Briefing for the ENVI delegation to the Porto Marghera refinery in Venice on 17-18 July 2017

KEY FINDINGS

- The EU has set a target to replace 10% of transport fuel of every EU country by fuels from renewable sources by 2020. In 2015, 6.7% of final energy used in the EU-28 came from renewable sources. However, efforts will have to increase in order to meet the 10% renewable energy target in 2020.
- Growing feedstocks for the use of biofuels can cause greenhouse gas emissions, generate negative effects for biodiversity and induce indirect land use changes by diverting formerly grown crops to environmentally sensitive lands. The EU seeks to promote the use of advanced biofuels which have less negative effects.
- Sustainability criteria for biofuels are laid down in the Renewable Energy Directive (2009). The Commission's proposal for a RED recast beyond 2020 could be an instrument to promote the sustainable use of biofuels. However, a number of sustainability criteria related to biodiversity included in the proposal are insufficient to guarantee that negative effects can be avoided.
- The EU's gross imports of biodiesel and bioethanol amounted up to 5.3 ktoe and 1.5 ktoe in 2015. From the feedstocks imported for the production of biofuels, especially palm oil causes high greenhouse gas emissions through deforestation.
- ENI's biorefinery in Venice is an innovative approach offering the conversion of different feedstock types to various products. However, refining would have to use second or third generation feedstocks to increase sustainability. Additionally, using the products from biorefining as biogenic inputs for the chemical industry might be more environmentally sensible than producing energy outputs.

1. Introduction and background

Biofuels such as biodiesel and bioethanol are used as a renewable alternative to fossil fuels in the EU's transport sector. By promoting biofuels, the EU at the same time aims to reduce greenhouse gas emissions and to improve the EU's security of energy supply. The EU has set a target to replace 10% of transport fuel of every EU country by fuels from renewable sources by 2020. Fuel suppliers are also required to reduce the greenhouse gas intensity of the EU fuel mix by 6% by 2020 compared to 2010.

Biofuels can be produced from various types of biomass. Conventional ("first generation") biofuels are made from the conversion of food crops (palm oil, soy, beets etc.). The production of conventional energy crops has the largest impact on indirect land use changes (iLUC) as it might induce other crop production move to environmentally sensitive lands such as rainforests or grasslands. As a result, high amounts of carbon can be released and critical functions for biodiversity are at risk. The production of first generation biofuel can thus cause GHG emissions and harm to biodiversity. Advanced biofuels are not based on agri-food crops but produced from lignocellulosic feedstocks, non-food crops, or industrial waste and residue streams (see Annex IX of EC 2016c). They are supposed to have low CO_2 emission or high

External authors: Anne Siemons, Klaus Hennenberg, Hannes Böttcher
Responsible Administrator: Tina Ohliger
Editorial Assistant: Eva Asplund
Policy Department A: Economy and Scientific Policy,
European Parliament
PE 607.324

GHG reduction, and zero or low iLUC impact. Yet, they might still damage ecosystem processes when sourced from sensitive ecosystems.

In order to ensure that the use of biofuels contributes to climate change mitigation while at the same time protecting biodiversity, the EU has developed sustainability criteria for biofuels and bioliquids. These criteria require producing companies to fulfil sustainability standards, i.e. GHG-reduction of at least 35% compared to fossil fuels; protection of land with high biodiversity value, of land with high carbon stock, and of peatland; and fulfilling so-called cross compliance rules[1] when cropping in the EU. However, the RED criteria do not cover gaseous and solid forms of bioenergy used for electricity and heating and cooling.

Biofuel production has experienced an exponential growth over the last decade, both at European and global level. In that context, EU biofuel policies, originally strictly aimed at promoting domestic industry, had significant impacts on world biofuel production and trade patterns. The introduction of blending requirements for fossil fuels and biofuels and the phase-out of tax exemptions in several Member States led to a higher share of imports as blenders were interested in keeping biofuel costs to a minimum and preferred cheaper imports (e.g. palm oil for biodiesel) (Lamers 2013).

In 2015, 6.7% of final energy used in the EU-28 in the transport sector came from renewable sources with biofuels and biodiesel being the most important sources. This share has been rising over the past years but efforts need to be enhanced in order to reach the 10% target by 2020 (EC 2017). Transformation in the transport sector is difficult for various reasons, including high mitigation costs and political uncertainty.[2]

Biofuels are also discussed as a means to reduce GHG emissions from aviation. Current production is very limited, at less than 0.1% of global total consumption of all types of jet fuels. Analyses come to the conclusion that costs for the feedstocks currently used as well as supply and sustainability concerns make it impossible to scale up production to meet demand and achieve the greenhouse gas reduction targets set for the aviation sector by the International Civil Organisation for Aviation (ICAO) (IRENA 2017).

To prepare the ENVI delegation for their visit to the Porto Marghera refinery in Venice on 17-18 July 2017, this briefing paper summarises the main EU legislation and current debates on biofuels, gives an overview of production and consumption patterns of biofuels in the EU and provides background information on technological innovations in the area of biofuels which are used in the Porto Marghera refinery.

2. EU legislation on biofuels – an overview

The EU has regulated the production and consumption of biofuels since 2009. The European legislative framework on biofuels is structured as follows:

- The RED (2009/28/EC) sets renewable energy targets and biofuel blending targets.
- The iLUC-Directive (EU 2015/1513) supplements the RED (2009) by addressing, e.g., indirect land use change and food security.
- GHG targets for transport are set in the Fuel Quality Directive (2009/30/EC).

2.1. Renewable Energy Directive (2009/28/EC)

The RED (2009) set an overarching framework for the production and promotion of renewable energy in the EU. It includes the aim of at least 20% of total energy consumption from

[1] Cross compliance rules make supporting payments to agricultural producers conditional upon fulfilling certain environmental requirements.

[2] Until 2015, uncertain regulation regarding indirect land use change (iLUC) resulting from the use of biofuels increased the investment risk for producers and provoked uncoordinated action by Member States. Furthermore, public and consumer concerns decelerate the expansion of biofuels in the EU. Additionally, electric mobility to date remains a rather costly alternative to fossil fuels and lacks adequate infrastructure (EC 2017).

renewable sources by 2020 and requires Member States to ensure that 10% of their transport fuels come from renewable sources in 2020. The RED (2009) includes specific renewable energy targets for each Member State, ranging from 10% to 49%. Each country outlines its strategy to meet its target in national renewable energy actions plans (NREAPs).

In 2016, the Commission published the proposal for a recast of the RED (EC 2016c) for the period 2021 till 2030, setting an overall EU target of at least 27% renewables in final energy consumption in the EU by 2030 and introducing sustainability criteria for forest biomass.

Sustainability criteria for biofuels in the RED (2009)

The RED (2009) includes sustainability requirements in Art. 17 that aim to mitigate main negative impacts from biofuels on biodiversity and climate change.[3] Firstly, it requires biofuels to achieve GHG savings of at least 35% in comparison to fossil fuels (rising to 50% in 2017 and 60% in 2018 for new production plants, Art. 17.2). Secondly, it protects areas with high biodiversity value by excluding biofuels obtained from primary forests, protection areas and highly biodiverse grassland (Art. 17.4). Thirdly, it excludes biofuels which are grown on areas converted from land with previously high carbon stock such as wetlands, and forests with high and low tree cover (Art. 17.4). Fourthly, biofuels and bioliquids shall not be made from raw material obtained from land that was peatland (Art. 17.5), and lastly, raw materials used for the production of biofuels and bioliquids shall – within the EU – fulfil certain standards of sustainable agricultural production (Art. 17.6).

Yet, the sustainability criteria covered could be enhanced to ensure better protection of biodiversity and climate mitigation, especially when taking solid fuels into account:

- Protection of highly biodiverse forests that are not primary forests is not covered, e.g. conversion of highly biodiverse secondary rainforest to a teak monoculture.
- Sustainability requirements for forest management are absent.
- Sustainability requirements for agricultural production within the EU are rather weak (cross compliance rules only) and they are not covering production outside of the EU.

2.2. Main changes introduced by the iLUC Directive

Biofuel production often takes place on cropland which was previously used for other agricultural purposes. The food or feed that was grown on the respective land might be displaced to grasslands or forests. This process is called indirect land use change (iLUC). It causes net GHG emissions because grasslands or forests store high amounts of carbon. To regulate the impacts of biofuel production on land use change, the iLUC Directive (2015) introduced a cap for biofuels produced from energy crops[4] grown as main crops on agricultural land. Thus only up to a maximum of 7% of the 10% target can be achieved by using biofuels produced from energy crops with a high risk of iLUC. Electric mobility or advanced biofuels shall be used to reach the remaining 3%. Furthermore, the iLUC sets an indicative target of 0.5% use of advanced biofuels by 2020. Due to their positive characteristics, the energy content of advanced biofuels can be counted twice to meet the national biofuel targets compared to other renewable energy sources.

However, Member States may decide whether to exclude or include ligno-cellulosic energy crops under the 7% cap which can also cause iLUC. Thus, in summary, it is questionable to what extent the regulations of the iLUC Directive are suitable to reduce the risk of iLUC.

---

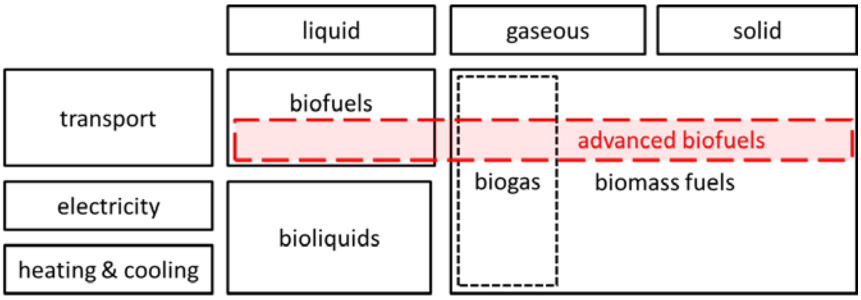
[3] While biodiversity and mitigation of climate change are explicitly protected by the RED, the regulation of water, soil, air, land use rights, labour rights and food security in third countries by the EU is not compatible with WTO regulations and thus not included in the RED. Instead they are covered under reporting requirements.

[4] E.g. cereal, sugars, oil crops and other main crops grown primarily for energy purposes on agricultural land.

2.3. Proposal for the recast of RED with relevance for biofuels

RED (2009) covers only biofuels and bioliquids. The proposal for the recast of the RED (EC 2016c) for the period beyond 2020 aims at including gaseous and solid biomass in EU legislation as well (see biomass types in Figure 1). The following sections highlight main aspects of the RED recast proposal related to bioenergy.

Figure 1: Illustration of bioenergy types given in the RED-Proposal



Source: EC 2016c, own presentation.

Mainstreaming renewables in heating and cooling energy supply

The RED recast proposal suggests that each Member State shall increase the share of renewable energy supplied for heating and cooling by at least 1 percentage point every year (Art. 23.1). Solid biomass fuels are a major renewable energy source in the heating and cooling sector today and presumably also until 2030. Thus, this target is likely to induce an increase of the use of solid biomass – besides solar heat and near-surface geothermal energy – for heating and cooling.

Mainstreaming renewable energy in the transport sector

For the transport sector, the RED recast proposal sets two binding targets for each Member State, including trajectories from 2021 until 2030 (Art. 25.1):

I. Minimum target of 1.5% in 2021 and 6.8% in 2030 for energy in transport from: advanced biofuels; renewable liquid and gaseous fuels of non-biological origin (e.g. power to gas, power to liquid); waste-based fossil fuels; or renewable electricity.

II. Minimum target of 0.5% in 2021 and 3.6% in 2030 for energy from advanced biofuels. This is a sub-target of point 1.[5]

The mandatory target of 10 % for renewable energy in the transport sector for each Member State is deleted from the RED recast proposal. However, Member States shall collectively ensure a share of renewable energy of at least 27% in all sectors (Art. 3.1). Without further regulation, the minimum targets of 1.5% in 2021 and 6.8% in 2030 included in the RED recast proposal would be the only EU targets for the transport sector. At the same time, setting increasing targets for the listed energy sources and especially for advanced biofuels, requires sound checks whether these amounts are sustainably available.

Application rules for sustainability and greenhouse gas emissions saving criteria

The Commission proposes that biomass fuels need to meet sustainability and emissions saving criteria only if plants exceed a certain size (≥ 20 MW (electricity, heating/cooling or fuels) for installations using solid biomass and ≥ 0.5 MW (electricity) for installations using gaseous biomass fuels). There is no exception for biofuels. However, due to the high thresholds, only small amounts of solid and gaseous biomass would have to comply with the sustainability criteria.

[5] Biofuels and biogas produced from used cooking oil, animal fat, and molasse shall be limited to a share of 1.7%.

Mitigation of impacts from direct land use change

The RED (2009) addresses risks that may occur from direct land use change in or after January 2008 with regard to biodiversity (Art. 17.3), carbon stock (Art. 17.4), and peatland (Art. 17.5). The related sustainability criteria have to be applied to all biomass types, including agricultural and forest biomass. According to the RED recast proposal, these criteria shall now apply only to agricultural biomass (Art. 26.2 to 26.4). That way, the RED recast proposal would allow that, e.g., primary forests, highly biodiverse grasslands, and wetlands may be degenerated by forestry, especially in case of production in third countries (EC 2016b). Furthermore, the new category ‘highly biodiverse forests’ is currently missing in the RED recast proposal.

Two changes dilute existing risk mitigation measures for **highly biodiverse grassland**:

- Highly biodiverse grasslands are protected only if they span more than one ha (RED 2009: no limit);
- Non-natural highly biodiverse grassland needs to be categorised as highly biodiverse by the relevant competent authority. This proposal undermines the precautionary principle of the RED 2009.

Land that was **peatland** in 2008 shall be available for forest activities but precluded for agricultural production. Due to no or low soil cultivation forestry activities affect soils much less than agriculture. Biomass from forests on peatland could be used if forestry practices are applied that protect the peat against oxidation (currently missing in the proposal).

References to **sustainable agricultural production** (Art. 17.6 of the RED 2009) shall be deleted in the RED recast proposal. Yet, it would be preferable to maintain at least a link to the sustainability requirements of the Common Agricultural Policy (CAP).

With regard to **forestry production**, the Commission proposes to apply criteria for sustainable forest management (Art. 26.5). However, these criteria are rather weak and not well defined and could allow forestry production to convert no-go areas like primary forests and highly biodiverse grassland and forests.

Finally, the RED recast proposal introduces requirements for **GHG emission reductions** to be achieved by biofuels, bioliquids and biomass fuels (biofuels: 50%-70%; solid and gaseous biomass fuels: 80%-85%).

Thus, in summary, the Commission’s proposal for the RED recast could be an instrument to promote the sustainable use of biofuels. Criteria for ensuring the reduction of GHG emission appear to be sufficiently addressed. However, a number of sustainability criteria related to biodiversity are insufficient to guarantee that negative effects can be avoided. Particularly, the risk of indirect land use change is not adequately addressed in our assessment and the use of biomass from forests would require more stringent regulation.

2.4. Fuel quality directive

The RED is supported by the Fuel Quality Directive (2009/30/EC) on the promotion of the use of energy from renewable sources and GHG savings. It introduces requirements on fuel suppliers to reduce the GHG intensity of energy used for road transport. Life cycle GHG emissions per unit of energy from fuel and energy supplied should be reduced by up to 10% by 31 December 2020 compared with existing fuel baseline standards whereof 6% are mandatory and 4% voluntary. Furthermore, the Directive revises specifications for petrol and diesel characteristics, and it supports the sustainability criteria given in RED (2009).

2.5. EP Resolutions on biofuels

The EP has adopted a number of resolutions with reference to biofuels, including:

- Resolution of 18 May 2017 on **road transport in the EU**, proposing biofuels as a means to promoting low-emission road transport;

- Resolution of 4 April 2017 on **palm oil and deforestation of rainforests** pressing for halting the production, import and use of unsustainable palm oil through i.a. sustainability criteria, the development of appropriate legislation and awareness raising;
- Resolution of 16 February 2017 on an **Aviation Strategy for Europe**, asking to encourage the use of renewable fuels in aviation transport;
- Resolution of 5 October 2016 on the **next steps towards attaining global goals and EU commitments on nutrition and food security in the world**, red-flagging the impacts of crop-based biofuel production on global food supply.

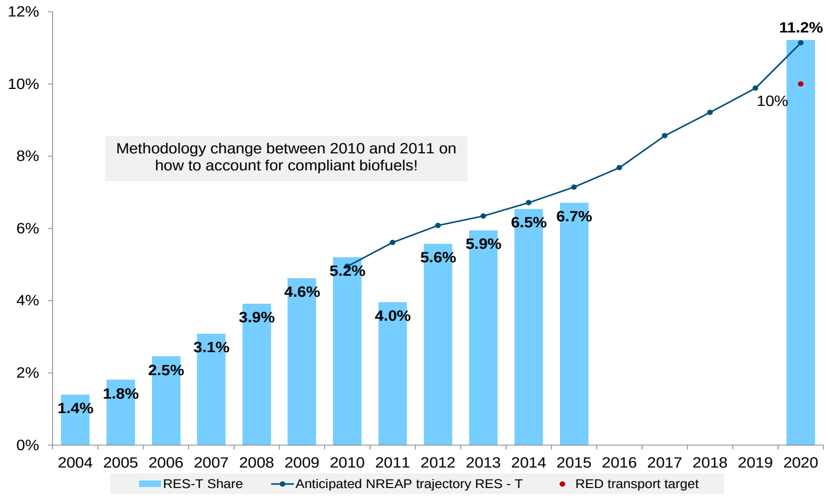
3. Production and consumption of biofuels in the EU

In the transport sector, 6.7% of final energy used in the EU-28 in 2015 (i.e. 20.3 Mtoe) came from renewable sources. Finland and Sweden are the two countries with the highest shares of renewable energy in the transport sector in 2015 (22% and 24%). Figures for other EU Member States vary between 0% and 9% in 2015. Three countries (Austria, Finland and Sweden) already fulfilled the 10% target for 2020 in 2015 (Eurostat 2017a). For the EU-28, the EU Reference Scenario 2016 projects a renewable energy share in the transport sector of 11.2% in 2020 (EC 2016a). Accordingly, the transport target put forward in RED (2009) can be reached. However, current progress reveals that efforts will need to be increased as the EU was below its planned NREAP trajectory in 2015 (see Figure 2) and additionally, various Member States need to undertake additional efforts in order to fulfil the target for the transport sector on a national level. The share of renewable energy in EU-28 total energy consumption was 16.6% in 2015 (Eurostat 2017a). Projections indicate that the EU-28 is well on track to reach its renewable energy target in 2020 (EC 2017).

3.1. Biofuels used in the transport sector

The share of renewable energy used in the transport sector rose steadily until 2010 but decreased in 2011. From that year onwards, Member States had to apply the sustainability criteria for biofuels set in the RED (2009). This reduced the amount of compliant biofuels that can be counted towards the 10% target for the transport sector. After 2011, biodiesel and bioethanol have not shown a significant growth trend. The use of renewable electricity only grew at a rate of about 0.1 Mtoe per year between 2010 and 2015 (EC 2017).

Figure 2: Share of renewable energy consumption in the transport sector (%)



Sources: Renewable energy share in transport (Eurostat 2017a); aggregated NREAP trajectory and projected 2020 renewable energy share in transport (EC 2017); RED transport target (EU 2009).

Calculations of renewable energy shares are based on sector-specific methodologies laid down in the RED (2009).

Together, all biofuels in the transport sector make up 71% of all renewable energy sources used in that sector (Eurostat 2017a). Biodiesel is the most important source of renewable energy, representing about 80% of total use of biofuels in transport in 2015. The main consumers of biodiesel are France, Germany and Italy, each consuming over 1 Mtoe every year since 2009. Yet, the deployment in Member States still lags behind the indicative targets set in the NREAP trajectories. Bioethanol (bio ETBE) is the second largest source of renewable energy for the transport sector. The share of bioethanol amounted up to 20% of biofuels used in the transport sector in 2014. Main consumers in 2015 were Germany, the UK and France, followed by Spain, Sweden, Poland and the Netherlands (EEA 2017; Eurostat 2016). Overall, Germany, France, Italy, Sweden and the UK are the largest consumers of biofuels in compliance with the requirements of the RED (2009) (EC 2017).

The large majority (=92%) of all biofuels used in the transport sector comply with the sustainability criteria and requirements for verification of compliance with those criteria set in Article 17 and 18 of the RED (2009) (Eurostat 2017a). Only compliant biofuels are counted towards the achievement of the 10% target for the transport sector.

Further sources of renewable energy are hydrogen and synthetic fuels, renewable electricity and other sources incl. biogas. They only make up a very small share of renewable energy used in the transport sector in the EU (Eurostat 2017a). The share of biofuels produced from wastes, residues, lingo-cellulosic and non-food cellulosic material in the EU biofuel mix has increased from 1% in 2009 to about 23% in 2015. Main promoters of this development are the UK, Germany, Finland and Sweden. Italy, France and Germany used the highest amounts of renewable electricity in the transport sector in 2015 (EC 2017).

3.2. Biofuels used in other sectors

In the heating and cooling as well as in the electricity sector, liquid biomass plays a minor role. Only 0.1% of total gross final energy consumption in the heating and cooling sector in the EU is consumed as biofuels. Austria, Belgium, Denmark, Germany, Italy and the Netherlands are the only countries which used bioliquids in the heating and cooling sector in 2015 (figures calculated from EEA 2017; Eurostat 2016). Similarly, liquid biomass only makes up 0.2% of total gross final energy consumption in the electricity sector. Only Italy (and Germany and Belgium to a negligible extent) deploys bioliquids in the electricity sector (figures calculated from EEA 2017; Eurostat 2016).

3.3. Production of biofuels in the EU: imports and domestic production

Biofuel production has experienced an exponential growth in the past years, both at EU and global level. In the EU, primary production of biodiesel was 11.1 Mtoe and 2.2 Mtoe for bioethanol (Eurostat 2017c). Production facilities for first generation biodiesel (FAME) exist in all EU Member States except for Finland, Luxembourg and Malta (202 biorefineries in 2016). Hydrogenated vegetable oil (HVO) was produced in eleven biorefineries in six EU countries in 2016 (the Netherlands, Finland, Italy and Spain; small amounts are produced in Portugal and France). The number of FAME refineries has been declining over the past years while HVO capacities have slightly increased (USDA Foreign Agricultural Service 2017).

Bioethanol is produced in nine EU Member States (France, Germany and the UK are the main producers with production mainly based on wheat but also sugar beets; smaller amounts are produced in Hungary, Belgium, the Netherlands, Spain, Poland and Austria). 71 refineries based on first generation feedstocks existed in 2016 and one refinery produced bioethanol from cellulosic feedstocks. Numbers of biorefineries for bioethanol have been rather stable over the past years (USDA Foreign Agricultural Service 2017).

Within the EU, land use changes for the production of crops dedicated to energy production is monitored through Member States' Progress Reports under the RED (2009). While monitoring has improved over the years, improvements are still needed, for example with regard to common methods of data collection and reporting methodologies. No or low figures reported by large Member States indicate data gaps. Nevertheless, some general observations can be made from Member States reports. In 2014 the largest part of land was used for the production of common arable crops and oilseeds (97%) in the EU. Bulgaria, Germany, France and Italy reported the largest amount of land use for common arable crops and oilseeds. For other energy crops such as grasses and sorghum, Finland and the UK report the largest amounts. Germany and France together provided 57% of the acreage used for biofuel production in the EU in 2014 (EU Member States 2015).

The EU has made progress in the production of biofuels from waste, residues, non-food cellulosic and ligno-cellulosic material. Most of the available resources come from agricultural residues, particularly in France, Germany and Denmark. It is estimated that 157 million tonnes of agricultural and forestry residues and wastes could be available for biofuel production without additional negative impacts. Yet, the availability of waste is expected to decrease due to higher recycling and policies to reduce waste (Searle & Malins 2016).

3.4. EU trade on biofuels

The EU is a net importer of both, biodiesel and bioethanol. Gross imports have increased over the last years to 5.3 ktoe of biodiesel and 1.5 ktoe of bioethanol (Eurostat 2017c). Of those imports, Member States imported 69% of biodiesel and 35% of bioethanol from other Member States. Germany, Italy and Sweden were the main importers of biodiesel in 2015; Germany and the UK for bioethanol (Eurostat 2017b).[6]

In 2015, 24% of biodiesel and 64% of bioethanol imported from outside of the EU was of non-specific origin (Eurostat 2017b). Biodiesel imports from specified non-EU origin mainly came from Malaysia, Argentina, Switzerland and Indonesia. Small amounts of bioethanol were imported from Russia, Australia, the Ukraine and Turkey (Eurostat 2017b).

Yet, it is more difficult to assess the origin of the EU's imports of feedstock which are processed into biofuels in the EU. No data is available that contains detailed information on the country of origin of such imports and on which share of the imported feedstock is used for biofuel production within the EU. Some information can be drawn from available data on imports of agricultural commodities/feedstocks that can be used for production of biofuels.[7]

About half of the biodiesel produced in or imported to the EU is based on rapeseed oil as feedstock (46%) which is mainly domestically grown. Other feedstocks include palm oil (18%), used cooking oil (UCO) (18) and animal fats (8%) (USDA Foreign Agricultural Service 2017). Major supplying countries of palm oil to the EU are Indonesia, Malaysia and Papua New Guinea (UN Comtrade 2017, data for 2015).[8] Bioethanol produced in and imported to the EU is mainly based on sugar beet (43%), corn (27%) and wheat (20%) (USDA Foreign Agricultural Service 2017). Sugar beet is mainly imported from Egypt, the Russian Federation and Belarus, wheat/starch mainly comes from Canada, the Ukraine, Serbia, China and the USA while the main suppliers for corn are the Ukraine, Brazil and Serbia (UN Comtrade 2017, data for 2015).

Particularly the production of palm oil in Indonesia and Malaysia implies high risks of iLUC, and is likely to induce greenhouse gas emissions through deforestation for the production of oil crops. Additionally, high risks for biodiversity can be expected (Valin et al. 2015).

[6] Eurostat data does not cover all biodiesel imports into the EU. There are additional categories for which data is not reported publicly. Also, fossil fuel blends with biodiesel content up to 30% is covered by custom codes of petroleum products and thus not included in the data.

[7] This information is only partly available in Member States' Progress Reports under the RED so that data from the USDA Foreign Agricultural Service and Comtrade is used in this briefing.

[8] Yet, this data does not explain to what extent the imports are used for the production of biodiesel within the EU.

In order to assess whether feedstocks imported to the EU comply with the RED sustainability criteria, a number of certification systems are recognized under the RED Furthermore, certification systems like RSPO (Round Table on Sustainable Palm Oil) and ISCC (International Sustainability and Carbon Certification) require additional environmental (soil, water) and social criteria (labor rights, land use rights, food security). However, these are voluntary and in the past, they have not been effective in halting deforestation for the production of palm oil.

Against this background the European Parliament voted to phase-out the use of palm oil in biofuels by 2020 in its resolution on palm oil in biofuels (April 2017). According to the Parliament, the imported palm oil requires the use of about one million hectares of tropical soils. MEPs thus called on the EU to introduce sustainability criteria for palm oil and palm oil-based products which are imported to the EU (European Parliament 2017).

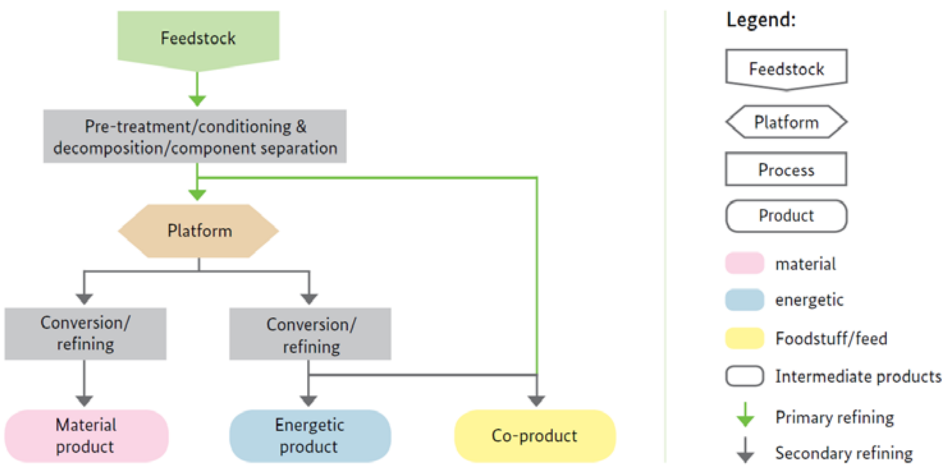
4. Biorefineries – technical overview and project examples

4.1. Biorefining – definition and overview

The International Energy Agency (Bioenergy Task 42 on biorefineries) has defined biorefining as the sustainable processing of biomass into a spectrum of marketable products (food, feed, chemicals, materials) and bioenergy (biofuels, power and/or heat) (IEA 2015). Biorefineries can thus either produce energetic products, such as fuels to replace more greenhouse gas intensive fossil-based sources of energy, or non-energetic products such as bio-chemicals or biomaterials to replace fossil-based materials which can then be further processed in the chemical industry.

Biorefining usually consists of two steps: Firstly, the biomass components are separated into intermediates (such as cellulose, starch, sugar, vegetable oil, lignin, plant fibres, biogas or synthesis gas). Secondly, the intermediates are further converted and processed into specific products for energetic or material uses. The by-products that occur as a result of primary and/or secondary refining can be used for the supply of process energy or they might be further processed into food or feed. A biorefinery can be set up by expanding an existing biomass processing facility (e.g. a sugar starch, pulp mill, oil mill or ethanol plan) or it can be newly conceptualised (German Government 2012). A schematic presentation of a biorefinery system is given in Figure 3.

Figure 3: Schematic presentation of a biorefinery system



Source: German Government 2012.

To assess the sustainability of a biorefinery, various aspects need to be taken into account. Firstly, the type of feedstock is critical. For biorefineries, (1) renewable resources which are cultivated specifically as industrial or energy crops, (2) biogenic residual materials from agriculture and forestry, (3) industrial biogenic residual materials resulting from industrial processing or biogenic residual materials from food production or (4) biogenic waste materials arising in the usage phase of the finished products can be used (German Government 2012).

Besides considering the sustainability criteria explained above, the conversion technologies used, the respective conversion and energy efficiency of a refinery, the types of products (including co-products) that are manufactured and which products are substituted by the bio-products are key to the contribution of biorefinery to climate mitigation and the protection of biodiversity (Wellisch et al. 2010). Lifecycle analyses can be used to assess the overall sustainability of production processes of biofuels.

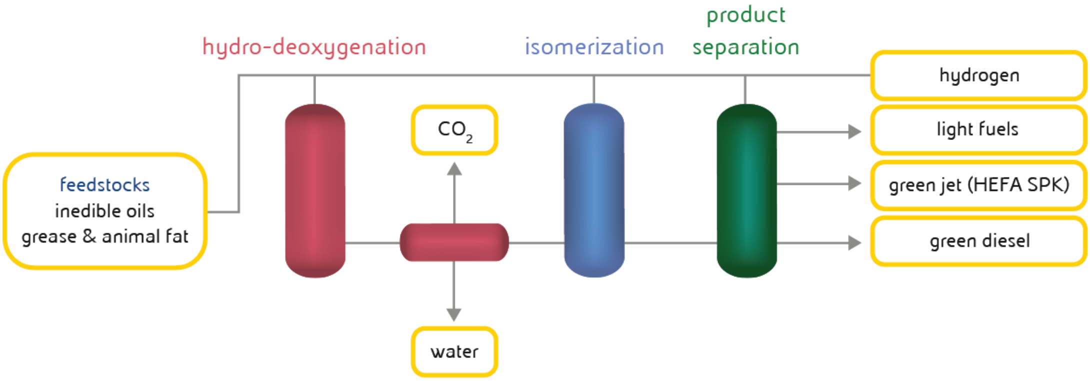
Examples of similar refineries to ENI's biorefinery can be found in Finland (run by Neste Oil and the forest product company UPM), the Netherlands (run by Neste Oil) and Spain (run by CEPSA). Plants for producing cellulosic ethanol exist in Spain (Abengoa Bioenergy), Italy (Beta Renewables) and Finland (St1 Biofuels Oy in cooperation with North European Bio Tech Oy) (USDA Foreign Agricultural Service 2017).

4.2. ENI's biorefinery in Porto Marghera

ENI's Green Refinery project is located in Porto Marghera in Venice. This refinery has realised the conversion of the existing Venice Refinery into a "biorefinery". ENI developed a new hydrotreatment process, called Ecofining^{TM}, to produce high quality biofuels, mainly Green Diesel[9] (HVO) but also Green Jet, Green Naphtha and Green LPG, each one exploitable as bio-components for transportation fuels. Different biological feedstocks form the basis for this process: first generation feedstock (vegetable oils in competition with the food supply chain), second generation feedstock (animal fats, used cooking oils and agricultural waste) and also third generation feedstock (oils from algae or waste). Currently, organic oil and fat is processed.

The Ecofining^{TM} process consists of two stages of reactions (see Figure 4): (1) the biological feedstock is completely deoxygenated under hydrogen partial pressure, producing a mix of linear paraffins; (2) the mix of linear paraffins is than isomerized on proprietary catalyst to the final products. The product properties, can be controlled independent of the type of bio-feedstock used.

Figure 4: Simplified Ecofining^{TM} process flow



Source: ENI 2017b.

Since 2014, the Venice biorefinery has been able to process approximately 360,000 tonnes of vegetable oil (refined palm oil) per year. ENI is planning a second biorefinery in Gela, Sicily with even higher production capacities (ENI 2017a).

ENI's biorefinery is an innovative and efficient approach offering the conversion of different feedstock types to different products. The sustainability of the process strongly depends on

[9] The high quality of the Green Diesel is highlighted by higher heating value and energy density than classical biodiesel like FAME1, very high cetane number, optimum cold flow properties (Cloud point -20°C) and low density, which makes it real "drop-in" biofuels instead of fuel additives (ENI 2017b).

the sustainability of the used feedstock. Currently, ENI processes first generation feedstocks like palm oil (see discussion in section 3.4). However, the possibility to make use of residues and wastes as feedstocks is promising. Also the products are of interest: Green Jet could address fuel needs in the aviation sector while Green Naphtha and Green LPG (methane) can be used as biogenic inputs for the chemical industry. Thus, ENI's biorefinery-type may strongly enhance the use of biomass for material use as postulated in the EU bio-economy strategy (EC 2012).

5. Conclusions and recommendations for the ENVI delegation

The following issues could be addressed by the ENVI delegation at their visit:

- How high are carbon losses of the refinery? What is the energy efficiency like?
- Which level of GHG reduction is achieved for Green Diesel compared to fossil diesel?
- What are the environmental advantages compared to "classical" biofuel and biogas production?
- How is the sustainability of raw materials proven, e.g., against the RED criteria? Which certification systems are applied?
- Which feedstocks could possibly be processed in the refinery – only organic oil/fat or also lignocellulosic material or mixed waste?
- Why is Green Diesel the main product – due to technical or market reasons?
- What are the typical proportions of the main product Green Diesel and the by-products? Would it be possible to focus the production on Green Naphtha alone or Green Naphtha in combination with Green Jet for example?

Due to biological processes in crop production, biomass can never be produced in a carbon neutral way. Additionally, the competition with area for food production and the risk of iLUC at a global level further limit the potential contribution of biomass to climate mitigation. Against this background, primarily grown crops cannot be considered as a sustainable alternative to fossil energy sources. Residual materials from agriculture and forestry might play an important role for the biodiversity of a specific land and thus, their impact depends on the amount harvested from an area. Industrial residual materials and biogenic waste materials can be considered best suited for the production of biofuels as they do not have implications on land use. Measures to promote biofuels should thus focus on advanced biofuels with low iLUC impacts and high overall GHG emissions savings.

However, the more technologies to decompose biomass into high-quality intermediate products advance, the less reasonable it might be from an environmental point of view to process these products into biofuels. Instead, it will be more expedient to use them for non-energetic purposes in the chemical industry and replace fossil fuels by electric mobility supplied with energy from renewable sources to the degree possible (aviation as an exception). It will thus be crucial to develop efficient strategies for the material use of biomass products, e.g., in chemical industries and to use biomaterials as biofuels only at the very end of processing (cascading use of resources). At the same time, the replacement of fossil fuels with biofuels should always be balanced against the possibility to use electric energy produced from renewable sources, including renewable liquid and gaseous transport fuels of non-biological origin like power to gas and power to liquid processed by electricity.

6. References

EEA (2017). Renewable energy in Europe 2017. Recent growth and knock-on effects (EEA Technical Report). Copenhagen. https://www.eea.europa.eu/publications/renewable-energy-in-europe-2017, accessed 26 Jun 2017.

ENI (2017a). A new lease of life for refining. https://www.eni.com/en_IT/operations/stories-people/green-refinery-eng.page?lnkfrm=serp, accessed 23 Jun 2017.

ENI (2017b). Green Refinery: reinventing petroleum refineries. https://www.eni.com/docs/en_IT/enicom/publications-archive/company/operations-strategies/refining-marketing/eni_Green-Refinery_esecutivo.pdf, accessed 26 Jun 2017.

EU (2009). Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC. http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32009L0028&from=EN, accessed 15 Aug 2014.

EU Member States (2015). Progress Reports on the promotion and use of energy from renewable sources: Article 22 of the RED 2009/28/EC. https://ec.europa.eu/energy/en/topics/renewable-energy/progress-reports, accessed 26 Jun 2017.

EC (2012). Innovating for sustainable growth: A bioeconomy for Europe: Communication from the Commission to the European Parliament, the Council, the ECOSOC and the Committee of the Regions (No. COM(2012) 60 final). http://ec.europa.eu/research/bioeconomy/pdf/official-strategy_en.pdf, accessed 26 Jun 2017.

EC (2017). Study on technical assistance in realisation of the 2016 report on renewable energy, in preparation of the Renewable Energy Package for the period 2020-2030 in the EU: "RES-Study", Tasks 1 and 2 (No. ENER/C1/2014-688). Brussels. https://ec.europa.eu/energy/sites/ener/files/documents/res-study_final_report_170227.pdf, accessed 21 Jun 2017.

EC (2016a). EU Reference Scenario 2016: Energy, transport and GHG emissions - Trends to 2050. https://ec.europa.eu/energy/sites/ener/files/documents/ref2016_report_final-web.pdf, accessed 26 Jun 2017.

EC (2016b). Impact assessment: Sustainability of bioenergy, accompanying the document Proposal for a Directive of the EP and of the Council on the promotion of the use of energy from renewable sources (recast) (No. SWD (2016) 418 final). https://ec.europa.eu/energy/sites/ener/files/documents/1_en_impact_assessment_part4_v4_418.pdf, accessed 10 Jul 2017.

EC (2016c). Proposal for a Directive of the EP and of the Council on the promotion of the use of energy from renewable sources (recast) (No. COM(2016)767 final/2). http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0767R%2801%29&from=EN, accessed 22 Jun 2017.

European Parliament (2017). Resolution of 4 April 2017 on palm oil and deforestation of rainforests. http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+TA+P8-TA-2017-0098+0+DOC+XML+V0//EN, accessed 26 Jun 2017.

Eurostat (2016). SHARES 2014. http://ec.europa.eu/eurostat/de/web/energy/data/shares, accessed 26 Jun 2017.

Eurostat (2017a). SHARES 2015. http://ec.europa.eu/eurostat/de/web/energy/data/shares, accessed 26 Jun 2017.

Eurostat (2017b). Imports - renewable energy - yearly data 1990-2015 (nrg 126a). http://ec.europa.eu/eurostat/web/energy/data/database, accessed 26 Jun 2017.

Eurostat (2017c). Supply, transformation and consumption of renewable energies - annual data (nrg_107a). http://ec.europa.eu/eurostat/web/energy/data/database, accessed 26 Jun 2017.

German Government (2012). Biorefineries roadmap. https://www.bmbf.de/pub/Roadmap_Biorefineries_eng.pdf, accessed 26 Jun 2017.

IEA (2015). The "Biorefinery Fact Sheet" and its application to wood based biorefining (Case Studies of IEA Bioenergy Task 42 "Biorefining"). Graz. http://www.iea-bioenergy.task42-biorefineries.com/upload_mm/5/e/b/dc3a42c3-eea3-45b2-b3b7-0132dff16f6c_B5_Template_Proceedings_NWBC_2015_Jungmeier%2020150731a.pdf, accessed 26 Jun 2017.

IRENA (2017). Biofuels for aviation: Technology brief. https://www.irena.org/DocumentDownloads/Publications/IRENA_Biofuels_for_Aviation_2017.pdf, accessed 26 Jun 2017.

Lamers, P. (2013). Sustainable International Bioenergy Trade: Evaluating the impact of sustainability criteria and policy on past and future bioenergy supply and trade. Dissertation: Utrecht University, Copernicus Institute of Sustainable Development. https://dspace.library.uu.nl/handle/1874/289087, accessed 22 Jun 2017.

Searle, S. & Malins, C. (2016). Waste and residue availability for advanced biofuel production in EU Member States. Biomass and Bioenergy, (89), pp. 2–10.

UN Comtrade (2017). UN Comtrade Database. comtrade.un.org, accessed on 26 Jun 2017.

USDA Foreign Agricultural Service (2017). EU-28 Biofuels Annual (No. GAIN Rrport Number: NL7015). https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_The%20Hague_EU-28_6-19-2017.pdf, accessed 26 Jun 2017.

Valin, H.; Peters, D.; van den Berg, M.; Frank, S.; Havlik, P.; Forsell, N. & Hamelinck, C. (2015). The land use change impact of biofuels consumed in the EU: Quantification of area and GHG impacts. https://ec.europa.eu/energy/sites/ener/files/documents/Final%20Report_GLOBIOM_publication.pdf, accessed 26 Jun 2017.

Wellisch, M.; Jungmeier, G.; Karbowski, A.; Patel, M. & Rogulska, M. (2010). Biorefinery systems - potential contributors to sustainable innovation. Biofuels, Bioproducts and Biorefining, 4(3), pp. 275–286.

This document is available at: http://www.europa.europa.eu/supporting-analyses
Contact: Poldep-Economy-Science@ep.europa.eu
Manuscript completed in July 2017.

Internal Ref: ENVI 2017-08
PE 607.324

CATALOGUE: QA-04-17-647-EN-C (paper)
CATALOGUE: QA-04-17-647-EN-N (pdf)
ISBN: 978-92-846-1269-7 (paper)
ISBN: 978-92-846-1268-0 (pdf)
doi:10.2861/94458 (paper)
doi:10.2861/824062 (pdf)