 bnl in 2020.

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



Source: OECD and FAO Secretariats.

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European ethanol production mainly wheat, coarse grains and sugar beet based is projected to increase to almost 16.5 bnl in 2020. The production of second generation ethanol is assumed to increase in the last years of the *Outlook* and to reach 1.6 bnl by 2020. Gasoline consumption is assumed to stagnate over the projection period when compared to the base period. This combined with the solid development of ethanol use for fuel should lead to an average ethanol share of 8.2% in gasoline types for transport fuels by 2020.

When the energy content of ethanol and biodiesel is added together and the contribution of second generation biofuels is counted twice as in the RED mitigation target calculations, this *Outlook* projects that the share of renewable energy sources coming from biofuels could reach almost 8.5% of transport fuel use of the gasoline and diesel vehicles fleet, up from 5% on average over the 2008-2010 period. Thus, this Outlook implies that the 2020 EU RED target would not be reached.

In Canada, the mandate calls for an ethanol share of 5% in gasoline type fuel use in volume terms. It is projected to be filled by 2011 and maintained throughout the projection period. Canadian ethanol consumption is thus projected to grow in line with fuel consumption. Domestic production is expected to rise over the projection period to reach almost 2.4 bnl in 2020. Biodiesel use is projected to comply with the biodiesel blending mandate of 1.6% (2% in volume terms) for all transport diesel as well as heating oil by 2012.

In Australia, the ethanol share in gasoline type fuel use is expected to remain almost unchanged over the projection period at about 1.6%. It is assumed to be driven by policies in place in New South Wales and Queensland where ethanol blending mandates have been introduced in 2010. The biodiesel share in diesel type fuel use should remain at around 2.7% all over the projection period. Most of biodiesel production should be based on animal tallow.

Developing countries

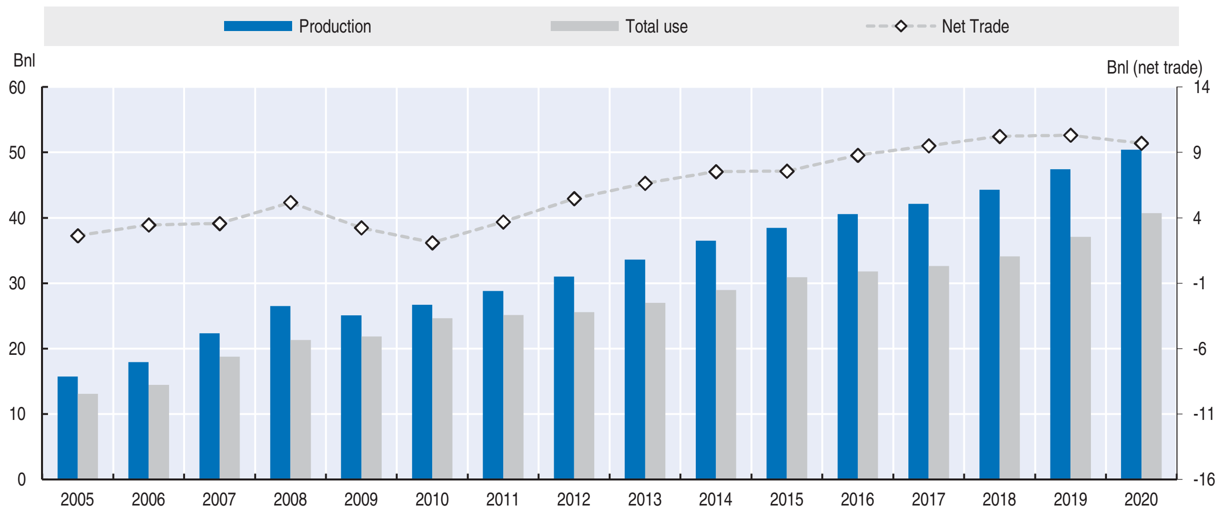
In 2010, biofuels production was significantly below expectations in most developing countries having implemented mandates or ambitious targets for the use of biofuels. Brazil and Argentina are the exceptions. This results primarily from the fact that commercial cultivation of alternative crops usable for biofuel production like jatropha or cassava is in most cases still on a project or small-scale level. This does not allow for large-scale biofuel production, except in a few countries like Nigeria or Ghana where cassava cultivation is well established. Over the projection period, due to slow growing domestic biofuel supply in the developing world, it is likely that biofuel consumption remains significantly below targets and/or mandates. Exceptions are countries which already have a high potential for sugar cane or vegetable oil, predominately palm oil, production.

Brazil, India and China, should account for 85% of the 71 bnl ethanol production in the developing world expected by 2020. In China, the majority of ethanol produced is used for non-fuel uses in the food and chemical industry. Asian and South-American regions should also become notable ethanol producers. In Thailand, production is expected to grow by 1.5 bnl to reach about 2.2 bnl by 2020.

Investments in ethanol producing capacities are expected to continue to occur and ethanol production derived from sugar cane is expected to rapidly expand, growing by almost 6% per year over the projection period to meet both domestic and international demand. Brazil is projected to be the second largest ethanol producer, with a 33% share of global production in 2020. The situation on Brazilian ethanol market should be different from the one that prevailed in 2010 as ethanol production is expected to regain competitiveness with respect to sugar production due to a combination of factors: raw sugar prices are projected to be lower in the early years of the Outlook period, sugar cane area is expected to expand, sugar cane yields are expected to recover from the bad 2010 harvest and investments in the ethanol markets are expected to continue such that production capacities should be further expanded. About half of the sugar cane output is expected to be channelled to ethanol production. Brazilian ethanol domestic use is expected to increase over the projection period to reach 41 bnl in 2020 (Figure 3.6). This growth is mainly driven by the growing fleet of flexi-fuel vehicles.

The greatest biodiesel producer in the developing world will still be Argentina which will account for about 25% (3.2 bnl) of total biodiesel produced in the developing countries and 8% of global biodiesel production by 2020. In Brazil, biodiesel production based on soybean oil or possibly palmoil is also expected to increase beyond 3 bnl by 2020 as a result of an increasing domestic demand driven by biodiesel mandates. By contrast, Argentina (after fulfilling her domestic consumption target) should continue to focus on export markets due to the incentives offered by the differential export tax system. The same is true for Malaysia, where production should further increase to about 1.3 bnl in 2020. Other East Asian countries like Thailand, Indonesia and India will also significantly increase their domestic biodiesel production, each to about 1-1.5 bnl. However, most of this would be for domestic consumption due to ambitious domestic biodiesel blending targets.

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



Source: OECD and FAO Secretariats.

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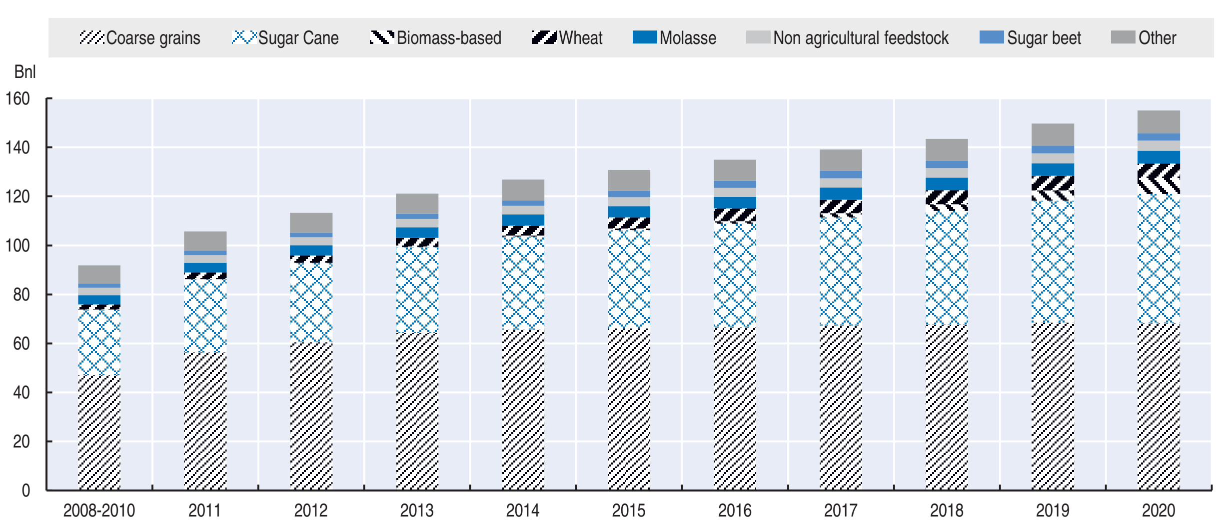
Feedstocks used to produce biofuels

Figure 3.7 presents projected ethanol production growth by the various feedstocks used. Maize and sugar cane should remain the major ethanol feedstocks over the coming decade. By 2020, 44% of global ethanol is expected to be produced from coarse grains and 36% from sugar cane. Cellulosic ethanol production should represent only 5% of global production. In developed countries, the share of corn based ethanol over total ethanol produced should decrease from 89% on average over the 2008-10 period to 78% in 2020. Wheat based ethanol should account for 6% of ethanol production in developed countries compared to 3% over the base period, most of this development being in the EU. Sugar beet based ethanol should account for about 4% of ethanol production throughout the

Figure 3.7. **Evolution of global ethanol production by feedstocks used**



Source: OECD and FAO Secretariats.

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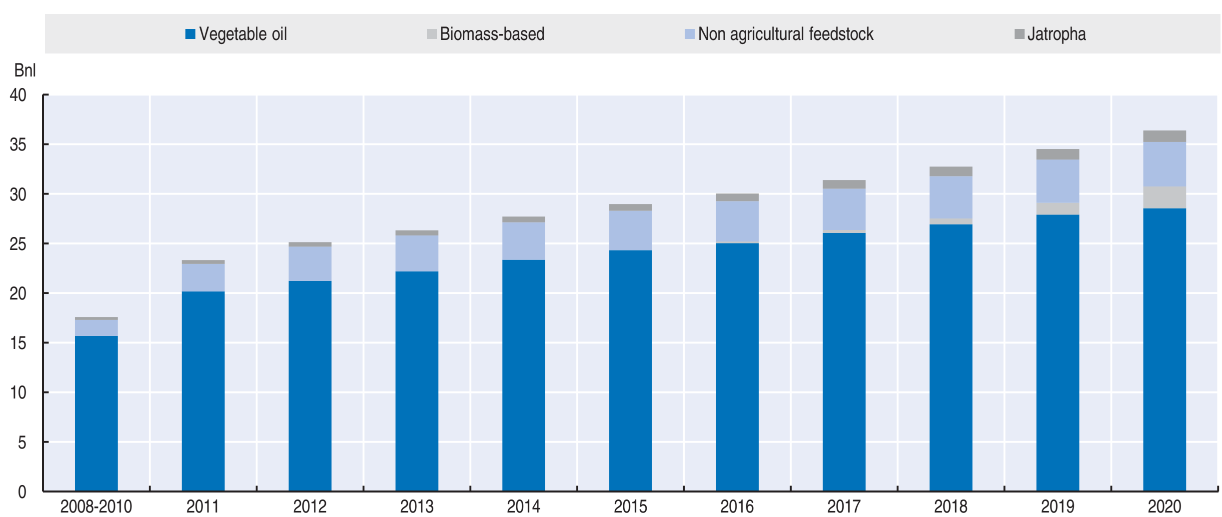
projection period. Cellulosic ethanol production is expected to become increasingly important in developed countries from 2017, to represent about 8% of total ethanol production by 2020.

In developing countries, more than 80% of the ethanol produced in 2020 is expected to be based on sugar cane which results from the dominance of Brazilian ethanol production. Ethanol based on roots and tubers such as cassava is projected to account for only about 4%. The picture differs if the Brazilian ethanol market is excluded. In that case, in the developing world, if the share of molasses in ethanol production reaches 40% of ethanol production, the shares of sugar cane based ethanol as well as coarse grains based ethanol should be of 17%. The share of roots and tuber is also much higher (15%). In particular the cultivation of cassava for ethanol production might have a high potential in the developing world. However, high production costs and small-scale production structures, especially in comparison to sugar cane, currently hamper a noticeable market expansion.

Figure 3.8 presents the split of the projected biodiesel production growth between the various feedstocks used. More than 75% of global biodiesel production is expected to come from vegetable oil in 2020. Jatropha should account for 7% of global biodiesel production in 2020. In developed countries, the share of vegetable oil based biodiesel over total biodiesel produced should decrease from 85% on average over the 2008-10 period to 75% in 2020. Biodiesel produced from non agricultural sources such as fat and tallow, as well as from waste oils and by-products of ethanol production, should represent about 15% of total biodiesel produced in the developed world over the projection period. Second generation biodiesel production is expected to grow in developed countries from 2018 and to represent about 10% of global biodiesel in 2020.

Figure 3.8. **Evolution of global biodiesel production by feedstocks used**



Source: OECD and FAO Secretariats.

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The most important biodiesel feedstock in the developing world should remain vegetable oils based on palm or soybean oil. This will be a result of the strong production increase in Argentina and Brazil, where biodiesel is produced predominately from soybean oil. The share of jatropha is expected to only account for 10% (19% when excluding Brazil and Argentina) of biodiesel produced in 2020 in the developing world due to the slow growth of cultivation capacities. Rapeseed oil is of minor importance for biodiesel production in developing countries with the exception of Chile where the climatic conditions allow for rapeseed cultivation. Biodiesel production from rapeseed oil is also expected to develop in transition countries like Ukraine and Kazakhstan. Less important from a global perspective but notable from a national perspective is the production of biodiesel based on tallow in Paraguay and Uruguay, as a result of the large livestock sector in these countries.

Biofuel use will continue to represent an important share of global cereal, sugar crops and vegetable oil production over the Outlook period. By 2020, 12% of the global production of coarse grains will be used to produce ethanol compared to 11% on average over the 2008-10 period 16% of the global production of vegetable oil will be used to produce biodiesel compared to 11% on average over the 2008-10 period and 33% of the global production of sugar compared to 21% on average over the 2008-10 period. Over the projection period, 21% of the global coarse grains production's increase, 29% of the global vegetable oil production's increase and 68% of the global sugar cane production's increase are expected to go to biofuels.

Trade in ethanol and biodiesel

Trade in ethanol[10] is expected to represent about 7% of global production on average over the projection period. It is expected to recover from the 2010 situation where Brazilian ethanol exports were very low. To keep pace with demand and given the expected slow growth in second generation ethanol production, net imports from the US should reach 9.5 bnl in 2020. Imports of sugarcane based ethanol can be counted in the RFS2 mandate towards the "advanced" category. Part of the US ethanol imports are expected to be Brazilian ethanol dehydrated in the Caribbean, imported with duty-free access under the Caribbean Basin Initiative. At the global level, growth in trade comes almost entirely by expanding exports from Brazil and Thailand. Brazilian ethanol exports are expected to reach 9.7 bnl by 2020. For Thailand, ethanol exports are expected to increase to about 0.5 bnl in 2020. In the EU, ethanol imports should initially grow to meet increasing ethanol demand to reach about 4 bnl in 2013. Due to the sustainability criteria of the RED and the expected development of cellulosic ethanol in the latter years of the Outlook period, ethanol imports are expected to decrease to 2.3 bnl by 2020.

Argentina is expected to remain the most important biodiesel exporter. Here, exports should reach about 2.5 bnl by 2020. Malaysian exports will also increase by 0.4 bnl to total 0.8 bnl and Colombia will export 0.25 bnl in 2020. Biodiesel trade will remain low as most countries with binding mandates tend to produce biodiesel domestically. Import needs from the EU are expected to remain fairly constant over the projection period at around 2 bnl per year as European production is expected to increase in line with European demand.

Main issues and uncertainties

The development of biofuel markets is subject to many uncertainties which are discussed in this section. Box 3.1 draws on OECD (2010, 2012) to describe possible implications of the projected expansion of agricultural bioenergy feedstocks on water systems.

Evolution of policies

The last few years have shown how biofuel markets can be strongly affected by changes in policy packages, macroeconomic events and changes in crude oil prices. The interplay of those different factors impacts on the profitability of the industry and thus modifies investors' decisions and spending on R&D. At the moment, there is considerable uncertainty concerning the renewal of the US blender tax credit and ethanol tariff. If those policy elements were to be removed, the full integration of the US in the world ethanol market would change the prospects of this *Outlook*. For example, US biodiesel production could decline substantially as was the case when the renewal of the blenders credit was delayed in 2010. Brazilian ethanol exports could be channelled directly to the US with sugar cane based ethanol being relatively more competitive than corn based ethanol. With the maturity of the biofuel industry and the growing concerns on the competition between food and fuel and its impact on food prices, it is possible that government subsidies and other budget-sensitive measures in support of biofuel production or consumption could be subject to gradual cuts.

From first generation biofuels to other sources of renewable energy

Biofuels produced from agricultural feedstock were, and still are, envisaged as a first step towards the development of renewable energy sources for liquid transportation fuels. The future transition to second generation biofuels produced from lignocellulosic biomass, waste material or other non-food feedstocks depends on the advancement of R&D over the next few years and on investments that are currently being made, as well as on the continuation of biofuel policy packages that have set up ambitious mandates for the production of second-generation biofuels. In this context, commercial production does not depend solely on full economic viability. This *Outlook* remains very cautious on the medium-term potential of second generation biofuels which is only expected to be realised towards the very end of the projection period. Continued slow development of second generation biofuels could lead to additional import demand for the countries with strong biofuel use mandates. Other sources of renewable energy could play a larger role in future years. The RED explicitly allows for renewable electricity used in the transport sector to count towards the 10% renewable energy share in transport fuels. The pace of development of electrical or hybrid vehicles remains uncertain for the time being but could potentially reduce the need for biofuels derived from agricultural products to meet the mandates set up by European member states.

Sustainability criteria

The sustainability criteria that are embedded in the policies of major countries consuming biofuels are expected to continue to affect biofuel markets. Biofuel producers in the United States and in the EU have to comply with more drastic GHG emission targets. The RFS2 Final Rule requires specific GHG emission reductions for the various biofuels. Conventional renewable fuels must reduce GHG by 20% when compared to gasoline, advanced biomass-based diesel and non-cellulosic advanced biofuels by 50% and cellulosic biofuels by 60%. Existing conventional ethanol production facilities are exempt from this requirement, but new plants will have to comply. The RED specifies that a given biofuel has to achieve a saving of at least 35% in GHG. This 35% threshold will rise to 50% in 2017 for existing plants and 60% for new production facilities.

On the trade side, the impacts of the sustainability criteria may also be considerable as they could limit the availability of imported biofuels or biofuel feedstock if countries do not comply with the policies in place in importing countries. Disputes are likely to develop on the GHG emission savings of different biofuels. For example, for the US RFS2, the default

GHG emission saving of soybean oil based biodiesel is defined as 57%, above the 50% threshold fixed by the policy. For the RED, this default saving is only 31%, below the 35% threshold fixed by the policy. This difference could affect trade of soybean, soybean oil (for biodiesel production) or soybean oil based biodiesel once the RED is implemented. Meanwhile, trade in palm oil based biodiesel may be affected by requirements to certify environmentally and socially sustainable production.

Development of biofuel industries in developing countries

Availability of reported data concerning biofuel production and use is not good in many developing countries. The stated intention in some of these countries is to substantially increase production capacities as well as domestic use in the coming years. If the countries have low domestic production capacities for biofuel feedstocks, it is uncertain that they will be able to meet domestic demand without using imports. In countries where traditional biofuel feedstocks are not produced in large quantities, plans are in place or being developed to increase the production capacities of alternative, non-edible feedstocks, first and foremost jatropha. These crops might be a very effective option for biofuel production. However, competitive large-scale jatropha production does not currently exist and the current production quantities from small-scale plantations are far below the initial expectations. Rapid improvement of planting materials adapted to different growing conditions using biotechnology and advanced breeding methods could dramatically change jatropha's potential. Thus, it is still possible that a notable increase in these alternative feedstocks may occur but as to when and to what extent is very uncertain.

Another aspect concerning developing countries is where high biofuel production capacities have already been installed. Some of these countries could become important exporters in the future, such as Malaysia and Indonesia in the case of biodiesel. Current production in Malaysia accounts for approximately 45% of the available production capacity, estimated at 1.75 bnl in 2010. Even less of available capacity is currently used in Indonesia, where only about 10% of the installed capacity (estimated to about 4 bnl) was used in 2010. It is not clear if these capacities might be more fully utilised or might even continue to grow over the next years. The EU RED sustainability and certification scheme is likely to affect palm oil based biodiesel imports and thus might negatively impact Malaysian and Indonesian biodiesel production and exports.

Box 3.1. **The implications of the projected expansion of agricultural bioenergy feedstocks on water systems**

World agriculture faces an enormous challenge in the coming decades, to produce more food, feed and fibre due to rising populations and incomes and changing dietary habits. With additional pressures from growing urbanisation, industrialisation and climate change, sustainable management of water systems will be vital.

The projected growth in agricultural bioenergy feedstock production (*e.g.* from grains, oilseeds, etc) has raised concerns about the pressure this may have on water systems. In practice, as the cultivation of feedstocks for agricultural bioenergy is no different than the same crops destined for food, fibre or feed purposes, their environmental consequences should be similar. Nevertheless, the rapid expansion of bioenergy feedstock production has raised concerns related to the competition for water resources in regions where scarce water resources are an issue and the impacts on water quality where water pollution is a concern.

Box 3.1. **The implications of the projected expansion of agricultural bioenergy feedstocks on water systems** *(cont.)*

Overall impacts on ***water resources*** from cultivation of agricultural feedstocks to produce bioenergy (biofuels, power and heat) can be difficult to trace. The extent to which feedstock production draws on the need for irrigation varies by feedstock type and region. Rain-fed rapeseed in Europe, for example, requires no irrigation, while maize in the United States is largely rain-fed, with only about 3% of national irrigation water withdrawals devoted to biofuel crops. Globally some 1% of water withdrawn for irrigation is estimated to be applied for biofuel crops. The amount of water needed to produce each unit of energy from second generation biofuel feedstocks (*e.g.* harvest cellulosic residues) is three to seven times lower than the water required to produce ethanol from maize, rapeseed, etc.*

Second generation feedstocks, such as from trees, can capture a greater share of annual rainfall, compared to annually sown crops, in areas where much of the rainfall occurs outside the normal crop growing season, and also help reduce soil erosion and bring flood control benefits. While second generation feedstocks offer the potential for reducing irrigation water demand, it is not necessarily a clear outcome, as this may depend on the feedstocks grown, location of production and the reference first generation feedstocks. Moreover, some second generation feedstocks may require irrigation during establishment and to achieve high yields, hence, the final impact on water balances are uncertain.

The ***water quality*** impacts from bioenergy feedstock production derive from the management practices used in their cultivation, including the use of agro-chemicals, while the processing plants to convert raw materials to bioenergy can also have impacts on water quality. Much of the projected production of biofuels are expected to be derived from maize, which could result in increased levels of soil sediment and nutrient water pollution, particularly where maize is cultivated on marginal agricultural land which contributes to the highest soil sediment and nutrient run-off loads. This may have significant consequences for water quality, especially rivers and coastal areas. For wood plantations used as bioenergy feedstocks, the clearance of streamside vegetation in wood management systems may change physical properties of water systems, such as the turbidity, stream temperature and light infiltration of water bodies. If nutrient inputs are required for wood plantations, infiltration of nutrients may also pose a risk to groundwater.

A key ***conclusion*** from most studies on the links between bioenergy production from agricultural feedstocks on water is that in general feedstocks from annual crops, such as maize and oilseeds, can have a more damaging impact on water systems than second generation feedstocks, such as reed canary grass and short rotation woodlands. Another important conclusion is that the location of production and the type of tillage practice, crop rotation system and other farm management practices used in producing feedstocks for bioenergy production will also greatly influence water systems. Moreover, the increasing use of bioenergy from agricultural and food wastes and residues (*e.g.* straw, manure, food waste, animals fats) may help to lower the demand for production of feedstocks from cultivated crops and hence, reduce environmental impacts.

But a note of caution is important here, as the potential impacts on water resource and quality from growing agricultural feedstocks for bioenergy production have not been fully evaluated.

* See Hoogeveen, J; J-M Faurès; N. Van de Giessen (2009), "Increased Biofuel Production in the Coming Decade; To What Extent will it Affect Global Freshwater Resources?", *Irrigation and Drainage*, Vol. 58, pp. S148-S160.

Sources: For the full bibliography from which this Box is drawn see OECD (2010), *Sustainable Management of Water Resources in Agriculture*, Publishing Service, Paris, *www.oecd.org/agriculture/water*; and OECD (2012 forthcoming), *Sustainable Management of Water Quality in Agriculture*, Publishing Service, Paris.

Notes

1. Brazil, Sao Paolo (ex-distillery).
2. Producer price Germany net of biodiesel tariff.
3. Cycles in raw sugar production imply fluctuations in the world raw sugar price. The ratio between the world ethanol price and the world raw sugar price is not expected to remain stable over the Outlook period. However, the strong expected decrease in world raw sugar price in the early years of the Outlook period is expected to lower the pressure on world ethanol markets.
4. More information can be found on the RFS2 Final Rule on the following website: *www.epa.gov/otaq/renewablefuels/420f10007.htm*
5. The 110 bnl figure represents the sum of the Conventional Renewable fuels mandate in 2020 (15 bn gallons, *i.e* 57 bnl) and of the mandate for total advanced biofuels except biomass-based diesel (14 bn gallons, *i.e.* 53 bnl).
6. All biofuel use shares are expressed on the basis of energy contained unless otherwise specified.
7. Expressed in volume share. See *www.epa.gov/otaq/regs/fuels/additive/e15.index.htm*
8. "For the purposes of demonstrating compliance with national renewable energy obligations placed on operators and the target for the use of energy from renewable sources in all forms of transport referred to in Article 3(4), the contribution made by biofuels produced from wastes, residues, non-food cellulosic material, and ligno-cellulosic material shall be considered to be twice that made by other biofuels". Directive 2009/28/EC of the European Parliament and Council (Renewable Energy Directive), 2009.
9. Diesel consumption is assumed to increase by 9% in the EU over the Outlook period when compared to the 2008-10 period.
10. Note that trade projections for ethanol, in addition to pure fuel alcohol, also include ethanol for other purposes as well as the ethanol share in gasoline blends.

Reference

IEA (2010), Sustainable Production of Second-General Biofuels: Potential and Perspectives in Major Economics and Developing Countries.

ANNEX 3.A

Statistical tables: Biofuels

Table 3.A.1. Biofuel projections: Ethanol

	PRODUCTION (MN L)		Growth (%)[1]	DOMESTIC USE (MN L)		Growth (%)[1]	FUEL USE (MN L)		Growth (%)[1]	SHARE IN GAZOLINE TYPE FUEL USE(%)				NET TRADE (MN L)[2]	
										Energy Shares		Volume Shares			
	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	Average 2008-10est.	2020	Average 2008-10est.	2020
NORTH AMERICA															
Canada	1 483	2 359	3.08	1 530	2 408	0.57	1 324	2 202	0.66	2.2	3.4	3.3	5.0	-48	-49
United States	42 857	63 961	1.89	44 663	73 474	3.32	42 338	70 484	4.13	5.3	8.4	7.7	12.1	-1 806	-9 514
of which second generation	3	4 368	..	..	..	..	..	..	..	..	..	..	..	..	..
WESTERN EUROPE															
EU(27)	5 651	16 316	10.50	7 186	18 690	7.31	4 687	16 173	8.09	2.3	8.2	3.4	11.8	-1 536	-2 374
of which second generation	0	1 626	..	..	..	..	..	..	..	..	..	..	..	..	..
OCEANIA DEVELOPED															
Australia	299	492	0.75	299	492	0.75	299	492	0.75	1.0	1.6	1.5	2.3	0	0
OTHER DEVELOPED															
Japan	307	946	13.28	704	1 715	5.81	90	1 687	18.26	0.0	0.0	0.0	0.0	-398	-769
of which second generation	0	593	..	..	..	..	..	..	..	..	..	..	..	..	..
South Africa	384	421	0.44	93	47	0.07	0	0	4.62	0.0	0.0	0.0	0.0	291	374
SUB-SAHARIAN AFRICA															
Mozambique	25	59	6.17	21	29	0.56	0	9	1.48	0.0	3.3	0.0	4.8	4	29
Tanzania	29	55	7.14	33	52	5.97	1	19	37.15	0.1	2.7	0.2	4.0	-4	3
LATIN AMERICA AND CARRIBBEAN															
Argentina	303	470	2.20	240	402	0.97	110	272	1.47	1.6	3.4	2.3	5.0	63	68
Brazil	26 091	50 393	5.98	22 589	40 695	5.15	21 061	38 383	7.28	47.3	67.1	57.2	75.3	3 502	9 698
Columbia	310	587	5.63	353	385	-1.20	315	347	-1.33	4.5	5.6	6.6	8.1	-44	202
Mexico	64	90	2.29	168	275	2.29	0	0	..	0.0	0.0	0.0	0.0	-104	-184
Peru	71	217	2.55	25	175	1.47	20	174	1.48	1.1	8.2	1.7	11.7	46	41
ASIA AND PACIFIC															
China	7 189	7 930	0.71	7 041	6 685	0.18	2 024	2 975	4.34	1.8	1.5	2.6	2.3	148	1 246
India	1 892	2 204	1.78	2 109	2 818	1.48	183	800	1.48	0.9	3.0	1.4	4.5	-217	-614
Indonesia	210	248	0.99	169	168	0.15	0	0	6.77	0.0	0.0	0.0	0.0	41	80
Malaysia	66	74	0.80	87	85	0.09	0	0	5.38	0.0	0.0	0.0	0.0	-21	-11
Philippines	118	603	12.74	263	450	3.49	193	350	-0.30	2.1	3.0	3.1	4.4	-144	153
Thailand	672	2 111	9.32	599	1 602	8.72	424	1 389	4.54	3.8	11.2	5.6	15.9	73	509
Turkey	64	88	0.98	108	142	3.43	50	87	5.23	0.6	0.9	0.9	1.3	-44	-54
Viet Nam	150	423	4.75	95	334	14.84	8	255	25.87	0.1	3.5	0.2	5.1	55	90
TOTAL	**91 657**	**154 962**	**3.98**	**91 821**	**155 983**	**3.95**	**73 742**	**136 123**	**4.45**	**5.3**	**8.8**	**7.7**	**12.6**	**3 792**	**11 012**

1. Least-squares growth rate (see glossary).
2. For total net trade exports are shown.
.. Data not available.
Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932427664

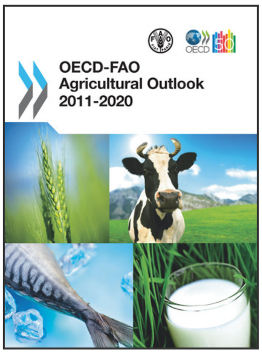
Table 3.A.2. Biofuel projections: Biodiesel

	PRODUCTION (MN L)		Growth (%)[1]	DOMESTIC USE (MN L)		Growth (%)[1]	SHARE IN DIESEL TYPE FUEL USE(%)				NET TRADE (MN L)[2]	
							Energy Shares		Volume Shares			
	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	2011-20	Average 2008-10est.	2020	Average 2008-10est.	2020	Average 2008-10est.	2020
NORTH AMERICA												
Canada	236	594	6.57	202	672	3.65	0.4	1.6	0.5	2.0	34	-78
United States	1 658	4 002	2.24	909	4 757	5.39	0.3	1.3	0.4	1.6	748	-755
WESTERN EUROPE												
European Union	9 184	17 610	5.17	10 802	19 794	4.75	3.9	6.6	4.9	8.1	-1 619	-2 184
of which second generation	0	2 190	..	..	..	..	..	..	..	..	..	..
OCEANIA DEVELOPED												
Australia	627	719	1.14	627	719	1.14	2.7	2.7	3.4	3.3	0	0
OTHER DEVELOPED												
South Africa	57	100	3.65	57	100	3.66	0.0	0.0	0.0	0.0	0	0
Sub-Saharian Africa												
Mozambique	51	80	1.85	0	32	1.47	0.0	0.0	0.0	0.0	51	48
Tanzania	50	61	-0.13	0	58	159.22	0.0	0.0	0.0	0.0	50	3
LATIN AMERICA AND CARIBBEAN												
Argentina	1 576	3 231	3.36	247	656	2.13	1.9	4.0	2.3	5.0	1 329	2 576
Brazil	1 550	3 139	2.66	1 550	3 139	2.66	2.7	4.0	3.4	5.0	0	0
Columbia	302	768	4.88	228	430	4.77	1.6	4.0	2.0	5.0	75	338
Peru	174	130	3.74	174	315	4.35	1.6	4.0	2.0	5.0	0	-185
ASIA AND PACIFIC												
India	179	3 293	26.87	241	3 291	26.87	0.0	0.1	0.0	0.1	-61	2
Indonesia	369	811	6.65	272	1 100	14.37	1.3	5.7	1.7	7.0	98	-289
Malaysia	765	1 331	3.96	206	500	8.35	1.6	4.0	2.0	5.0	559	831
Philippines	158	271	3.97	158	200	1.70	0.0	0.0	0.0	0.0	0	71
Thailand	584	1 697	8.15	561	1 200	5.67	1.9	4.0	2.3	5.0	24	497
Turkey	62	52	5.54	62	187	3.39	0.0	0.0	0.0	0.0	0	-135
Viet Nam	8	100	17.76	0	100	17.93	0.0	0.0	0.0	0.0	8	0
TOTAL	**17 608**	**41 917**	**5.99**	**16 314**	**40 938**	**6.44**	**2.0**	**3.8**	**2.5**	**4.7**	**2 111**	**2 737**

1. Least-squares growth rate (see glossary).
2. For total net trade exports are shown.
.. Data not available.

Source: OECD and FAO Secretariats.

StatLink http://dx.doi.org/10.1787/888932427683



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