Executive Summary

Implementation Agendas: 2018-2019 Update
Compare and Contrast Transport Biofuels Policies

IEA Bioenergy

IEA Bioenergy Task 39
December 2019

Executive Summary

Implementation Agendas: 2018-2019 Update
Compare and Contrast Transport Biofuels Policies

Mahmood Ebadian
University of British Columbia, Canada

James D. McMillan
National Renewable Energy Laboratory, USA

Jack (John) N. Saddler
University of British Columbia, Canada

Susan van Dyk
University of British Columbia, Canada

Published by IEA Bioenergy

Contributors

The Task's periodically issued Implementation Agendas report has been updated to summarise current policies being used within Task 39 member countries to encourage the production and use of biofuels. This report also describes the market penetration of biofuels in Task 39 member countries as well as China and India which are two of the world's major countries also aspiring to increase their production and use of biofuels. The policy environment has changed substantially since the last report update in 2014, and the report's format has been revised to try to better compare and contrast the relative success of the various policies being used to promote biofuels development and use around the world. A questionnaire was sent to Task 39 representatives (and ExCo members) in 2017, and collected responses were compiled and used to update the country specific chapters of this report. A copy of this questionnaire is provided in Appendix I. The Task 39 country representative contributors to this report are listed below by their country and institutional affiliations.

Country	**Country Representative**	**Institution**
Australia	Steve Rogers	Licella
Austria	Dina Bacovsky	BIOENERGY 2020+ GmbH
Brazil	Glaucia Mendes Souza	University of São Paulo and FAPESP Bioenergy Program BIOEN
Canada	Alex MacLeod[1] Jack Saddler[2], Mahmood Ebadian[2]	[1]Natural Resources Canada; [2]University of British Columbia
Denmark	Claus Felby	University of Copenhagen
European Commission	Adrian O'Connell Laura Lonza	Joint Research Centre, European Commission
Germany	Franziska Mueller-Langer[3] Nicolaus Dahmen[4]	[3]Deutsches Biomasseforschungszentrum; [4]Karlsruhe Institute of Technology
Japan	Shiro Saka[5] Satoshi Aramaki[6]	[5]Kyoto University [6]New Energy and Industrial Technology Development Organization
The Netherlands	Timo Gerlagh	Netherlands Enterprise Agency
New Zealand	Ian Suckling	Scion
South Africa	Emile van Zyl	University of Stellenbosch
South Korea	Jin Suk Lee[7] Kyu Young Kang[8]	[7]Korea Institute of Energy Research; [8]Dongguk University
Sweden	Tomas Ekbom[9] Leif Jonsson[10]	[9]Swedish Bioenergy Association; [10]Umea University
USA	Jim McMillan	National Renewable Energy Laboratory
China	Mahmood Ebadian	University of British Columbia
India	Mahmood Ebadian	University of British Columbia

Executive Summary

Global production and use of transport biofuels

Global biofuels production has continued to increase over the last decade, from over 37 million tonnes oil equivalent (Mtoe) in 2007 (~64 billion liters) to over 84 Mtoe in 2017 (~145 billion liters). It increased 3.5% from 2016 to 2017, which is well below its annual growth rate of 11.4% over the past decade however the most growth in three years. The highest growth was observed in the Asia Pacific region, which realized an annual growth rate of 20.1% over the period 2006-2016 and a 6% increase from 2016 to 2017. The Americas and Europe still continue to have the highest shares of biofuels production. In 2017, North America, South and Central America and Europe had world shares of 45.5%, 26.9% and 16.8%, respectively.

The main biofuels being produced are ethanol, biodiesel (fatty acid methyl ester or FAME), and renewable diesel fuels produced by hydrogenating (hydrotreating) animal and vegetable oils and fats (also known as hydrotreated vegetable oil (HVO) or hydrotreated esters and fatty acids (HEFA) fuels), as well as a growing amount of biomethane in some countries such as the United States (US), Sweden, and Germany. In energy terms, in 2017, an estimated 65% of biofuel production was ethanol, 29% was FAME biodiesel and 6% was HVO/HEFA fuels; while growing rapidly as a transport fuel, biomethane contributed less than 1% of total biofuel use.

Global biofuels production is forecast to grow at a modest annual growth rate of 3% over the next five years, with most growth expected to come from Latin America and non-OECD countries in Asia[1]. In Brazil, the drivers for biofuel demand remain strong and it is anticipated that the new RenovaBio policy will accelerate new investment to increase biofuel production capacity. China intends to roll out 10% ethanol blends in gasoline nationwide, which will require a six-fold increase in national output, and this is simulating new investment in ethanol production capacity. The growth prospects for conventional biofuel production in Europe and North America are more limited. The recent announcement in the European Union (EU) of a specific target for advanced biofuels and biogas of at least 0.2% in 2022, 1% in 2025 and at least 3.5% in 2030, however, is stimulating interest from large oil companies as they develop their strategies to achieve these targets. The cellulosic and advanced biofuels targets under the Renewable Fuel Standard (RFS) program in the US also continues to stimulate interest in establishing and increasing advanced biofuel production in North America.

Although conventional biofuels (i.e., sugar/starch-based ethanol and FAME biodiesel) comprised more than 93% of global biofuels market share in 2017, worldwide efforts continued to demonstrate production and use of drop-in and other advanced biofuels. This is largely in response to the growth in policies requiring or promoting biofuels that demonstrate improved sustainability attributes, especially lower life cycle net carbon emissions (lower carbon intensity) and less potential to exacerbate undesirable land use change; for example, fuels produced from agricultural, forestry, industrial or municipal wastes and residues. In 2017, the growth of advanced biofuels was led by HVO/HEFA fuels, followed by ethanol from cellulosic materials such as corn fibre, and by fuels from thermochemical gasification- or pyrolysis-based processes. Demand for HVO/HEFA biofuels is expected to continue to grow because of their "drop-in" properties and low carbon intensities,

[1] This region groups together all Asian countries apart from China, India, Japan and South Korea. The region ranges from Afghanistan through Mongolia, to Southeast Asia and the islands of the Pacific.

especially when produced from waste and residue oleochemical feedstocks such as tallow and used cooking oil, which account for an increasing share of HVO/HEFA feedstocks. These fuels are now primarily produced in Europe, Singapore and the US, and production is expected to continue to grow as new facilities come on line and new investments are made to increase existing plant capacities.

Production of advanced biofuels from cellulosic feedstocks, including cellulosic ethanol, has so far only been demonstrated at relatively small scales globally due to slower than forecast progress in scale up and commercial deployment. Most cellulosic ethanol is now being produced in the US and EU. In 2017, total production in the US was 38 million liters, mainly from corn kernel fibre and corn stover. A number of pilot, demonstration and pre-commercial advanced biofuels plants in other countries such as Canada, Brazil, Austria, China, India and Italy are also producing or have produced advanced biofuels from lignocellulosic biomass feedstocks ranging from agricultural and forest residues and the cellulosic portion of municipal waste streams, however large volume commercial production remains to be proven. Policy interest in advanced biofuels remains strong. The Biofuture Platform, a 20-member country collaboration initiated by Brazil, has advocated an increase in low-carbon biofuel consumption. India aims to deliver twelve advanced biofuel plants, several of which are in development, and China intends to vigorously develop cellulosic ethanol. EU policy support for advanced biofuels after 2020 is also expected to strengthen, building on an increasing number of quota policies announced by member states.

Global biofuels trade

In recent years, the international trade of biofuels has increased to meet the global demand for renewable fuels. Ethanol and biodiesel constitute much of this trade because they are the most established and largest volume biofuels, but there is potential for more trade of drop-in biofuels such as HVO/HEFA fuels. Ethanol has been traded for decades and has developed into a large-volume global market. In contrast, biodiesel trade is less established and has been encouraged by policies and incentives that promote biofuels, particularly in the EU. The current major participants in liquid biofuels trade are the US, the EU, Brazil, and Argentina. The volume and direction of biofuel trade depends on many factors, including policies, tariffs, crop yields, feedstock availability and biofuels supply and demand within individual countries. Some of the most significant policies influencing where biofuels are imported and produced are the EU's Renewable Energy Directive (RED and REDII), the US's Renewable Fuels Standard (RFS) and California's Low Carbon Fuel Standard (LCFS). International import/export tariffs also play an important role.

Transport biofuels policies

Policies and fossil fuel prices are the main factors driving the rate of biofuels growth in specific countries and world regions. Many forms of policy instruments are being used, including blending mandates, fuel and carbon taxes and renewable or low carbon fuel standards, as well as a variety of fiscal incentives and public financing mechanisms. Table 1 summarizes the types of biofuel policies being implemented to propel further biofuel production and use in IEA Bioenergy Task 39 member countries as well as in China and India.

Table 1. Policies for production and use of biofuels in Task 39 member countries plus China and India

Country	**Biofuels mandates**	**Fuel excise tax reduction/exemption**	**Other policy mechanisms**
Australia	- No national renewable fuels target - New South Wales: 5% biodiesel and 6% ethanol (volume) - Queensland: 0.5% biodiesel and 4% ethanol (volume)	- Producer grant scheme (fuel excise reduction)	-
Austria	- 6.3% biodiesel, 3.4% ethanol and 5.75% biofuels (energy content) - 0.2% advanced biofuels target by 2022 (energy content)	- Tax concessions for fuels with a biofuel share of at least 4.4% - Pure biofuels exempted from mineral oil tax	-
Brazil	- 27% ethanol and 10% biodiesel (volume) - 100% hydrous ethanol is also marketed in all gas stations in Brazil.	- There are tax incentives for biofuel producers, blenders and users including tax incentives for ethanol-flex fuel vehicles, tax incentives for ethanol fuel and federal tax exemptions and incentives for biodiesel production	-
Canada	- Federal use mandates: 5% ethanol and 2% biodiesel (volume) - Five provinces of British Columbia, Alberta, Saskatchewan, Manitoba and Ontario established a blending requirement of 5% to 8.5% for ethanol and 2% to 4% for biodiesel (volume)	-	- British Columbia's Carbon Tax and Low Carbon Fuel Standard - Ontario's auction for carbon allowances - Alberta's carbon levy
Denmark	- 5.75% biofuels (both ethanol and biodiesel) (volume) - 0.9% for advanced biofuels by 2020	- CO_2 excise exemptions for biofuels	-
European Union (EU)	- Cap on food and feed crops of max 1% above 2020 consumption with a maximum of 7% (energy content) - Sub-target for advanced biofuels of 0.2% for 2023, 1.0% for 2025 and 3.5 for 2030 (energy content) - Use of high iLUC crops should gradually decrease to 0% in 2030 unless they are certified to be low-iLUC	-	-
Germany	- GHG reduction of 3.5%/4%/6% in the fuel mix for the entire fuel sector from 2015/2017/2020 onwards	There is no tax relief for FAME biodiesel, HVO/HEFA fuels, vegetable oils and ethanol: - FAME biodiesel, HVO/HEFA fuels and vegetable oils have the same fuel tax as diesel fuel (€ 0.4104/liter) - Ethanol has the same fuel tax as gasoline fuel (€ 0.6545/liter) - The fuel tax for CNG and biomethane is € 0.0139/kWh until 2023	- A carbon tax is indirectly applied via CO_2 tax for passenger cars
Japan	- 500 million liter ethanol mandate (volume) - Introducing 10 million liters (crude oil equivalent) of second generation biofuels (volume)	- No diesel oil delivery tax for B100 - A special tax incentive for the consumption of ethanol - Import of bio-ETBE encouraged through a zero tariff	-

Table 1. Policies for production and use of biofuels in Task 39 member countries plus China and India (continued)

Country	Biofuels mandates	Fuel excise reduction/exemption	Other policy mechanisms
Netherlands	- 16.4% biofuels (both ethanol and biodiesel, double counting advanced biofuels) (energy content) - 1.0% for advanced biofuels in 2020	-	-
New Zealand	- No mandate on biofuel use or any biofuel volume obligations	- Fuel excise exemption for ethanol (including imported ethanol) - No excise exemption for biodiesel	- Emissions trading scheme
South Africa	- No mandate on biofuel use or any biofuel volume obligations	- Fuel excise exemption for ethanol - Biodiesel manufacturers receive a rebate of 50% on the general fuel levy	-
South Korea	- 2.5% mandate for biodiesel (volume)	-	-
Sweden	- GHG emissions reduction of 2.6% for gasoline and 19.3% for diesel	- The tax exemption has varied from full to reduced tax exemption but from January 2018 all biofuels are fully exempted from tax	-
The United States (US)	- Volume targets for biofuels including conventional corn-based ethanol and advanced, cellulosic and diesel biofuels	-	- California's Low-Carbon Fuel Standard (LCFS) - Biodiesel producer's credit
China	- No official national mandate for ethanol and biodiesel use in the transportation sector - 11 provinces and cities (known as pilot provinces and cities) selected as fuel ethanol pilot zones for mandatory E10 blending (volume) - Small trial program using 2% and 5% biodiesel blends carried out in a few provinces (volume)	- An excise tax exemption for waste oil-based biodiesel production - No excise tax exemption for ethanol	- Fuel ethanol subsidies: halted since 2016 for conventional grain ethanol (1 G); subsidies for 1.5 generation ethanol (from cassava or sweet sorghum) since 2013-2017 but phased out in 2018; cellulosic ethanol production subsidy of $0.07 per liter (600 RMB per ton) - Import tariffs on US-origin ethanol
India	- No official national mandate for ethanol and biodiesel use in the transportation sector - The 20% and 5% blending targets are proposed (volume)	- No excise tax exemption/reductions for ethanol and biodiesel	- Deregulated diesel prices - Allow 100% foreign direct investment in biofuel technologies - Over $30 million USD investment in biofuel R&D and second generation ethanol technology - Biofuel imports are banned but the import of feedstock for production of biodiesel is permitted to the extent necessary

As Table 1 illustrates, blending mandates remain the most widely adopted mechanism for increasing production and use of renewable fuels in the road transport sector. Mandates of various forms are prevalent in all geographic regions and for countries spanning different levels of economic development. Worldwide, 64 countries currently have biofuels mandates and targets. The bulk of mandates continue to come from the EU's 27 member states, where the recently revised Renewable Energy Directive (REDII) specifies a 10% renewable content by 2020. Fourteen countries in the Americas (North, Central and South America) have mandates or targets in place or under consideration, 12 in the Asia-Pacific region, 11 in Africa and the Indian Ocean region, and 2 in non-EU countries in Europe.

As in past years, in 2017 national and sub-national governments continued to require specific shares of FAME biodiesel or ethanol to be blended into transport fuels. As shown in Table 1, all Task 39 member countries except South Africa and New Zealand have biofuels mandates in place. In addition to blending mandates for conventional biofuels, the US and some EU member states, including Austria, Denmark, Netherlands and Italy, also have developed or are developing blending mandates for advanced biofuels, which are becoming mandatory as of 2021 across the EU based on the new provisions of the RED II. In China, while there are not yet official national mandates for ethanol or biodiesel use in the transport sector, 11 provinces and cities (known as pilot provinces and cities) have been selected as pilot zones for mandatory fuel ethanol (E10) blending. Similarly, small trial programs to use 2% and 5% biodiesel blends have been carried out in a few provinces. Similar to China, India does not yet have official national mandates for ethanol or biodiesel, however blending targets for biodiesel and sugar/starch ethanol of 5% and 20%, respectively, are being considered. Implementation of national biofuels mandates are anticipated in both China and India in the near future. The United Kingdom (UK) has recently implemented its Renewable Transport Fuel Obligations Order (RTFO II) and created a specific target for certain types of advanced biofuels including aviation and high blends.

Biofuel blending mandates have proven to be effective for establishing biofuels markets and shielding biofuels from low oil prices. However, mandates alone have not proven as successful for expanding or maintaining strong biofuels markets without proper enforcement and accompanying measures. An example is the collapse of biodiesel production in Australia's state of New South Wales, where biofuels mandates in place since 2007 have been ineffective. The mandates are not also helpful in increasing the markets beyond the mandated levels, for example the blend wall issue in the US.

The main reasons biofuels mandates have not worked well in some jurisdictions are varied and include lack of secure supply of feedstock, high costs for feedstocks due to competing uses, low crude oil prices, shortage of infrastructure such as fuel pumps to sell biofuels, food security concerns and sustainability issues such as the potential to exacerbate detrimental impacts of indirect land use change (ILUC). While biofuel mandates have helped to reduce transport sector greenhouse gas (GHG) emissions, they have not always been successful in meeting GHG reduction targets since biofuel obligations are either based on biofuels' volume or energy content rather than decarbonisation potential. In other words, biofuel mandates alone often have not provided sufficiently strong incentives to spur producers to continue to innovate to reduce the carbon intensity of their biofuels.

Fuel excise tax reduction/exemption-based policies and import/export tariffs have been used mainly to make the production and use of biofuels economical at early stages of market development. As biofuels production becomes more cost competitive, e.g., as production costs decrease or the price of petroleum rises, fuel excise reduction/exemption incentives are often either modified or lifted. These types of policies have been employed in 10 of Task 39's member countries (Australia, Austria, Brazil, Denmark, Germany, Japan, New Zealand, South Africa, Sweden and the US). Similar to mandates, the implementation of fuel excise tax reduction/exemption-based policies alone in a jurisdiction has not been a strong enough driver to foster biofuels market expansion when deployed in isolation. New Zealand and South Africa provide examples of this, where even though some excise tax exemptions exist, there is no or only very small levels of biofuels production and use.

Low carbon fuel standards (LCFS) are a newer policy approach that is proving to be more successful for driving increased production and use of biofuels, particularly lower carbon intensity advanced biofuels. Rather than obligating defined production volumes or blending levels, this approach incentivizes reductions in the carbon intensity of fuels production, including for renewable biofuels. In addition to encouraging more efficient production of conventional biofuels, LCFS-based policies spur the development and expanded production of more life cycle efficient advanced biofuels. Under LCFS policies, fuels that can be produced at a lower carbon intensity compared to the petroleum-based gasoline and diesel fuels they displace generate higher carbon credits, which results in higher market values for these fuels. The state of California in the US and the province of British Columbia in Canada are two jurisdictions at the forefront of implementing this type of policy. Across the EU as a result of the RED, but specifically Germany and Sweden have also implemented GHG reduction quota obligations for biofuel use in their transportation sectors.

LCFS policies are helping to spur investors, entrepreneurs, scientists, and engineers to develop innovative low-carbon transportation technologies and strategies, and are also driving on-going innovations in the conventional biofuels market to reduce carbon intensities. One prime example is the development of bolt-on and integrated conversion technologies enabling existing corn-ethanol dry mills in the US to convert corn kernel fibre coproduct into cellulosic ethanol. Another is reusing or selling the carbon dioxide (CO_2) produced by ethanol fermentation instead of considering the CO_2 coproduct stream to be a waste. Beyond these innovations, existing conventional ethanol plants can also lower their carbon footprint by transitioning away from fossil fuel-based energy to obtain their heat and/or electricity supply from renewable sources such as biogas/renewable natural gas, municipal solid wastes (MSW) or agricultural- or forest-based biomass.

In addition to conventional biofuels, LCFS policies are spurring production and use of low-carbon advanced biofuels and HVO/HEFA biofuels. The higher credits generated by lower carbon intensity advanced biofuels can make their production more economical. Due to the higher production cost of HVO/HEFA biofuels compared to conventional FAME biodiesel, these fuels are mainly being sold in markets such as California and British Columbia where LCFS policies are in force that incentivize biofuels based on their carbon intensity, or where there are other supporting policies based on GHG emission reductions such as in Germany and Sweden.

A hybrid of successful policy mechanisms that have been stimulating increased production and use of biofuels within EU member states are the EU's Energy Directive (RED, 2009/28/EC) and Fuel Quality Directive (2009/30/EC). These directives are binding on all EU member states and need to be implemented into member states' respective national laws.RED requires countries achieve at least a 10% share of renewable energy in transport fuels in 2020 and simultaneously specifies that only sustainable biofuels count towards this 10% target. The principle sustainability criterion for biofuels under the RED are minimum GHG emission reduction thresholds compared to regular fossil gasoline and road diesel; and these GHG reductions become progressively stricter in the lead-up to 2020. Other sustainability criteria – defining the eligibility of biofuels to count towards the mandatory target – include the origin of feedstocks, namely the environmental, biodiversity and soil characteristics they stem from. In parallel, the FQD requires EU countries achieve at least a 6% carbon intensity reduction over their lifecycle of all fuels traded in the Union, including fossil fuels.

In 2018, the EU further revised their renewable energy directive, now referred to as REDII, to also include solid biomass sustainability criteria and stricter biofuel sustainability criteria than before, as well as quotas for the use of advanced biofuels made from certain feedstocks. The revised agreement states that at least 14% of transportation fuel must come from renewable sources by 2030. Conventional or first-generation, crop-based biofuels are capped at 2020 levels plus an extra 1% but cannot exceed 7% of final consumption of road and rail transport. In addition, the share of advanced biofuels and biogas must be at least 1% in 2025 and at least 3.5% in 2030. Food crops, such as palm oil, that can result in high indirect land use change (ILUC) (when not cultivated in a sustainable manner) are to be phased out unless third-party certified as low-ILUC biofuels.

Market-pull instruments including biofuels blending mandates and fuel/CO_2 excise reduction/exemptions are broadly effective to support technologies that are relatively mature, as they create a demand for biofuels that is typically met with commercial conversion technologies such as conventional ethanol or biodiesel. However, such instruments can be limited in their capacity to pull early-stage technologies into the market, since these biofuels are often not yet commercially viable, or are typically more expensive to be produced commercially, thus struggling to compete against fossil fuels and conventional biofuels. In contrast, regulatory frameworks such as California's LCFS, the EU's REDII, Brazil's RenovaBio and Canada's Clean Fuel Standard (CFS) are examples of policies that aim to pull advanced biofuels into the market by providing fuel agnostic financial incentives to produce biofuels products at the lowest carbon intensities.

Despite the dominance of market-pull instruments (i.e., biofuels blending mandates, fuel/CO_2 excise tax reductions/exemptions and LCFS), significant resources also have been dedicated to supporting technology research, development and demonstration (RD&D), in particular through grant instruments dedicated to advanced biofuels. Such measures are technology-push instruments which are typically effective to drive early stage technology development (such as advanced biofuels) towards demonstration and commercialization. Technology-push instruments help reduce the cost of research and development to drive new ideas and reduce cost, taking early stage technologies through the valley of death that exists between initial development and demonstration.

Financial measures used to encourage expanded biofuels production and use take a number of forms, including:

- Grants for conversion technology development to increase technology readiness levels to de-risk the technology and supply chain development. Various grants and financial programs are developed mainly to de-risk early market development and initial commercial projects for technologies with long-term market potential but high investment risk
- Loan guarantees to buy down the risk of financing larger first-of-a-kind commercial facilities
- Corporate tax breaks to newly built biofuels production facilities
- Guaranteed return on renewable energy assets
- Compensation for depreciation of acquired renewable energy assets
- Rebates and bonuses to car buyers for the purchase of certain vehicles such as flex-fuel vehicles (FFVs) and other rebates such as reduced license fees and tax credits. For example, Brazil has successfully introduced policies expanding their fleet of FFVs. This has facilitated the widespread deployment of higher-level biofuels blends (e.g., high blend of 27% ethanol in Brazil), and the use of unblended biofuels like hydrous ethanol in FFVs
- Funding available from municipalities and companies for buying alternative fuel vehicles

New engines that allow to harmonize biofuels and electric power trains (biofuel hybrid vehicles), with gains in efficiency and environmental performance are already in commercial stages that may influence how fast biofuels can accomplish, competitively, targets of GHG emissions mitigation considered in transport and energy policies for several countries.

Despite all these financial measures, progress on production of advanced biofuels has been hampered by the slow rate of commercialisation and the fact that advanced biofuels, at this stage of development and in the current market and policy environment, are not cost-competitive with conventional starch or sugar-based biofuels. Due to the immaturity of advanced biofuels feedstock supply chains in terms of feedstock production and supply logistics, feedstock sustainability, and also conversion technology efficiency, the vast majority of existing pilot, demonstration and pre-commercial advanced biofuels projects in Task 39 member countries as well as in China and India are supported by various types of financial incentives provided by federal, state and municipal government agencies.

Compare and contrast transport biofuels policies

Table 2 summarises strengths and limitations of existing biofuels policies.

More biofuel policies are beginning to introduce sustainability criteria for conventional biofuels. Since 2009, the EU's RED stipulates minimum reductions in GHG emissions compared with fossil fuels and prohibit growing biofuels feedstocks in areas converted from land with previously high carbon stocks (e.g., wetlands or forests) or producing them from raw materials obtained from land with high biodiversity (e.g., primary forests or grasslands) - up to 2020 biofuels must save at least 50% or 60% depending on when the biofuel facility came into operation, increasing to at least 65% post-2020. Only biofuels that comply with all sustainability criteria can contribute to national renewable energy targets and are eligible to receive support. Canada has released a set of guiding principles for sustainable biofuels, and the state of California has established an LCFS policy framework requiring a reduction in life-cycle carbon intensity for transport fuels. In some cases, sustainability concerns can lead to revisions in supporting policies, such as the new package of clean energy and emissions reduction goals passed by the European Commission under RED II,

which include a scaling down of conventional biofuels and an increasing role for advanced biofuels and other low-carbon alternatives, such as renewable electricity, for powering transport. In Brazil, the forthcoming adoption of the Renovabio program, introducing a LCFS (low-carbon fuel standard) in vehicular fuels, has reinforced sustainability in biofuels production.

Biofuels policies for aviation and marine sectors

Policies to promote renewable energy in the transport sector continue to focus primarily on road transport, especially at the national level. Other important sub-sectors of transport such as rail, aviation and shipping have until recently drawn comparably less policy attention despite also being large energy consumers and GHG emitters. Transport policies and industry efforts are increasingly focusing on deploying biofuels for all long-haul transport sectors (i.e., road, rail, aviation and shipping), where electrification is much more challenging. The aviation industry recognises the need to address climate change by decarbonizing and has adopted a number of targets, including a 50% reduction in net aviation CO_2 emissions by 2050 (compared to 2005 levels). Few direct support policies now target the use of renewable fuels in the aviation sector. Indonesia introduced a 2% renewable jet fuel mandate in 2017, which is set to increase to 5% by 2025. EU's new REDII allows aviation biofuels as an opt-in to count more highly (using a multiplier of 1.2) in the contributions towards the region's renewable transport target. In 2018, in addition to new policy developments, the Netherlands, Norway, UK and US re-committed to promoting alternative jet fuel production. As of year-end 2017, five renewable jet fuels, plus 5% co-processing of bio-crude, were certified for blending with fossil-based jet fuels (at levels ranging from 10% to 50%).

Shipping is another long-distance transport sector that is under increasing pressure to reduce its carbon and sulfur emissions. It now mainly uses heavy fossil-based fuels that contain sulphur and heavy metals. Along with aviation, shipping is one of the hardest transport sectors to decarbonise. Apart from technological challenges, the deployment of renewables in shipping faces numerous barriers, such as the large price gap between renewable and conventional fuels and very limited regulations, particularly regarding the GHG emissions attributes of maritime fuels. International shipping is regulated by the International Maritime Organisation (IMO). Since the Paris agreement (which did not include international shipping), the IMO has developed reduction strategies for GHG emissions and other air pollutants. In 2016, the IMO agreed to a 0.5% cap on sulphur in its fuels by 2020. In 2018, the IMO reached an agreement on an "initial strategy" to reduce CO_2 emissions from shipping. The initial Strategy identifies measures that could indirectly support the GHG reduction efforts. One of these measures concerns the use of zero-carbon or fossil-free fuels for the shipping sector and the development of robust lifecycle GHG / carbon intensity guidelines for alternative fuels.

Table 2. Strengths and limitations of existing biofuels policies

Policy instrument	**Strengths**	**Limitations**
Biofuel blending mandates	- Effective for developing a biofuel market at early stages - Effective in establishing biofuels markets and in shielding biofuels from low oil prices - Greater certainty of increased development - broadly effective to support technologies that are relatively mature, as they create a demand for biofuels, which is typically met with commercial conversion technologies such as conventional ethanol or biodiesel	- Need to balance costs of infrastructure while demand is low in early stages - Need suitable governance to ensure compliance - Not necessarily so useful in expanding /maintaining markets - Not necessarily successful for meeting GHG reduction targets - Limited in their capacity to pull early-stage technologies into the market, since these are often not commercially viable, or are typically more expensive to be produced commercially - struggling to compete against first generation biofuels
Excise duty reductions/exemptions	- Increases the competitiveness of biofuels with fossil fuels, especially at early stages of development, if fossil vs renewable fuels are taxed differently - Can be also considered for the production of biomass such as dedicated biomass crops (e.g. switchgrass, carinata, willow) in order to ensure sufficient feedstocks for production of conventional and advanced biofuels and ultimately achievement of mandates for use - Broadly effective to support technologies that are relatively mature, as they create a demand for biofuels, which is typically met with commercial conversion technologies such as conventional ethanol or biodiesel	- As fuel excise rates vary, this may not be a strong enough driver to foster the biofuels market as an stand-alone policy - Limited in their capacity to pull early-stage technologies into the market, since these are often not commercially viable, or are typically more expensive to be produced commercially - struggling to compete against first generation biofuels
Low carbon fuel standards (LCFS)	- Technology neutral - Favours technologies able to offer the most significant decarbonisation relative to cost - Spurs the development and production of more life cycle efficient advanced biofuels	- Unlikely to simulate demand for higher cost, less-developed technologies with long-term potential - Determining life cycle emissions is complex and time consuming and requiring big data collection

Table 2. Strengths and limitations of existing biofuels policies (continued)

Policy instrument	**Strengths**	**Limitations**
Low carbon fuel standards (LCFS)	- Encourages conventional biofuel producers to lower their carbon footprint by transitioning away from fossil fuel-based energy and making better use of their by-products such as CO_2	- Results of life cycle analysis depend on system boundaries, allocation methods and other assumptions and are subject to debate - Need suitable governance to ensure compliance - Need suitable verification process to measure the carbon intensity of biofuels produced from different feedstock-conversion technology pathways
Research and development, demonstration funding and financial de-risking measures, mainly for advanced biofuels and power-to-X technologies	- Necessary to support early market technology development and initial commercial projects with longer-term market potential but high investment risk - Successful in de-risking technology and catalysing private investment for subsequent stages, somewhat sparing public budgets as technologies advance into commercial stages	- Financial risks associated with potential project failures
Sustainability policy	- Propel the production and use of advanced biofuels using non-food crop feedstocks such as municipal solid waste (MSW), used cooking oil, and agricultural and forest residues	- Could constrain further production of conventional biofuels from food crops, even for cases where there is little potential for detrimental indirect land use changes - Could make waste production profitable, which is not in line with overall waste reduction initiatives and polices

Challenges for the further growth of transport biofuels industry

Despite many active R&D projects and continuing advances being made in conventional and advanced biofuels technologies – and a large potential to further increase biofuels production and use globally – the biofuels industry faces significant challenges. Petroleum prices remain modest and future policies to promote renewable fuels and improve vehicle fuel efficiency standards remain highly uncertain. On-going high uncertainty about future policy and funding programs to support conventional and advanced biofuels continues to be a major obstacle to accelerating biofuels development, especially in some major biofuels producing jurisdictions like the US. Worldwide, the food versus fuel debate has driven increased development focus towards advanced biofuels over the last 7-8 years, with countries putting in place specific targets for advanced biofuels and caps on conventional biofuels. However, commercialization of these advanced biofuels technologies has been much slower than earlier forecast, with only limited volumes being produced so far, with the result that most targets for expansion of advanced biofuels production and use have not been met. Extensive research and development into production of advanced fuels is on-going, however, with the research focus increasingly shifting towards drop-in biofuels for heavy-duty transport as well as enabling a faster route to large scale lower carbon biofuel production by co-processing of bio- and fossil-based feedstocks at oil refineries.

Conclusions

Policies have proven to be a key component in the development, deployment and use of biofuels such as bioethanol, biodiesel and "drop-in" biofuels. The IEA Bioenergy's Task 39 is fortunate to have several "biofuel countries" as members, representing a diverse range of biofuels producers and consumers. One of the Task's activities has been to collect information on existing/emerging biofuels policies and production and use levels over the period 2006-2017. In all cases, biofuels policies have played an important role in developing regional and national biofuels markets. Most policies have primarily promoted the production and use of road transport biofuels with the rail, aviation and shipping sectors drawing less policy attention despite being significant fuel consumers, carbon emitters and potentially large markets for biofuels. A mixture of market-pull and technology-push policy instruments has been most successful at encouraging biofuel production and use. While many of the original policies were developed to promote energy security, more recent policies, such as the California and British Columbia low carbon fuels standards (LCFS), have GHG reduction as a primary goal. Although various jurisdictions have combined policies in different ways, blending mandates continue to be one of the most successful mechanisms used to increase biofuel markets.

IEA Bioenergy

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/