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Framework conditions for retrofitting Europe's industry with bioenergy

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1 Introduction

The BIOFIT project, supported by the Horizon 2020 programme of the European Union, aims to facilitate the introduction of bioenergy retrofitting in Europe's industry, thus reducing greenhouse gas emissions. Retrofitting often means lower capital costs, shorter lead times, faster implementation, less production time losses and lower risks. The project facilitates the introduction of bioenergy retrofitting in five specific industries, namely:

- Pulp and paper industry
- First generation biofuels industry
- Fossil refineries
- Fossil power generation
- Combined Heat and Power (CHP)

The selection of these industries is related to the specifications of the call text in the Horizon 2020 programme, under which BIOFIT was submitted in the call for proposals.

Actions on retrofitting the energy industry are closely linked to the legal, institutional, and political frameworks at national and European level. This is also shown by the large discrepancies between the energy sectors in the various countries in Europe or overseas. Therefore, the present report on "Framework conditions of retrofitting Europe's industry with bioenergy" provides an overview on the markets, policies, barriers and drivers for retrofitting sectors in Europe and in the target countries (Austria, Bosnia and Herzegovina, Finland, Germany, Greece, The Netherlands, Spain, Sweden) of the project. This will be a basis for the elaboration of the BIOFIT case studies as well as for the elaboration of recommendations.

2 Framework conditions at EU Level

The framework conditions for bioenergy use in industries at the EU level are characterized by the different developments of biomass production in the agricultural, forestry, and waste (municipal, industrial) sectors and the related use of biomass feedstock for energy purposes. The resulting markets are impacted by the overall European policies in the sector, which are requesting the Member States to transpose the policies into national legislation. This chapter provides an overview on the markets, policies, barriers and drivers for bioenergy retrofitting in the five considered BIOFIT industries.

2.1 Markets

Pulp and paper industries

The pulp and paper industry includes companies that use wood as raw material and produce pulp, paper, paperboard and other cellulose-based products. Pulp is a very important raw material. It is lignocellulosic fibrous material prepared by chemically or mechanically separating cellulose fibres from wood, fibre crops, waste paper, or rags. The pulp is fed to a paper or cardboard machine where it is formed and the water is removed from it by pressing and drying processes.

According to preliminary figures of the Confederation of the European Paper Industries (CEPI, 2019) for 2018, the paper and board production in the CEPI member countries[1] was stable with 92.2 million tonnes compared to the previous year (see Figure 1). The market is characterized by new capacities, but also closures. The industry sector has undergone some consolidation, while at the same time there is ample interest in high-valued bio-based products such as biofuels, bio-composites and bio-based plastics. Because many pulp mills are no longer integrated to paper mills, the sites use less energy than before, which opens the opportunities for production of higher-valued bioenergy products from their side streams (e.g. black liquor ethanol or tall oil biodiesel). On the other hand, the separate paper mills may face the challenge of bio-based feedstock availability.

The pulp and paper industry sector is already using 685 PJ biomass (about 60% of their total fuel consumption, which was more than 1,165 PJ in 2016[2]). The primary energy use was 1,328 PJ in 2016. There are roughly 150 pulp mills and 750 paper mills in Europe. The main renewable energy feedstock in pulping industry is wood handling residues, especially bark. Pulp mills also have several exploitable process side streams depending on the pulping process. One important side stream that can be exploited in bioenergy production is sludge, which is an organic residue after the wastewater treatment in a pulp and paper mill. Per 1 ton of paper produced, about 50 kg of dry sludge is generated[3]. Thus, the opportunities for

[1] Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

[2] Statistical data source: http://www.cepi.org/keystatistics2017

[3] See https://link.springer.com/book/10.1007%2F978-3-319-11788-1

increasing on-site bioenergy production in pulp and paper sector are i. a. the increased use of side streams and residues as well as biogas production from pulp mill sludge.

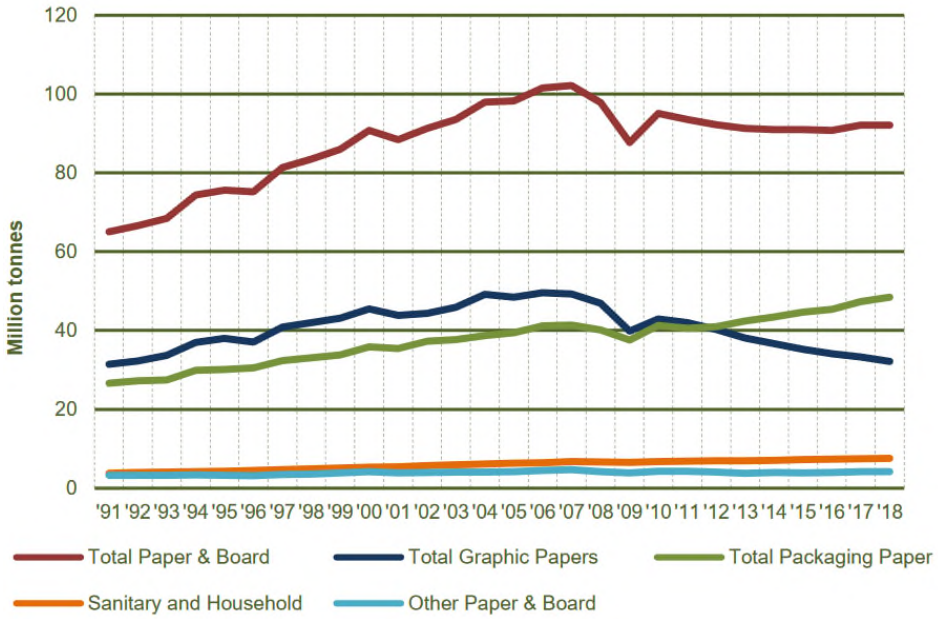

Figure 1: Production of paper and board in CEPI countries (CEPI, 2019)

Biofuels

The 1st generation biofuels sector in Europe involves the production of biodiesel (fatty acid methyl esters - FAME), hydrogenated vegetable oil (HVO) and bioethanol from various food crops. FAME and HVO are produced from oil bearing crops such as rapeseed. Bioethanol is produced from sugar or starch containing crops, such as sugar beet, grain and wheat. The main advantage of these fuels is that they can be blended with regular transport fuels. An overview on the market shares of the different biofuels is shown in Figure 2 and the trend of biofuels development in the last years is shown in Figure 3. The amount of 2nd generation biofuels is currently negligible.

For Europe, biodiesel production is more important than bioethanol production with a production of 11.5 million t/year of biodiesel in 2015, against 1.9 million m^3/year for bioethanol. These quantities are produced by hundreds of dedicated plants scattered across Europe. Recently, production volumes are decreasing, because of decreased support from governments (e.g. Spain has decreased blending requirements), and because of uncertainty regarding the sustainability of 1st generation biofuels. A transition of 1st to 2nd generation biofuels is expected, because the latter involve not food crops but lignocellulosic feedstocks and waste oils, have a better GHG balance, and are not subject to the cap on biofuels from food and feed crops to be imposed by the revised Renewable Energy Directive (RED II).

Opportunities for retrofitting are the conversion of 1st generation biofuels plants to produce more – or only – 2nd generation biofuels, by (e.g.) cellulosic ethanol add-ons, multi-feedstock

biodiesel add-ons or biogas add-ons. An example is the Crimson Biodiesel retrofit in Bakersfield, California, commissioned by BDI from Austria. Other retrofit options include improving the GHG balance (e.g. by producing biogas from waste streams) or more advanced electrofuel enhancements.

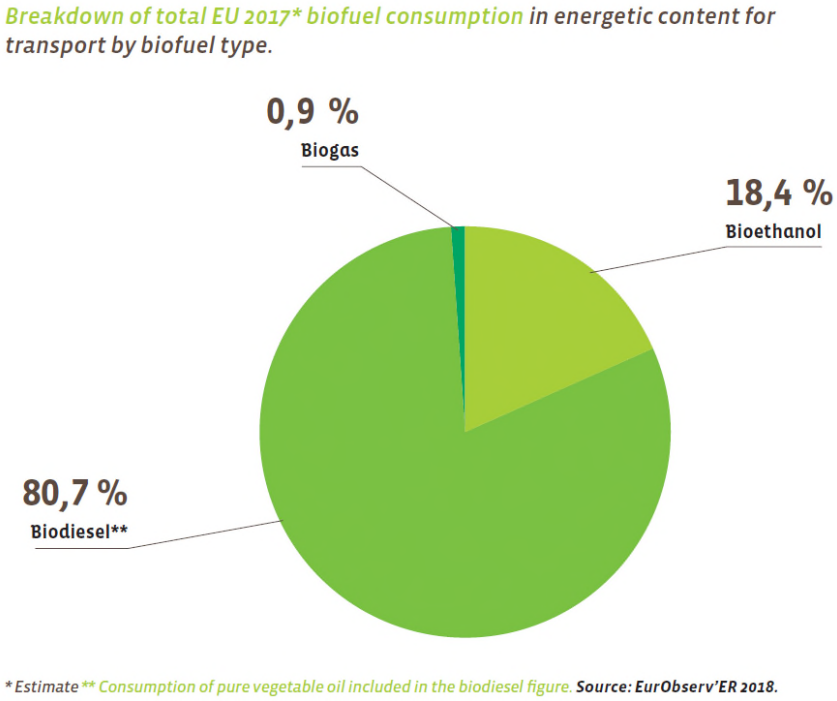

Figure 2: Breakdown of total EU 2017* biofuel consumption in energetic content for transport by biofuel type (Source: EurObserv'ER 2018b)

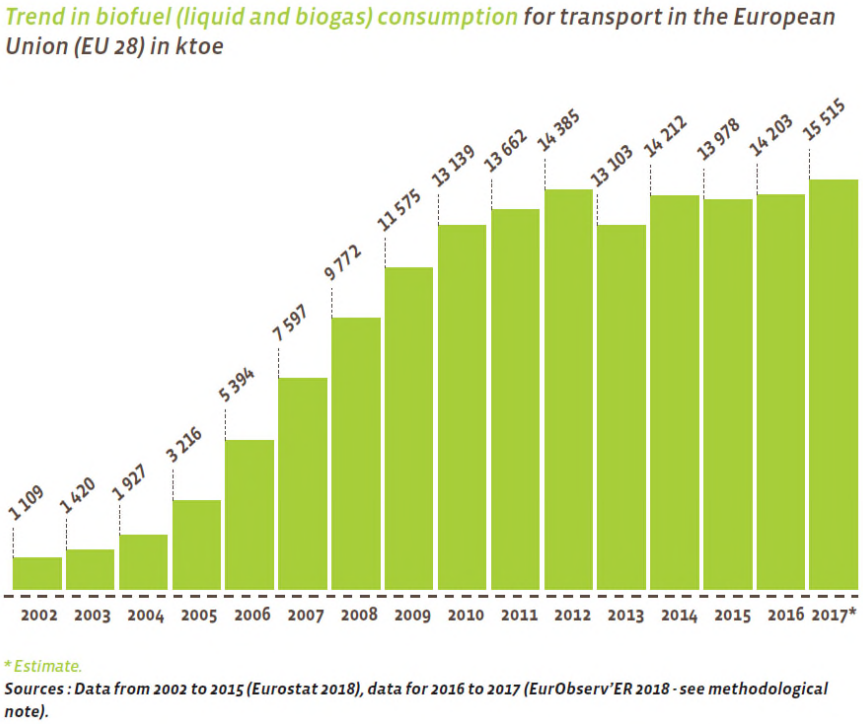

Figure 3: Trend in biofuel (liquid and biogas) consumption for transport in the European Union (EU 28) in ktoe (Source: EurObserv'ER 2018b)

Fossil refineries

Fossil refineries are usually very large industrial complexes where crude oil is processed and refined into added value products such as petroleum naphtha, gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas (LPG). The crude refining capacity of the around 90 operational refineries in the EU is 13.2 million barrels / day, representing 13% of world capacity. The transport sector in the EU is currently for 95% dependent on liquid (fossil) fuels and is responsible for more than 25% of GHG emissions in the EU. It is widely accepted that one of the refining industries' main challenges is the transition to a low-carbon economy, against a backdrop of decreasing demand and increased competition.

The production of HVO biodiesel in existing refineries is an opportunity for retrofitting in refineries. This is already carried out on a large scale by ENI in Porto Marghera (Italy), Total (La Mede, France), PREEM (Gothenburg, Sweden), and Neste Oil (Porvo, Finland)[4]. Total HVO production in the EU is 1.9 million tonne/year. Biomass feedstocks range from primarily palm oil (ENI) to Used Cooking Oil (UCO) (Total) and tall oil (PREEM). In Finland, UPM[5] produces bio-oil and Fortum[6] pyrolysis oil from lignocellulose. Other options are to upgrade intermediate

[4] https://www.neste.com/companies/products/renewable-fuels/neste-my-renewable-diesel
[5] https://www.upmbiofuels.com/products/
[6] https://www.fortum.com/products-and-services/power-plant-services/fortum-otso-bio-oil

bioenergy carriers produced from lignocellulosic biomass like pyrolysis oil or bio-oil from hydrothermal liquefaction to transport fuels or for heating purposes. These last two options have, however, not been demonstrated on full scale.

Figure 4: Refineries and steam crackers in EU-28 (2016) (Source:[7]: Petrochemicals Europe, 2019)

Fossil power and CHP industries

Power plants without heat use as well as combined heat and power plants (CHP) that are operated with fossil fuels (natural gas, coal, fossil oil) are providing large shares of energy in many European countries. Thereby, the size of facilities varies from very small units, being even household CHP units, to large scale facilities in the Gigawatt range.

About 25% of power production in Europe is still coming from coal. More than 1,000 coal fired power plants produce electricity all over the EU, Switzerland, Norway and Turkey. Coal firing is reliable and cost effective, but there is pressure to reduce carbon emissions and other

[7] https://www.petrochemistry.eu/about-petrochemistry/petrochemicals-facts-and-figures/maps-refineries-and-crackers/

pollutants emissions, with several countries (e.g. UK, France, Italy, Netherlands, Portugal, Austria, Ireland, Denmark, Sweden and Finland) pledging a coal phase-out till 2030.

Several facilities exist, that are already only using biomass as feedstock and some are co-firing fossil fuels with biomass. An overview of the types of biomass used for biomass-based power generation is shown in Figure 5. The dominant source is solid biomass, followed by biogas. The gross inland consumption, gross electricity production and heat consumption from solid biomass is shown in Figure 6.

The shares of new biomass firing boilers capacity with electric capacities higher than 5 MW are shown in Figure 7.

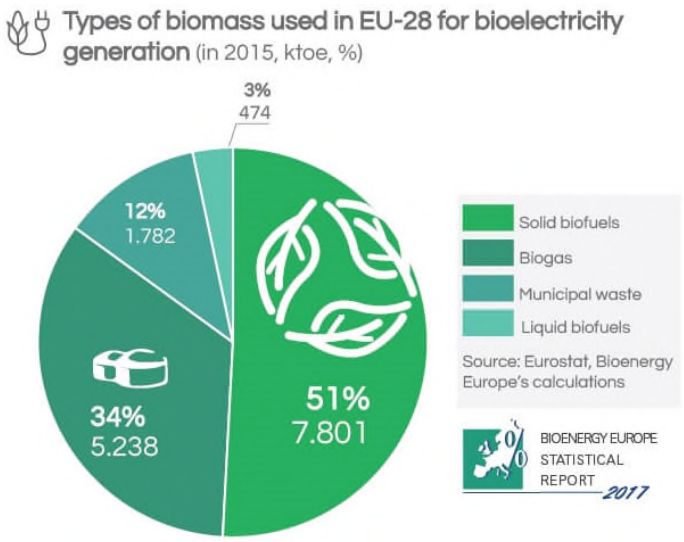

Figure 5: Types of biomass used in EU-28 for bioelectricity generation (Source: Bioenergy Europe, 2019)

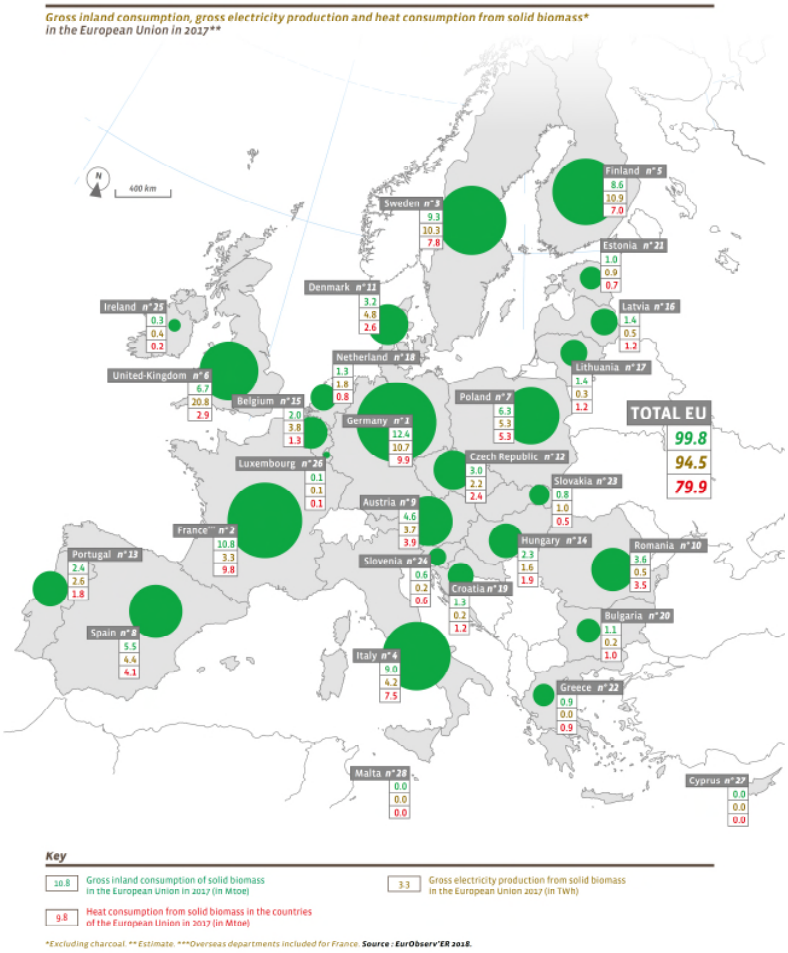

Figure 6: Gross inland consumption, gross electricity production and heat consumption from solid biomass[8] (Source: EurObserv'ER 2018a)

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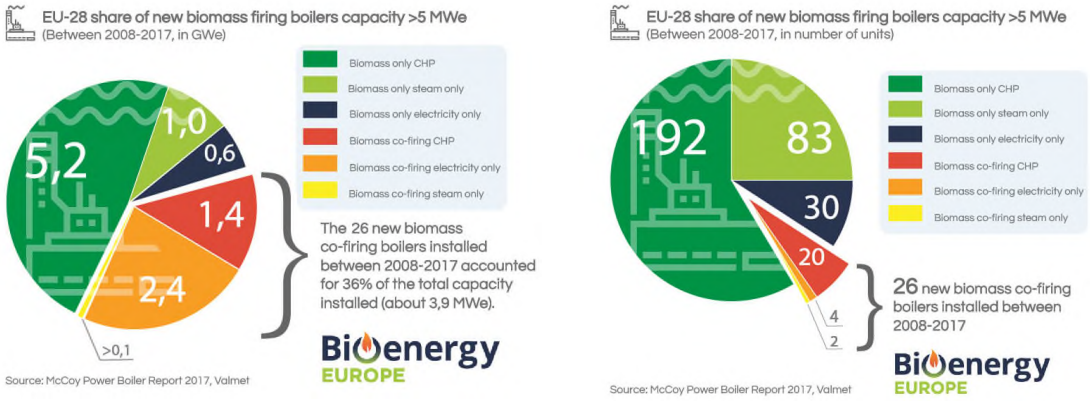


Figure 7: EU-28 share of new biomass firing boilers capacity >5 MW_{el} in GW_{el} (left) and in numbers (right) (Source: Bioenergy Europe, 2019)

2.2 Policies

Biomass and waste accounted for about two-thirds of all renewable energy consumption in the EU in 2012 (EC, 2019a). A good framework for the development of renewable energies in Europe, including bioenergy, was introduced by the **Renewable Energy Directive** (RED) (Directive 2009/28/EC). The directive was amended by the informally called **ILUC Directive** (Directive (EU) 2015/1513) which especially specified several sustainability issues related to biomass. The RED was recasted in 2018 with the introduction of the **Revised Renewable Energy Directive** (RED II) (Directive (EU) 2018/2001). The RED II is part of the "Clean Energy for All Europeans Package".

This **Clean Energy for All Europeans Package** (EC, 2019b) brings regulatory certainty, in particular through the introduction of the first national energy and climate plans, and will encourage essential investments to take place in this important sector. It empowers European consumers to become fully active players in the energy transition and fixes two new targets for the EU for 2030: a binding renewable energy target of at least 32% and an energy efficiency target of at least 32.5% - with a possible upward revision in 2023. For the electricity market, it confirms the 2030 interconnection target of 15%, following on from the 10% target for 2020. These ambitious targets will stimulate Europe's industrial competitiveness, boost growth and jobs, reduce energy bills, help tackle energy poverty and improve air quality.

The RED II "establishes a common framework for the promotion of energy from renewable sources. It sets a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy in 2030. It also lays down rules on financial support for electricity from renewable sources, on self-consumption of such electricity, on the use of energy from renewable sources in the heating and cooling sector and in the transport sector, on regional cooperation between Member States, and between Member States and third countries, on guarantees of origin, on administrative procedures and on information and training. It also establishes sustainability and greenhouse gas emissions saving criteria for biofuels, bioliquids and biomass fuels."

The overall objective of RED II is to define a binding overall Union target for 2030. "Member States shall collectively ensure that the share of energy from renewable sources in the Union's gross final consumption of energy in **2030** is at least **32%**." It requests the member states to introduce suitable policies and legislation to achieve this target.

The RED II defines, among others, important terms which are considered in the BIOFIT project:

- '**biomass'** means the biodegradable fraction of products, waste and residues from biological origin from agriculture, including vegetal and animal substances, from forestry and related industries, including fisheries and aquaculture, as well as the biodegradable fraction of waste, including industrial and municipal waste of biological origin;
- '**agricultural biomass'** means biomass produced from agriculture;
- **'forest biomass'** means biomass produced from forestry;
- **'biomass fuels'** means gaseous and solid fuels produced from biomass;
- **'biogas'** means gaseous fuels produced from biomass;
- **'bioliquids'** means liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass;
- **'biofuels'** means liquid fuel for transport produced from biomass;
- **'advanced biofuels'** means biofuels that are produced from the feedstock listed in Part A of Annex IX;

Besides the RED II, of course also other European acts are impacting the markets of the five BIOFIT sectors.

The **Fuel Quality Directive (FQD)** of 23rd April 2009 obliges the Member States to reduce GHG emissions related to the consumption of transport fuels by 10% by 2020 (European Commission 2009). Environmental criteria for fossil fuel components such as petrol and diesel are determined. These criteria are the same as defined in the RED. Additionally criteria for diesel fuel are set (Annex II of the FQD).

Biofuels and bioliquids used in the EU must fulfil the **requirements of sustainability**. To ensure this, companies can participate in Voluntary Schemes that verify the compliance with the sustainability criteria set by the EU. For the certification process, the whole production chain is reviewed by independent auditors. Most verification schemes are privately run but approved as valid by the European Commission.

In 2015 the Directive to reduce indirect land use change for biofuels and bioliquids ((EU)2015/1513) came into force. This so called **iLUC Directive** amended legislation on biofuels – specifically the RED and FQD – to reduce the risk of indirect land use change and to prepare the transition towards advanced fuels. Among others the Directive limits the share of biofuels from crops grown on agricultural land that can be counted towards the 2020 renewable

energy targets to 7%, harmonises the list of feedstocks across the EU whose contribution would count double towards the 2020 target of 10% for renewable energy in transport and requires that biofuels produced in new installations emit at least 60% fewer greenhouse gases than fossil fuels.

Furthermore, in 2018, the **LULUCF[9] Regulation** (EU) 2018/841 was introduced on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework. However, although important to consider, Nabuurs et al (2018) conclude that this regulation does not change the manner in which harvested wood for bioenergy is accounted

In order to fulfil the requirements for different biomass feedstocks implemented by legislation, **quality certification schemes for solid biomass** are a useful tool. The certification scheme ENplus for example controls wood pellets from the entire supply chain, starting from the production up to the delivery to the end customer. In 2010 ENplus was first introduced in Germany and in the meantime the principle is applied in over 45 countries world-wide, including all or practically all countries in the EU.

The **Energy Efficiency Directive** (Directive 2012/27/EU) sets up a framework to increase the energy efficiency in the EU in order to achieve its 20% energy efficiency target by 2020. All Member States are required to utilize energy more efficiently at all stages of the energy chain, from production to final consumption.

The **Common Agricultural Policy (CAP)** is the EU policy in the agricultural sector and was introduced in 1962. Since then it has been amended several times. Aims of the CAP are to increase the productivity in the agricultural sector and to ensure a fair standard of living for the farmers. Furthermore, it targets to stabilize the markets and to ensure the availability of supplies and reasonable prices for consumers.

The CAP is based on two pillars. The first pillar includes direct payments to farmers through the European Agricultural Guarantee and Guidance Fund (EAGGF). The second pillar is aimed at rural development and is co-financed from the European Agricultural Fund of Rural Development (EAFRD). The CAP reform of 2013 aimed to enhance the competitiveness of EU agriculture, provide more sustainability and improve its environmental performance. Currently, the new CAP is being discussed for the next period.

In terms of a Forestry Policy, in 2013 a new **EU Forest Strategy for forests and the forest-based sector** (COM(2013) 659) has been elaborated. Even though the EU contributes through its policies since a long time to the implementation of sustainably managed forests in the respective Member States, a uniform policy on EU level for forests and the forest sector does not exist (European Commission 2013). The need for a common policy framework has been determined to ensure and coordinate the coherence of forest-related policies in the EU. Therefore, a common framework on EU level shall guarantee, among other things, the

[9] land use, land use change and forestry

sustainability of forest management, manage the increasing demand for raw material and renewable energy and protect forests and biodiversity (European Commission 2013).

2.3 Barriers and drivers for bioenergy integration

Selected overall barriers and drivers for bioenergy integration in the 5 BIOFIT industries are shown in Table 1.

Table 1: Barriers and drivers for bioenergy integration in the 5 BIOFIT industries in Europe

Industries	Barriers	Drivers
Pulp and paper	• The CAPEX of biomass integration facilities is relatively high. • The use of some pulp and paper production residues is restricted in the Waste Incineration Directive 2000/76/EC and require managing specific permits.[10] • Some member states do not promote all pulp and paper production residues as renewable energy sources, although European legislation defines a "biodegradable fraction of products, waste and residues from forestry and related industries" as such.[11]	• Biomass and processing waste are already available and must be treated. • RED II provides a supportive framework for biomass use in pulp and paper facilities.
Biofuels	• The production costs for advanced biofuels are still very high • The CAPEX of advanced biofuel facilities is very high.	• GHG mitigation requirements of biofuels, stated in the ILUC Directive and in the RED II are promoting advanced biofuels. • Within the 14% target of renewable energies in the transport sectors, as specified in the RED II, the contribution of advanced biofuels and biogas as a share of final consumption of energy in the transport sector shall be at least 0,2% in 2022, at least 1% in 2025 and at least 3,5% in 2030.

10 http://www.cepi.org/system/files/public/documents/publications/environment/2003/2003Discovering%20the%20High%20Potential%20of%20Pulp%20and%20Paper%20Production%20Residues.pdf

11 http://www.cepi.org/system/files/public/documents/publications/environment/2003/2003Discovering%20the%20High%20Potential%20of%20Pulp%20and%20Paper%20Production%20Residues.pdf

Refineries	• Crude oil production is still increasing worldwide • The large -scale introduction of electric vehicles may have an impact on the oil refineries. • The current turnover of the biomass share in oil refineries is very little in comparison to the traditional business with crude oil.	• The RED specifies that each MS shall set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14% by 2030
CHP and power plants	• Retrofitting CHP and power plants with biomass may generate an image of “greenwashing”. • Company shares of local, regional, and national bodies on CHP and power plants block in some European countries to phase out fossil heat and power generation. This is accompanied by lobbyism against the phasing-out of coal use. • Sustainable sourcing of large volume of biomass for a large-scale retrofitting case can be challenging. • Outside the EU, mechanisms that favor such retrofitting cases may be lacking (e.g. no CO_2 price, no support mechanism for power production from large-scale facilities).	• Considerably reduced CAPEX through retrofitting compared to new biomass power and CHP plants. • The image related to the environmental impact of CHP and power plants can be improved by the integration of biomass. • GHG mitigation strategies of the EU include targets for decarbonizing the power sector. • The EU ETS penalizes fossil fuel use and not bioenergy.

3 Framework conditions in Austria

3.1 Markets

Pulp and paper industry

The paper industry is one of the most energy-intensive branches of industry, because of the high heat demand of pulping of wood and drying of the pulp. Overall, the Austrian paper producers consumed around 4,600 GWh of electricity and 11,000 GWh of steam in 2017. This corresponds to almost 7% of Austria's electricity consumption. However, the pulp and paper industry produces 97% of this energy demand itself with mainly CHPs, but also hydropower. It uses 60% biomass made from bioleach, bark and wood waste. The fossil fuels used are mainly natural gas, and to a lower extent fuel oil and coal. In addition to their own energy supply, the pulp and paper companies also supply electricity and district heating to businesses and households. At present, more than 80,000 households could be completely supplied with energy (250 GWh of electricity and 1,620 GWh of district heating).

24 production facilities produce around 5 million tons of paper, cardboard and carton per year. That is far more than the domestic consumption of 2 million tons. As a result, the export rate is high. Nearly half of the 24 companies are large paper producers, each producing more than 100,000 tons a year. In Austria, fibres are mainly produced for integrated use, i.e. for subsequent paper production. There are eight chemical pulp producers and three mechanical pulp producers; twelve companies buy and process waste paper for their production, others use pulp from third parties. Those who buy pulp do not have biomass on site and therefore mostly use fossil fuels for their own energy generation.

The company AustroCel produces high-purity pulp for the textile industry. In future, the by-product brown liquor will be fermented and distilled for the production of bioethanol, with a planned capacity of 30,000 m³/a.[12]

First-generation biofuels industry

In 2016, a total of about 330 PJ of transport fuels was consumed in Austria, 6.7% of which were biofuels. More than half of it was FAME (biodiesel), followed by other liquid biogenic fuels, such as bioethanol and HVO. The majority of biofuels are used blended with fossil fuels. Half of the FAME produced in Austria is made out of wastes and residues (fats, oils etc.), listed in Annex IX Part B of the EU Renewable Energy Directive.

About 6% (77,000 ha) of Austrian arable land was utilized for transport biofuels production in 2015, but taking into account the substitution effects of protein feed, only 1% of arable land was used. In Austria one large bioethanol production facility and nine smaller FAME production facilities were operating in 2016. The entire demand for bioethanol can be covered by one production facility, the biorefinery in Pischelsdorf, operated by the AGRANA Bioethanol GmbH. It produces not only bioethanol, but also starch, bran, protein feed and

[12] https://en.austropapier.at/about-the-industry/mills/

high-purity carbon dioxide. Table 2 summarizes 1st generation biofuels producers and capacities.[13]

Table 2: Biofuels production facilities in Austria

Company	City	Kind of fuel	Capacity [ML/a]
AGRANA Bioethanol GmbH	Pischelsdorf	Bioethanol	246
Total bioethanol production			**246**
Biodiesel Süd GmbH	Bleiburg	FAME	22
Münzer Bioindustrie GmbH	Wien	FAME	157
Eco Fuels Danube GmbH	Krems	FAME	56
HPF Biokraft Hirtl GmbH	Fehring	FAME	5
Abid Biotreibstoffe GmbH	Hohenau	FAME	56
Novaol Austria GmbH	Bruck an der Leitha	FAME	107
Biodiesel Kärnten GmbH	Arnolstein	FAME	56
Münzer Paltental	Gaishorn am See	FAME	67
Brantner Energy GmbH	Krems	FAME	17
Total FAME production			**543**

So far, there is no commercial production of advanced biofuels, but AustroCel Hallein is planning to produce ethanol from the fermentation of brown liquor in its pulp refinery.

Fossil refineries

Including all petroleum products, such as fuels, oil for heating purposes, light and heavy fuel oil, lubricants and bitumen, but excluding petrochemical substances, oil consumption in 2017 was 11.3 million tons. This is an increase of 1.2% compared to the previous year (2016: 11.1 million tons), but below the peak value of 2005 (12.9 million tons).[14]

The Schwechat refinery, operating since 1960, is the only fossil refinery of Austria and is located in the east, close to the capital Vienna. It is one of Europe's largest and most modern inland refineries with a total annual processing capacity of 9.6 million tons of crude oil. It produces around half of all petroleum products used in Austria. High-quality mineral oil products and petrochemical raw material are produced through distillation and refining processes of crude oil and intermediates. The Schwechat refinery is supplied via the Adria-Wien Pipeline (AWP), a branch of the Transalpine Oil Pipeline (TAL), which is one of the most important crude oil pipelines from the Mediterranean Sea to the north.[15]

The operator of the Schwechat refinery, OMV, aims to invest up to 500 million € for reducing CO_2-emissions by 2025. OMV keeps investigating opportunities for including biomass as a feedstock, for producing biofuels, renewable hydrogen etc., but has so far not decided for any investment. To date, projects include a pilot plant, installed at the refinery for the production

[13] https://www.biomasseverband.at/wp-content/uploads/Basisdaten_Bioenergie_2017.pdf
[14] https://www.wko.at/branchen/industrie/mineraloelindustrie/basis-presseinformationen.html
[15] https://www.omv.com/pbd_download/677/512/Factsheet%20Refineries_EN_062018,0.pdf

of biogas, pyrolysis oil, raw fuel (diesel) and biochar, through a liquid phase pyrolysis of pre-treated biomass and conditioned carrier oil (bioCRACK, bioBOOST). Another project deals with waste plastics, which are converted to a so-called "synthetic crude oil" to produce fuels or raw materials for the plastics industry, without additional effort (ReOil). Additionally, a project regarding co-processing, for the production of biofuels, is conducted.[16]

Fossil power and CHP plants

The gross power consumption in 2017 amounted to 100,185 GWh, including 70,823 GWh of domestic power generation and 29,362 GWh of import. The Austrian electricity mix consists of 59.4% hydropower, 30% thermal power, 10.4% renewables and 0.2% others. The thermal power is generated by using 74.1% fossil fuels (natural gas, coal, oil), 14.8% biogenic fuels (solid, gaseous, landfill and sewage gas) and 11.1% others and is mainly generated by CHP plants (19,208 GWh from a total of 21,272 GWh).[17]

In 2016, bioenergy contributed a share of 6.4% to electricity production, produced in 128 biomass CHPs and 292 small decentralized biogas plants, with a common power generation of 2,954 GWh and a common district heat generation of 3,794 GWh.[18]

District heat production is increasing, mainly generated by new (local) biomass heat plants and by waste incineration. The share of CHP generation is also increasing and leads to higher efficiency of energy generation. The year 2010 shows a historic maximum of about 19 TWh electricity and 75 PJ district heat production from fuel combustion. In 2017, 13,493 GWh electricity from combustible fuels and 77,098 TJ public heat by combustible fuels were provided through public grids.[19]

There are about 150 electricity providers in Austria, 50 of them are active nationwide and about 125 are offering 100% green electricity.[20]

3.2 Policies

As part of the European Union, Austria is compelled to make its contribution to reach the 20-20-20 targets. According to the **Renewable Energy Directive**, for Austria an increase of the share of renewable energies in total gross final energy consumption to 34% until 2020 is targeted, with a split in sectors: electricity 70.6%, heating and cooling 32.6% and transport 11.4%. 51% of the increased renewable share is expected to be bioenergy, the rest hydropower, wind and photovoltaics. According to the **Effort Sharing Decision**, the reduction

[16] https://www.omv.at/de-at/ueber-omv/presse/pressemappe

[17] https://www.e-control.at/documents/20903/443907/e-control-statistikbroschuere-2018-englisch.pdf/ee740431-1047-e373-d9a9-324406ffaa8b

[18] https://www.biomasseverband.at/wp-content/uploads/Bioenergie-Atlas_O__sterreich_2019_klein.pdf

[19] https://www.umweltbundesamt.at/fileadmin/site/publikationen/REP0677.pdf

[20] https://www.e-control.at/en/konsumenten/strom/lieferanten-uebersicht

of GHG emissions has to account for 16%, compared to 2005. For achieving these targets, the following political framework has been established.[21]

The **Austrian Climate and Energy Strategy (#mission 2030)**, approved by the Federal Government in 2018, aims to reduce GHG emissions by 36% by 2030 and to decarbonize energy provision by 2050. The share of renewables shall be increased from 33.5% to 45-50% by 2030, with a sub target of fully renewable electricity production by 2030. Additionally, the energy efficiency shall be increased by 39% by 2030 as compared to 2015, with a 1,200 PJ limit of total primary energy demand in 2030.

One of the flagship projects of the Austrian Climate and Energy Strategy is focusing on the bioeconomy. Based on that, the **National Bioeconomy Strategy** was formed in 2018. The main topics of this strategy are: circular economy, innovation, efficiency measures, regional development and high-quality jobs.[22]

National funding of research is provided through the Austrian Research Promotion Agency (FFG). Additionally, the **New Energies 2020 R&D program** offers 16 million € for R&D activities regarding efficient energy use, renewable energies and intelligent energy systems. There is also funding for the construction of demo plants for the production of renewable energy.[23]

Pulp and paper industry

The **Forest Act** encompasses all measures dealing with the use, care, conservation and protection of forest land. Furthermore, there is a **Regulation on recycling of post-consumer and waste wood** with the objective of a, for humans and animals, harmless recycling of suitable waste wood in the wood industry.

First-generation biofuels industry

The **Fuel Ordinance Amendment** changed in 2012, lays down the **Biofuels Directive**, the Renewable Energy Directive and the **Fuel Quality Directive** in Austrian law. A quota for biofuels has been set: by 2020, 8.45% (with regard to energy content) of diesel and petrol have to be substituted by energy from renewable resources.

In Austria, the RED and FQD sustainability criteria have been implemented by two separated ordinances, the **Ordinance on Agricultural Feedstocks for Biofuels and Bioliquids** and the **Certification of Commercialized Biofuels**. Additionally, there is the **CAP Implementation**, which lays down the **European Common Agricultural Policy** and provides a framework for financial support to farmers, and there is the **Austrian Agri-environmental Programme**, which regulates agricultural and environmental issues.

[21] https://www.ieabioenergy.com/wp-content/uploads/2018/10/CountryReport2018_Austria_final.pdf
[22] https://mission2030.info/wp-content/uploads/2018/10/Klima-Energiestrategie_en.pdf
[23] http://task39.ieabioenergy.com/publications/ (Update on Implementation Agendas 2018)

The **Austrian Decree on Transportation Fuels** lead to an amendment of the Austrian tax law, stipulating that there would be no tax on biodiesel and ethanol to a certain limit. It allows blending of up to 7% of biodiesel with fossil diesel.

In December 2016 the Austrian Council of Ministers approved the national strategy framework, **Clean Energy in Transportation**, including legal and political measures and incentives for alternative fuels. The **klima:aktiv Mobility Programme** is part of this framework and supports alternative powered vehicles.

Further legislation, transposing the new **RED-II** into national law, has yet to be created and will constitute the framework for targets beyond 2020.[24]

Fossil refineries

Together with the amendment to the Fuels Ordinance, the **Mineral Oil Act** has been revised. Accordingly, tax concessions are granted for sulphur-free fuels with a biofuel share of at least 4.4%. Pure biofuels have been exempted from mineral oil tax since 2000. The **Bioethanol Blending Order** that entered into force on 1st October 2007 allows refunding of the mineral oil duty for E75 blends.

Fossil power and CHP plants

The **Green Electricity Act,** updated in 2012, is the supporting policy for energy from renewable sources in the electricity sector. It sets targets of new installations until 2020. The **Feed-in-tariff regulation** supports the pay-off of the investments. For biomass and biogas, new installations of 200 MW have been designated. It also includes investment grants for plants based on waste liquor of the paper and pulp industry as well as small and medium hydro power plants. The feed-in-tariff scheme has proven to be very successful, yet when the premium feed-in-tariff for an installation expires after 13 or 15 years this often puts the installation out of business, as continuing the production is not economic anymore.
In the course of the Austrian Climate and Energy Strategy, the **Renewable Expansion Law** will be issued in 2020. Details and the transition to this law are still being discussed. In any case, this should be an integrated law, including, among others, the Green Electricity Act, the **Electricity Management and Organization Act** and the **Natural Gas Act**.

The **CHP Act** defines high-efficiency CHPs and their funding schemes. The **Combustion Plant Ordinance** sets emission limits for domestic heating systems. Furthermore, there is a subsidy scheme for wood heating from the **Climate & Energy Fund** for replacing fossil fuels-based heating systems with pellet and wood chip central heating systems and pellet stoves. **Building Regulations** ban fossil-fuelled heating systems in new buildings.[25]

[24] http://task39.ieabioenergy.com/publications/ (Update on Implementation Agendas 2018)

[25] http://task40.ieabioenergy.com/wp-content/uploads/2013/09/iea-task-40-country-report-2014-austria.pdf

3.3 Barriers and drivers for bioenergy integration

Selected overall barriers and drivers for bioenergy integration in the 5 BIOFIT industries are shown in Table 3.

Table 3: Barriers and drivers for bioenergy integration in Austria

Industries	Barriers	Drivers
Pulp and paper	• Those companies which buy market pulp do not have biomass on site and therefore mostly use fossil fuels.	• The introduction of a CO_2 tax can be a driver for bioenergy. • Austria has a high domestic biomass potential
1st generation biofuels	• The prices and taxes on transport fuels are comparably low. This decreases the comparative price advantage of non-taxed biofuels. • There is a 7% blending cap, which limits the market for biofuels. Therefore, the existing production capacity is underutilized. • The prices for raw materials are high and volatile, and therefore reduce profit margin. • Currently, most funding programmes and incentives are focusing on electro-mobility.	• The Fuel Ordinance Amendment set a quota for biofuels. 8.45% (with regard to energy content) of diesel and petrol have to be substituted by energy from renewable sources. • The Austrian CAP Implementation provides a framework for financial support to farmers. • There is a funding scheme, provided by klima:aktiv, for alternative powered vehicles, including biofuels. • An ongoing trend of vehicles with alternative drivetrains can be seen.
Fossil refineries	• Raw material availability in reasonable distances.	• The introduction of a CO_2 tax can be a driver for bioenergy.
Power and CHP plants	• The Feed-in-tariff Regulation expires after 13 to 15 years, which often puts the installations out of business as continuing the production is not economic anymore.	• A sub target of the Austrian Climate and Energy Strategy is a fully renewable electricity production by 2030. • An increase of electric vehicles is estimated, because of monetary incentives and an increase of charging station installations. This would increase the demand for power production. • Power and CHP plants often are decentral and therefore create regional added value. • The introduction of a CO_2 tax can be a driver for bioenergy. • Austria has a high domestic biomass potential.

4 Framework conditions in Bosnia and Herzegovina

4.1 Markets

Pulp and paper market

Until 2004, there was one pulp factory and two pulp and paper factories in Bosnia. Today, all except one were closed. The active pulp and paper factory, BiH's Natron-Hayat d.o.o. Maglaj factory, is producing kraft paper for sacks from both imported and locally supplied raw materials.

The great reduction in demand for the small round wood that was used by these companies has caused problems. It reduced income for the forest companies, it removed the main market for smaller diameter trees cut in harvesting and thinning operations (which adversely effects long-term forest production). There is also a substantial volume of wood waste from sawmill operations and large quantities of small size coniferous wood. A part of this waste is used for briquette production. However, the value added is low and other solutions are needed. The ideal alternative would be a big industry; e.g. pulp mill, particle board mill or a pellet industry. However, even though a pellet industry is developed, the present problems in wood supply constitute a bottleneck for expansion of the investment.

Natron-Hayat d.o.o. Maglaj is an esteemed European company that has a good reputation in the production of various types of paper and paper packaging. It was founded on 15 April 2005 by Natron d.d. Maglaj (company) and the reputable company Kastamonu Entegre, which is a member of the internationally renowned Hayat Holding Group from Turkey. This newly established company has inherited a 50-year-old tradition and experience in the paper industry (based on the successful work of the former Natron d.d. Maglaj).

Natron-Hayat produces 100% cellulose virgin based brown kraft paper. Annual production of brown kraft paper is 85,000 tonnes.

Natron-Hayat produces the following products: Standard Kraft Paper, Semi Extensible Sack Kraft Paper, Packaging paper, MG (machine glazed) paper, crepe paper, finishing paper, paper sacks, paper bags, corrugated board and board packaging, cores. With its current production, Natron-Hayat meets not only the domestic market needs but also demand from outside the borders of Bosnia and Herzegovina.

For paper production, there are two big domestic companies: "Violeta" Ltd. located in Grude (FBiH) and SHP Celex a.d. located in Banja Luka (RS).

"Violeta" Ltd. is a regional leader in the production of paper-based hygienic products and it has its own production facilities in BiH. At the moment, the Violeta group employs about 700 workers and has 13 branch offices in BiH and Croatia. The factory of hygienic products in Grude is equipped with the state-of-the-art technology and contains several production lines for the production of wide range of products. In addition to toilet paper and tissues, for the portfolio was enlarged by wet wipes production. "Violeta" is the national market leader in the production and sales of wet wipes, kitchen towels, toilet paper, tissues and napkins.

The paper factory SHP Celex a.d. Banja Luka has been founded in 1966 as one of the most modern factories at that time in former Yugoslavia. It was privatized in 2001 by the Eco-Invest company from Slovakia and became a member of the SHP Group, the biggest paper group in South-eastern Europe. SHP Group is a member of Eco-Invest, and invested over 24 million EUR in SHP Celex up to now. Particular attention was given to the modernization of technology for production of cellulose paper and paper-based products.

Biofuels

System Ecologica near Srbac is the only major biodiesel factory in BiH which exports its production to EU and regional markets, such as to Serbian and North Macedonian markets.

The governments of both Bosnian entities adopted a system that differs from the usual one and which does not give the possibility of commercial application of biodiesel in traffic, although BiH has signed agreements to reduce CO_2 emissions.

System Ecologica has about 1,500 tons of monthly fuel, and their capacity is twice as high - up to 3,500 tons per month. The prospects for such increased production and the possibilities of placement on the market of Bosnia and Herzegovina are not promising now and the progressive development of this area is questionable. The raw materials are mainly imported from the USA, South America and the Caribbean.

Refineries

The oil industry in Bosnia and Herzegovina encompasses imports and refining of imported crude oil and production of petroleum products. The oil sector developed significant production capacities, comprising two refineries based on the most up-to-date world technologies, but presently only partly employed, including:

- Refinery Brod, which capacity is 4 million t/year, processes imported crude oil into various products (motor fuels, liquid petroleum gas, bitumen, etc)
- Refinery Modriča, which produces motor oils and various special purpose technical oils for the industry and other commercial purposes.

Recently, both refineries have been privatized and their full capacity production is expected soon. In addition, Bosnia and Herzegovina has significant storage and transport capacities.

Power sector and CHP

The electricity market of Bosnia and Herzegovina is dominantly characterised by three vertically integrated power utilities: “JP Elektropriveda BIH d.d.”, “Mješoviti Holding Elektroprivreda Republike Srpske a.d.” and “Elektroprivreda Hrvatske zajednice Herceg Bosne d.d.” , wherein Elektroprivreda BIH (EP BIH) generated 7.5 TWh, Elektroprivreda RS (ERS) 5.8 TWh, and Elektroprivreda Hrvatske zajednice Herceg Bosne (EP HZHB) 1.5 TWh.

Elektroprivreda RS is organised as a mixed holding and owns 2 thermal power plants with the related coal mines, 5 hydropower plants and 4 small hydropower plants. In Republika Srpska, energy is also generated in the plants using RES (16 small HPP and 38 solar power plants), with

a total power capacity of 44.5 MW. Electricity is also generated by the company Alumina for its own needs. In 2016, thermal power plant Stanari was commissioned and today generate 1.5 TWh of electrical energy, while in the future it is expected to annually generate 2 TWh. In the Federation of Bosnia and Herzegovina, EP BIH produces energy from 2 thermal power plants, 3 hydropower plants and 7 small hydropower plants. On the other hand, EP HZHB produces electrical energy from 7 hydropower plants. Along with the listed energy generating facilities, in Federation of Bosnia and Herzegovina electrical energy is produced in privately owned generation units, 109 of them, and in 3 industrial power generating units for 2015. In 2016, there were registered 161 production units (mainly sHPP and solar PV power plants) owned by 117 qualified producers. According to MOFTER, there are currently more than 150 small solar power plants in Bosnia and Herzegovina.

Even though there are a number of biomass-based DH systems all around the country of different power capacities (1 MW – 100 MW), there are currently only few biofuel or biomass power plants in operation in BiH that supply electricity to the grid. The only three biomass power plants are in operation. First one is a 37kWe biogas pilot plant at Livac Agricultural Cooperative in the Republic of Srpska (RS). Second one is a 1 MWel biogas power plant at a livestock farm in Donji Zabar, RS, owned by MG Gold, while third one is 250 kW CHP Prijedor.

There is a woodchip-based district heating system in Livno owned by the Esco Eco Energija Company. FBiH Regulatory Commission for Energy in (FERC) in 2012 issued a Preliminary Permit to Esco Eco Energija Company from Livno for construction of the biomass based Combined Heat and Power (CHP) plant. The planned electric capacity of the plant is 1,250 kWe. The company plans to continue with the construction of the biomass plant in the near future. There is large energy potential from residue in the agriculture, forestry and wood-processing industries. The technical primary energy potential is estimated at 13.75 PJ or 3,820 GWh. If this residue were used in power and CHP plants with net electric efficiency equal to 28%, approximately 1,070 GWh of electrical energy could be generated annually.

To assess the potentials of wood and agricultural biomass in Bosnia and Herzegovina, UNDP, GIZ and DBFZ (German Biomass Research Center) provided technical support to BHAS (Bosnian and Herzegovinian Agency for Statistics) in data collection and their adequate presentation at an **interactive online map of biomass potential in BiH.** Data on main and by-products of forestry and wood processing sectors as well as by-products of plant and animal production for period 2012-2017 had been collected. Data are visualized for their easier overview and available for different spatial levels. The online atlas is available since April 2019 at http://atlasbm.bhas.gov.ba/.

According to the European project S2Biom, the annual suitable biomass potential in BiH that comes from forests is up to 3.46 million dry tonnes.

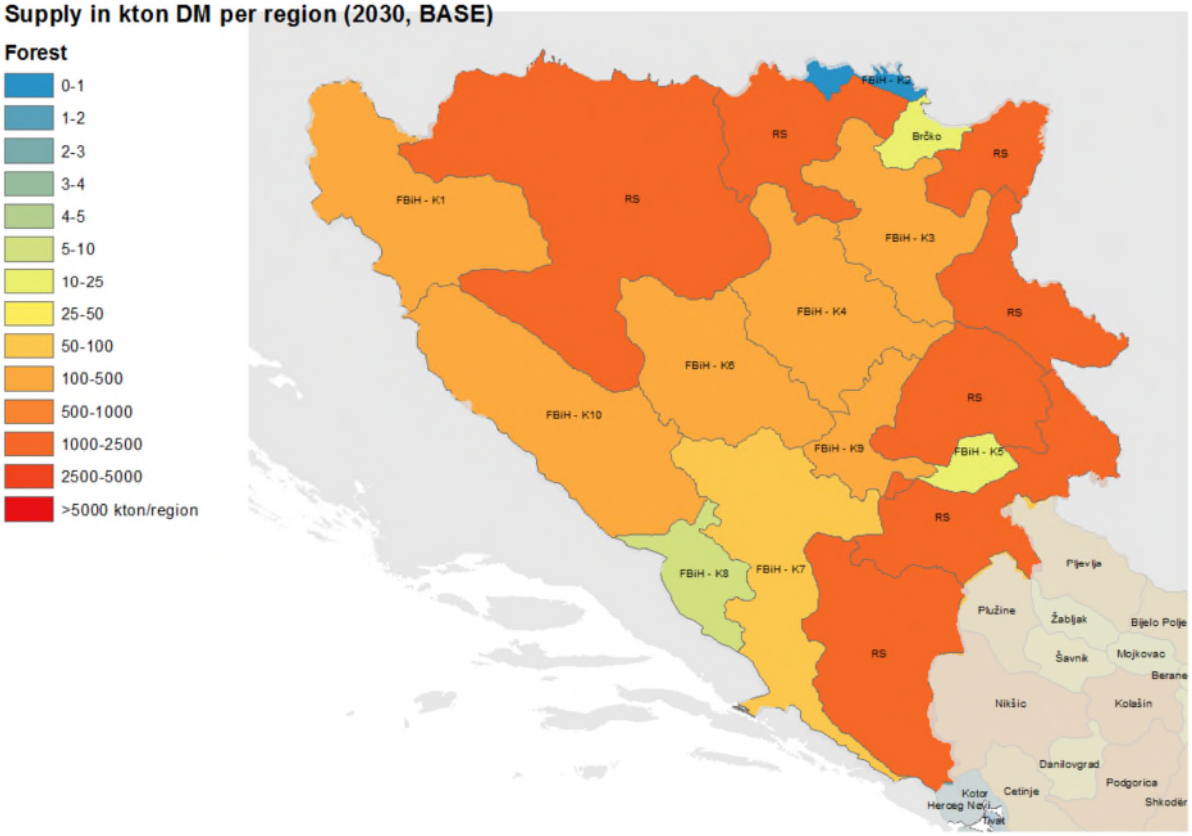


Figure 8: Annual suitable biomass potential in BiH that comes from forests

4.2 Policies

Pulp and paper (Forest Law)

The regulatory framework in BiH is complex and poses a major issue when addressing the needs for adaptive and participatory forest management. The sector is organized on the entity level. As regards forest legislation this entails:

- RS Forest Law (2008) provides the overall framework and is supported by a series of 32 regulations adopted during 2009–2010 relating to timber sales and technical norms of forest management. The Forest Law 2008 clarified the Entity ownership and administration responsibilities. Further elements of forest planning and principles of sustainable forest management are included in the 2008–2015 RS Spatial Plan, which provides for the development of planning documentation, including the Strategy for forestry development for the period 2011–2021 (published in 2012), as well as for revision of laws and regulations including the Law on Forests.

- Based on the Decision by the Constitutional Court of the Federation of Bosnia and Herzegovina of 14 April 2009 (Official Gazette of the Federation of BiH no. 36/09) Law on Forests (Official Gazette of the Federation of BiH no. 20/02, 29/03 and 37/04) is no

longer in force as of 27 November 2009. As a preliminary solution pending the adoption of the new law on forests, the Government of the Federation of BiH adopted the Regulation on Forests (Official Gazette of the Federation of BiH no. 83/09, 26/10, 33/10 and 38/10). As per the Decision of the Constitutional Court of the Federation of BiH no. U-28/10 of 23 March 2011 (Official Gazette of the Federation of BiH no. 34/11), the Regulation on Forests should have been in force until 6 December 2011. Since the Regulation on Forests as of 6 December 2011 is no longer in application and as the Law on Forests hasn't been adopted yet, the forest sector is legally unregulated at the level of Federation of BiH.

- Brčko District adopted its own Forest Law in 2010. Based on its provisions, there are Forest management plans for public forests (owned by the District) and for private forests (both plans for the period 2007–2016). Following the legislative obligations, the annual management plans are prepared and adopted by the Government of the District, which include necessary measures related to harvesting, silviculture, forest protection and guarding. In Brčko District, which is mainly lowland and agriculture area, forestry plays a subordinated role due to small area covered by forests and small amount of harvesting operations.

As mentioned earlier, direct competences in forestry are held at the level of entities (FBiH and RS) and Brčko district. The institutions at these levels are responsible for forest policy making and for forest legislation and law implementation. Apart from responsibilities for foreign trade and international economic relations, the Ministry of Foreign Trade and Economic Relations (MOFTER) is responsible for tasks and duties falling within the jurisdiction of the State of BiH, including defining policies and basic principles, co-ordinating activities and consolidating entity plans with those of international institutions in the areas of agriculture, energy, environmental protection, use of natural resources and tourism. Within MOFTER, Sector for agriculture, food, forestry and rural development exists, but regarding forestry issues it mainly deals with co-ordinating activities.

Biofuels

There is a law Law on petroleum products adopted by the Government of the Federation of Bosnia and Herzegovina that states that the conditions, method and procedure of production, trade, storage and use of biofuels in transport, as well as other issues of importance to encourage production and use biofuels will be regulated by a special law. However, this law has not yet been adopted, but there is a Regulation on Types, Contents and Qualities of Biofuels in Motor fuels at the level of the Federation of Bosnia and Herzegovina, which prescribes the names of types of biofuels, the limit value of biofuels, quality and proving, the share of biofuels and monitoring, supplier obligations and supervision of the implementation of this Regulation.

Refineries

There is the Law on Petroleum Products in the Federation of Bosnia and Herzegovina, which regulates: the development strategy of the oil sector, the policy of petroleum development sector, strategic plan for the development of the oil sector, action plan, harmonization of plans, balance of petroleum products, energy activities in the oil industry, conditions and method performance of energy activities, import of petroleum products, submission of data,

regulation of the oil sector, competencies and obligations of the Energy Regulatory Commission Federation of Bosnia and Herzegovina, license for work, content and method of issuing a license for work, registry of work permits, safe supply of petroleum products market, price oil derivatives, fees for establishing reserves of petroleum products, quality of petroleum products, labeling of pump machines, quality control, putting into operation LPG in bottles, operational stocks, mandatory stocks, oil derivatives reserves, founding and activity of the Petroleum Reserves Operator, administrative and inspection supervision.

Power sector

Bosnia and Herzegovina is a Contracting Party to the Treaty Establishing the Energy Community, as of 2006 when the country enacted the Decision on the Ratification of the Treaty (Official Gazette of BiH - International Treaties, issue no. 9/06). By entering into the Treaty, the country committed to the gradual adoption of the EU acquis, concerning the electricity and gas sector, environmental protection, competition, renewable energy sources, energy efficiency, oil and statistics. Bosnia and Herzegovina, however, is in a specific position since the Constitution foresees two jurisdictions over the energy sector. These cover responsibilities of entity governments and responsibilities of the state level exercised through the activities of the Ministry of Foreign Trade and Economic Relations of BiH (MOFTER BiH).

At the state level, the Ministry of Foreign Trade and Economic Relations is the responsible party for coordination activities over the state and entity governments regarding the implementation of the directives covered by the Treaty. It should, nonetheless, be noted that at the entity and Brcko District level different regulatory and policy frameworks apply.

In line with the Decisions enacted by the Ministerial Council of the Energy Community, Bosnia and Herzegovina has several energy targets, of which the ones most relevant to this project are set out below:

- achieving a national renewable energy sources (RES) target share of 40% RES in final energy consumption by 2020, as compared to the 2009 34% reference level,
- limitation of emissions of certain pollutants into the air from large combustion plants in line with the Large Combustion Plant Directive (LCPD) and the Industrial Emissions Directive (IED), by 2027,
- implementation of energy efficiency measures in line with the Energy Efficiency Directive, within deadlines specified by each target individually.

Each of the specified targets is or is still expected to be accompanied by an associated National Action Plan, involving policies, regulatory measures and mandatory targets. An overview of the status in each of the specified sectors is given below:

- **NREAP BiH - National Renewable Energy Action Plan of Bosnia and Herzegovina**, was adopted in March 2016 by the Council of Ministers of BiH. The plan is based on previously adopted entity action plans for the use of renewable energy sources and consolidates the measures set out therein. The sectoral goals for 2020 RES shares adopted by the NREAP are set out as follows: electricity sector 56.9% (baseline 50.3%), heating and cooling sector 52.4% (baseline 43.3%) and transport sector 10% (baseline 0.9%).

- **NERP BiH - National Emission Reduction Plan of Bosnia and Herzegovina**, was adopted in December 2015 by the Council of Ministers of BiH. The plan sets out emission ceiling values for nitrogen oxides (NOx), sulphur dioxide (SO2) and dust from the combustion plants covered by the plan. The target is to achieve a gradual emission reduction over the timeframe January 2018 - December 2027, in line with the LCP and IED Directives.

- **National Energy Efficiency Action Plan (NEEAP) of Bosnia Herzegovina** was adopted in 2018. Energy Efficiency Action Plan of Bosnia and Herzegovina takes into account the obligations related to energy efficiency in primary energy consumption, as prescribed in the Directive 2012/27/EU on energy efficiency. This resulted in the introduction of new energy efficiency measures in the area of generation of electricity and heating and cooling energy, inclusive of district heating, as well as new measures in the area of transmission and distribution of electricity and gas.

CHP

At the level of both entities there is a Law on the use of renewable energy source and high-efficient cogeneration. The purpose of this Law is to promote the production of electricity and heating and cooling energy from RES and efficient cogenration, as well as the use of RES in transport for domestic consumption and increase in total share energy consumption, and ensuring the development of incentive measures, the regulatory framework and the technical infrastructure.
When it comes to present support mechanisms, both entities have feed-in tariffs in place for CHP electricity exported to the grid. Other incentives include Priority access and dispatching for CHP and renewable plants, in terms of interconnection policies. A general overview of the current feed-in tariffs applicable to electricity exported to the grid by technologies associated to the heating/ cooling sector is provided in Table 4.

Table 4: Overview of current feed-in tariff support applicable to electricity from technologies associated to the heating and cooling sector

Technology	Federation of BiH	Republika Srpska
Biomass - solid (up to 10 MW)	0.11 - 0.15 €/kWh	0.11 - 0.12 €/kWh
Biogas (up to 1 MW)	0.13 - 0.44 €/kWh	0.12 €/kWh
CHP (up to 5 MW/ 10 MW)	0.07 €/kWh	0.03 - 0.08 €/kWh
Duration	**12 years**	**15 years**

It should, nonetheless, be noted that there are no specific feed-in tariffs for heat production from cogeneration or renewable sources. Besides, though feed-in tariffs are foreseen for CHP generated electricity, according to the dynamic quota from, no CHP will receive such support for now. With regard to technologies relevant to the heating and cooling sector, the quota foresees support for up to 70.04 GWh (19.45 MW) electricity from biomass plants in 2020, which corresponds to only 6.5% of the estimated technical potential. In addition, the current prices of thermal energy are not based on actual costs and most district heating companies are subsidised by local governments, as previously explained. Decision making is locally driven and differs substantially depending on the location, including the heat tariff methodology, calculation and approval, which results in significant differences in the heat tariff level as well.

4.3 Barriers and drivers for bioenergy integration

There are different types of subsidies in sector of bioenergy in Bosnia and Herzegovina, both at national and regional level. The main instruments are shown in Table 5.

Table 5: support instruments for bioenergy in Bosnia and Herzegovina

Short name of Instrument or Measure	Type of Instrument & Measure	URL
Decision on Feed-in tariffs and Premiums	Feed-In Tariff, Premium	https://s2biom.vito.be/node/1262
Decree on feed-in tariffs	Feed-In Tariff	https://s2biom.vito.be/node/1264
Green for growth fund	Loans, Investment Subsidies	https://s2biom.vito.be/node/1267
Programme of subsidies for agriculture and rural development	Investment Subsidies	https://s2biom.vito.be/node/1270
Regional energy efficiency programme for the Western Balkans	Investment Subsidies, Loans	https://s2biom.vito.be/node/1268
RES-E exclusion from concession procedure	Permitting	https://s2biom.vito.be/node/1263
Rulebook on subsidies for agriculture and rural development	Investment Subsidies	https://s2biom.vito.be/node/1269
Western Balkans sustainable energy direct financing facility	Loans	https://s2biom.vito.be/node/1266
Western Balkans sustainable energy financing facility	Investment Subsidies, Loans	https://s2biom.vito.be/node/1265

However, there are some barriers and obstacles which prevented bioenergy sector to develop at higher rate, so far. Table 6 summarize main barriers and possible drivers for different BIOFIT industries.

Table 6: Barriers and drivers for bioenergy integration in Bosnia and Herzegovina

Industries	Barriers	Drivers
Pulp and paper	• The CAPEX and OPEX of biomass facilities are relatively high.	• Biomass and processing waste are already available and must be treated. • Supportive framework for biomass use in pulp and paper facilities should be provided.
Biofuels	• The production costs for advanced biofuels are still very high. • The CAPEX of advanced biofuel facilities is very high.	• RED II requirements, which should be adopted for Energy Community countries, is supposed to accelerate regulation and enlarge penetration of biofuels.
Refineries	• Crude oil production is still increasing worldwide • The large -scale introduction of electric vehicles may have an impact on the oil refineries. • The current turnover of the biomass share in oil refineries is very little in comparison to the traditional business with crude oil.	• The RED, adopted in Bosnia and Herzegovina under Energy community Treaty, specifies that each MS shall set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14% by 2030
CHP and power plants	• Retrofitting CHP and power plants with biomass have relatively high CAPEX and OPEX. • Biomass logistic (lack of solid biomass market) slowing down biomass integration in power plants and CHP and retrofitting with biomass.	• The image related to the environmental impact of CHP and power plants can be improved by the integration of biomass. • GHG mitigation strategies of the EU include targets for decarbonizing the power sector that can accelerate biomass market as well as improve economic parameters. • The EU ETS penalizes fossil fuel use and not bioenergy.

5 Framework conditions in Finland

5.1 Markets

Pulp and paper industries

Due to its large forest reserves, the pulp and paper industry is one of the most important industry sectors in Finland. The export value of pulp and paper industry was over 9 billion € in 2017 (Figure 9) (total exports of Finland 60 billion €), and the sector is an important employer especially in rural regions of Finland (Natural Resources Institute Finland 2018). As an important part of the Finnish bioeconomy strategy, the sector is aiming for renewal. Energy products, chemicals, new materials (e.g. bioplastics and composites) and new business models are planned to be the areas that provide new opportunities (Finnish Forest Industries 2019). Important investments are made, e.g. the largest wood-processing plant in the Northern Hemisphere (Metsä Group's bio-product mill) was recently built in Äänekoski[26] and the world's largest softwood pulp mill is planned to be built in Kuopio[27]. The pulp and paper mills in Finland and their location can be seen in Figure 10.

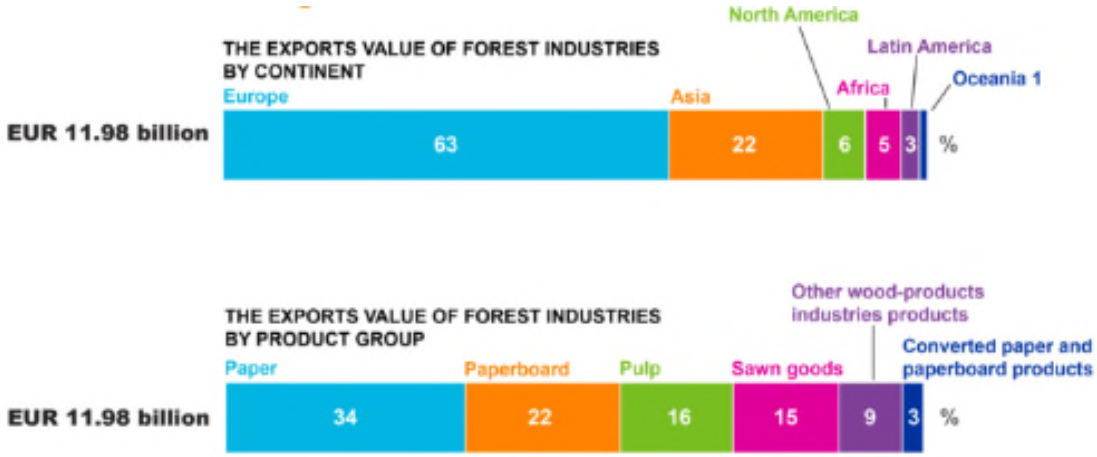


Figure 9: Exports of forest industry products from Finland in 2017. (Natural Resources Institute Finland 2018)

The forest industry in Finland uses mostly bioenergy to cover its energy consumption, and over 60% of the total renewable energy produced in Finland is produced by the forest industry sector (Statistics Finland 2018). The principal energy sources are the residual streams of the industry, such as black liquor, bark, and other residues.

[26] https://www.metsafibre.com/en/Pages/default.aspx

[27] http://finnpulp.fi/finnpulp-largest-softwood-pulp-investment-in-the-world.html

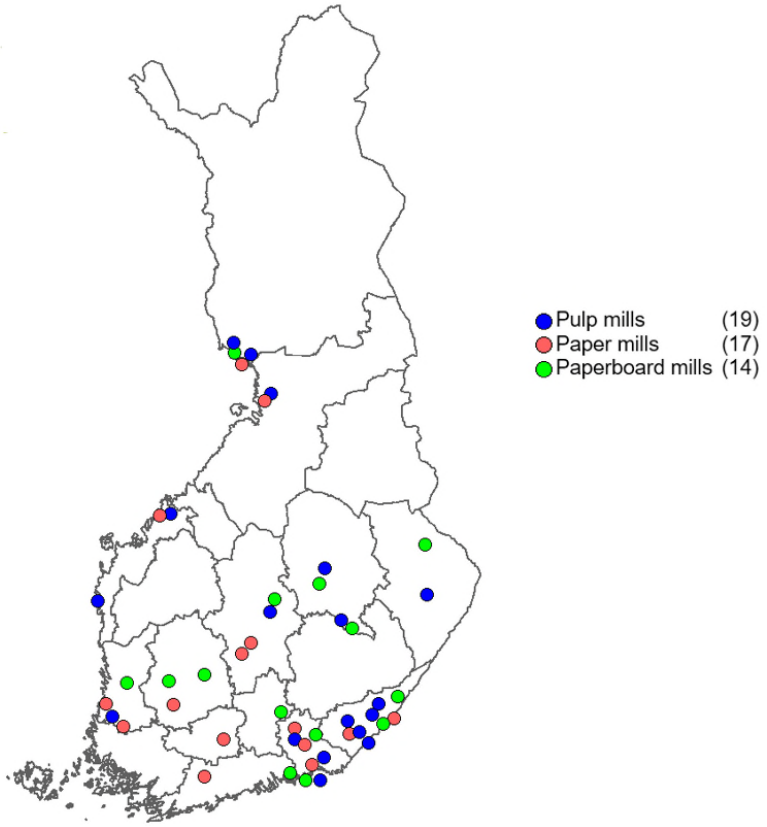


Figure 10: Pulp and paper mills in Finland (Source: Finnish Forest Industries 2018)

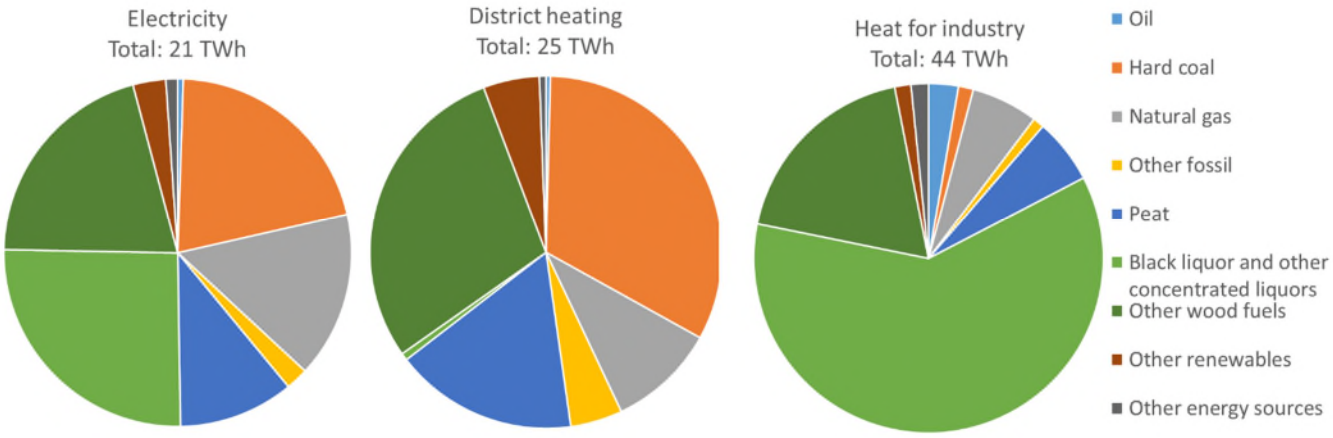


Figure 11: Fuels used for electricity and heat production in CHP plants in Finland 2017 (Source: Finnish Statistics 2018)

Biofuels

The current production capacity of biofuels in Finland is around 540,000 tons of liquid biofuels (Ministry of Agriculture and Forestry 2019), biggest share of which is HVO biodiesel by Neste from (mostly residual) plant oils and animal fats. In addition, liquid biofuels are produced by

St1 producing ethanol from biowaste and residues[28]; UPM producing BioVerno diesel from crude tall oil extracted in the pulp production process[29]; and Fortum, producing Otso bio-oil (for heating) from wood-based raw materials by using fast pyrolysis technology[30].

The use of biofuels in transport sector in Finland is around 9% of the total consumption in 2017. The consumption of biofuels has varied significantly between the recent years (Figure 12). This is because the fuel distributors can balance the fulfilment of their biofuel blending obligation between the years.

The traffic use of biogas (109 ± 3 TJ in 2017) does not stand out of the total consumption of transport biofuels in Finland. However, the absolute growth rate in traffic use of biogas in 2017 was 32 TJ (41% growth compared to previous year) was the highest since the start of its use in 1941. The amount of refuelling stations increased from 24 to 34. Half of the increase is due to local political decisions; biogas has been chosen for city traffic and waste transport in Vaasa and Jyväskylä. (Huttunen et al., 2017)

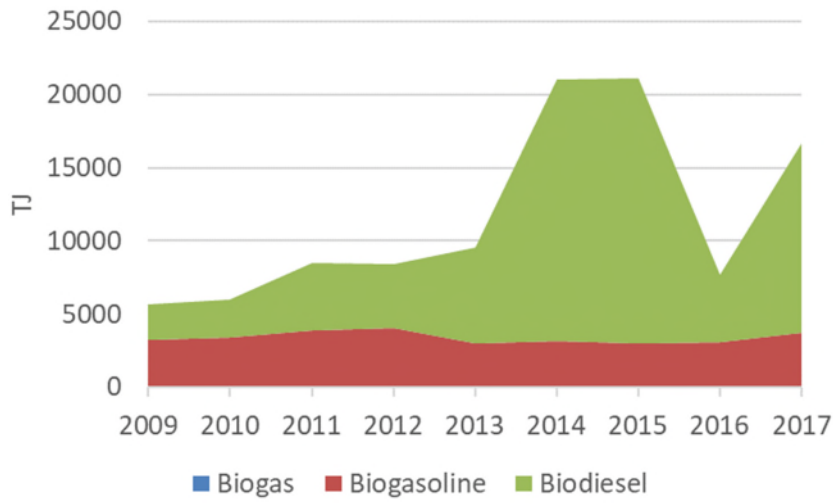


Figure 12: Consumption of liquid and gaseous transport biofuels in Finland (Source: Statistics Finland 2018b)

Fossil refineries

The only company refining oil in Finland is Neste, with a single refinery entity comprised of five production lines[31]. Four of the production lines are located in Porvoo, and the fifth one in Naantali. The refining capacity of crude oil in Porvoo plant is approximately 10.5 million tons per year (206,000 barrels per day) and in Naantali approximately 3 million tons per year (58,000 barrels per day). Among other products, Neste produces diesel, solvents, bitumen and small-engine gasoline. The crude oil is mostly imported from Russia. At Porvoo refinery, Neste

[28] https://www.st1.eu/about-st1/company-information/areas-operations/advanced-fuels-waste
[29] https://www.upmbiofuels.com/products/
[30] https://www.fortum.com/products-and-services/power-plant-services/fortum-otso-bio-oil
[31] https://www.neste.com/corporate-info/who-we-are/production/finnish-refineries

also has two units producing Neste MY renewable diesel, which is a HVO type of biodiesel produced with Neste's NEXBTL technology from plant oils, animal fats, and waste and residual oils.

Power sector

The power production in Finland comes from versatile sources and important share of electricity is imported from neighbouring countries (Figure 13). Biomass has an important role in CHP power production (see above). In conventional condensing power, around 1 TWh of biomass-based electricity is produced. The nuclear power production in Finland will increase, as the third reactor in Olkiluoto nuclear power plant is expected to be finalised in near future. Finland is part of the Nordic electricity market Nordpool, so the power production varies according to the hydrological and wind conditions in the market area32.

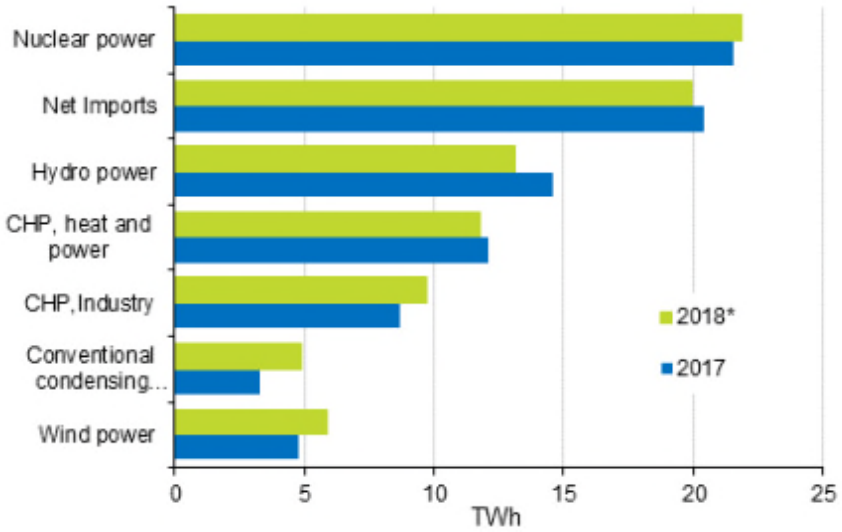


Figure 13: Electricity supply in Finland in 2017 and 2018 (in total around 90 TWh) (Source: Finnish Statistics 2019)

CHP

CHP production has a key role in the Finnish energy system. CHP plants are often connected to district heating networks, which are the most commonly used heating system in Finland. Around three fourths of district heating production in Finland is from CHP plants. CHP plants are also used in industry providing heat, steam and electricity for the processes. Biomass based fuels are already widely used in CHP plants (Figure 11). In future, the heating demand in Finland is expected to stay stable, but the needs for cooling of buildings is expected to increase. This could be handled with district cooling systems integrated with district heating, e.g. absorption cooling and by shifting the heat with heat pumps from district cooling to district heating grid. In future, CHP production will need to adapt to the increasing amount of wind power affecting its profitability, as well as district heating systems with increasing

[32] https://www.nordpoolgroup.com/

amount of heat pumps and solar heating systems, as well as heat storages (Rämä & Wahlroos 2018).

5.2 Policies

The overall target of the Finnish energy and climate policy is to reach a greenhouse gas reduction target of 80–95% by 2050 from the 1990 level (The Ministry of Economic Affairs and Employment, 2019). This requires that the energy system is modified to an almost emission-free state. In addition, significant actions are needed in transport sector and in industry as well as on other sectors. The Finnish climate and energy policy is based on the elements presented in Figure 14.

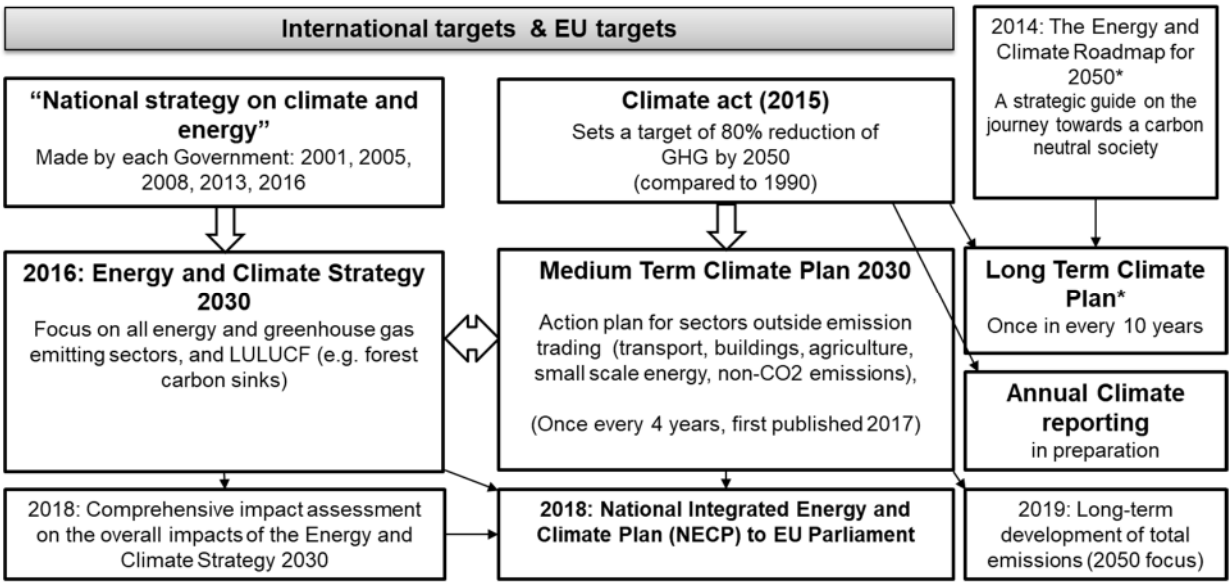


Figure 14: Instruments (bolded) and recent analysis on Finland's climate and energy policy

Former Finnish government (Prime Minister Juha Sipilä's Government 2016-2019) set ambitious targets for the Finnish energy policy:

- Share of renewable energy will be increased to more than 50% during the 2020s
- Self-sufficiency in energy consumption will reach 55% or more
- Important role for bioenergy, liquid biofuels and biogas
- Use of coal in energy production will be stopped during the 2020s
- Use of imported oil for the domestic needs will be cut by 50% during the 2020s
- The share of renewable transport fuels will be raised to 40% by 2030

The National Energy and Climate Strategy for 2030 outlined concrete actions and objectives that will enable Finland to achieve these targets. The Medium-term Climate Change Policy Plan for 2030 outlined especially the actions that need in effort-sharing sector (non-ETS

sector) emissions reductions (EU has set Finland an ambitious target of 39% emission reduction compared to 2005 for non-ETS sector). The strategy takes into account the Finland's special features, including the cold climate, long transport distances, extensive energy-intensive industry and domestic raw material resources, especially forest biomass. It looks at the energy and climate policy in different sectors comprehensively from the perspectives of emissions reduction, energy policy, growth and employment.

Measures to achieve the targets set have already taken place: with minor exceptions, Finland will phase out the use of coal for energy by May 2029 (Law on Coal Ban For Energy Use (416/2019)). To support the faster phase-out of fossil fuel-based CHP, the government wants to provide 45M€ support for switch to biomass CHP by 2025, and similar amount for non-combustion technologies, such as heat pumps or energy storages (IEA 2018). Generally, for the heat generation taxation is used to create incentives. However, currently the tax is based more on fuels energy and less on its CO2 content. The taxation favours domestic peat co-fired with biomass (IEA 2018). In addition, investment grants are available to companies, municipalities and farmers for installing heat pumps, geothermal, biogas, biomass and solar thermal installations.

Power generation is covered under the EU Emissions Trading Scheme (EU ETS). In addition, electricity generated from woodchips receives subsidies. Finland has amended its support scheme for electricity produced from renewable sources on 23 May 2018 (Government Bill 175/2017). The feed-in premium was abolished and competitive auctions introduced, in line with technology cost reductions in 2018. (IEA 2018; Ministry of Economic Affairs and Employment 2018)

Transport sector plays a key role in achieving Finland's national climate targets, producing around 40% of the Finnish greenhouse gas emissions in the effort-sharing sector. As reducing emissions will be more difficult in some sectors such as agriculture, the transport sector is preparing to cut its emissions even by 50% by 2030 (The Ministry of Economic Affairs and Employment 201933). Finnish biofuel policy was originally set under the Law on the Promotion of Biofuel Use in Transport (446/2007), and the Law on Biofuels and Bioliquids (393/2013), both amended in 2017 to comply with the EU Directive aiming to reduce indirect land use change (ILUC). The Law on the Promotion of Biofuel Use in Transport has been updated in 2019 (419/2019). The new law fixes the target of 30% of physical share of transport biofuels by 2030. 10% of the blending obligation should be filled with advanced biofuels. According to the energy and climate strategy, also an obligation to blend light fuel oil used in machinery and heating with 10% of bioliquids will be introduced.

In addition, fuel taxation favours biofuels over petroleum gasoline and diesel. The taxation takes into account the energy content, CO_2 emissions and particulate emissions of fuels. The CO_2 tax component is based on average equivalent life-cycle CO_2 emissions of the fuel, accounting emissions from production, transport and combustion. A flat rate tax reduction of

[33] TEM/88/04.10.02/2019 15.3.2019 REPORTING ON POLICIES AND MEASURES UNDER ARTICLE 13 AND ON PROJECTIONS UNDER ARTICLE 14 OF REGULATION (EU) No 525/2013 FINLAND

50% is applied to all biofuels that meet the sustainability criteria of the first EU Renewable Energy Directive, and advanced biofuels are fully exempted from the CO_2 tax (IEA 2018).

The pulp and paper industry as well as biorefineries are supported by the Finnish bioeconomy strategy. The strategy sets goals such as: creating a competitive operating environment for the bioeconomy; creating new business activities through risk financing, experiments, and transcending boundaries between different sectors; upgrading a strong bioeconomy competence base through developing education and research activities; securing the accessibility of biomass (The Ministry of Economic Affairs and Employment 2019).

An important and widely debated aspect in the Finnish bioeconomy and bioenergy politics is the impact of forest harvests on the development of carbon sink and storage of the Finnish forests. The Finnish forests form an important carbon sink. However, increasing the harvest amounts decreases the sink, compared to a situation with less intensive harvests. Furthermore, an important biodiversity impact due to intensive harvests have been reported (Koljonen et al. 2017). The impact of forest harvests in forest carbon sinks will be regulated under the EU LULUCF legislation ((EU) No 2018/841).

Table 7: Roles in energy and climate policy in Finland

Actor	Sectoral responsibilities
Ministry of Economic Affairs and Employment	Energy policy Energy use of industry, services and households, industrial processes, over-all energy consumption and production
Ministry of the Environment	Climate policy, Climate negotiations, GHG inventory F-gases, waste and energy use in buildings
Ministry of Agriculture and Forestry	Agriculture, forestry, land use, land use change and forestry –sector (LULUCF) Adaptation to climate change
Ministry of Transport and Communications	Transport
Ministry of Finance	Taxation, short-term economic development
Energy Authority	Independent national energy regulator of the gas and electricity markets with responsibilities under the Electricity Market Act and the EU third internal energy market package. Administrative competences with regard to renewable energy, RED sustainability criteria, emissions trading, energy efficiency, energy labelling and security of supply and consumer issues.
Tax Administration	Energy taxation Surveys the biofuel blending obligation of the Renewable energy directive.
Finnish Climate Panel	Under the 2015 Climate Change Act, the Climate Panel is nominated by government and gives scientific advice for policy-making.

5.3 Barriers and drivers for bioenergy integration

Potential barriers and drivers for bioenergy developments in Finland are presented in Table 8.

Table 8: Barriers and drivers for bioenergy integration in Finland

Industries	Barriers	Drivers
Pulp and paper	• Discussion on the sustainability of increased forest harvests - impacts on forest carbon sinks and on biodiversity. • Setting of the forest reference level required in the EU LULUCF -legislation and the impacts on harvests in Finland.	• Increased pulp demand for packaging materials may create more investments in the Finnish pulp industry. This will increase the bioenergy use and create possibilities for biorefinery concepts producing also biofuels e.g. from residual materials.
Biofuels	• Expensive investments. • Potential mushrooming of electric vehicles. • Sustainability issues related to biofuels (ILUC, biodiversity, impacts on forest and soil carbon stocks) • Sufficiency of the biomass resources.	• The high targets for emission reductions and for increasing the use of biofuels in Finnish transport sector.
Refineries	• The sustainability issues related to palm oil and other raw materials related to the palm oil production (e.g. indirect land use change issues). • Availability of residual bio oils.	• The high targets for emission reductions and for increasing the use of biofuels in Finnish and EU transport sector. • New products, such as bioplastics.
CHP and power plants	• The role of CHP may change, as other heat sources (e.g. heat pumps, solar heat) are getting more popular and electricity price decreases. These may reduce the profitability of CHP combined to district heating systems. • Sustainability issues related to bioenergy.	• Target for RE production and price of emission allowances. • Legislation on banning coal in Finland will require increased replacement of coal in the CHP plants. This will probably be partly done with biomass and may benefit from economical supports. • Increase of forest industry/shifting to bioeconomy will produce side streams for combustion, but can also increase regional competition of raw material. • Biomass is storable • CHP fits well for demand fluctuation between summer and winter

6 Framework conditions in Germany

6.1 Markets

Pulp and paper industry

The German pulp and paper industry employs 40,000 people and has an annual turnover of approximately 14.5 billion EUR. Recycling paper plays an important role as a feedstock for paper mills. Around 75% of the total paper and board is produced from recycling paper in Germany. New paper mills are thus mostly built with technology dedicated to recycling paper utilization (VDP, 2018).

In 2015 there were 22 operational pulp mills in Germany. Following a significant increase in the production capacity of pulp mills between 1999 and 2005 from 1.9 mil t to 3.1 mil. t, the production capacity has decreased again in recent years to 2.9 mil t in 2015. At the same time there was a shift from mechanical pulping (-25%) to sulfate pulping (+20%). A total of 2.6 mil t of pulp were produced in 2015, resulting in an average capacity utilization of 88% (Mantau, 2018).

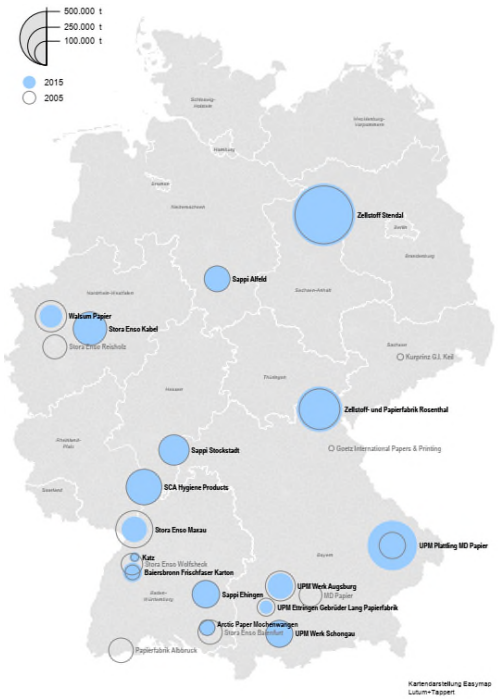
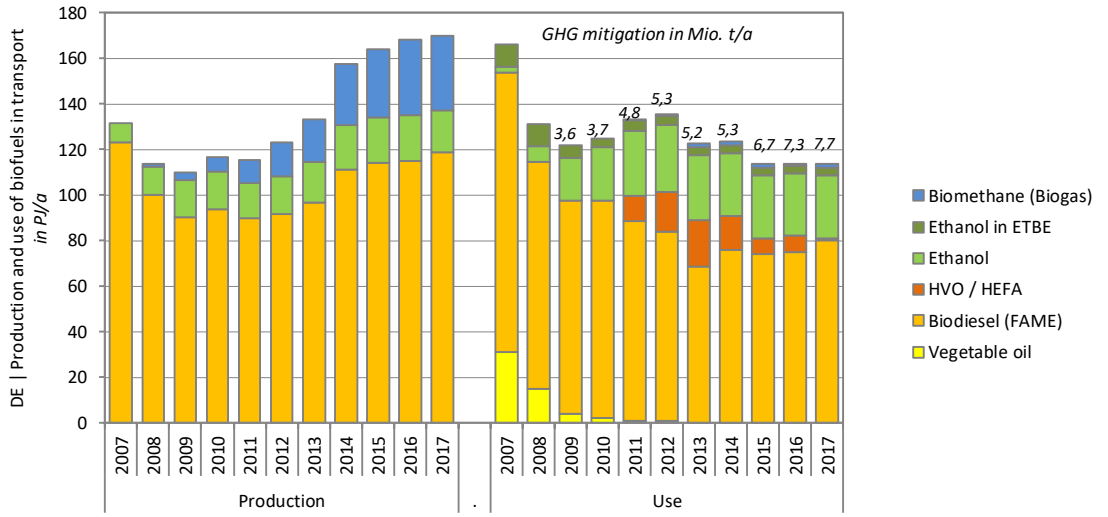


Figure 15 Pulp mills in Germany and the development of their production capacity from 2005 until 2015 (Mantau, 2018)

First-generation biofuels industry

In Germany, biodiesel, bioethanol and biomethane are produced and used as transport fuels. The last 10 years show a relatively stable production of liquid biofuels.

Biodiesel (fatty acid methyl esters - FAME) is produced in approximately 30 plants with a total production capacity of 4 million t/a. In the biodiesel production, the share of used cooking oil (UCO) as a feedstock strongly increased over the past years, while the share of rapeseed oil has decreased. Bioethanol is produced in five plants with a total production capacity of appx. 700,000 t/a. The feedstocks for German bioethanol are grains (3/4) and sugar-beet (1/4). For biomethane the production capacity has increased significantly and has surpassed the bioethanol production.



Data base: BDBe 2016, 2019; BLE 2015a, 2018; BNetzA und BKartA 2018; Destatis 2018; OVID 2019a, 2019b; VDB 2015
[a] HVO / HEFA: no production in DE.; Biomethane: production also for electricity and heat sector, [c] GHG mitigation: 2009 + 2010: 35% based on RED, 2011-2017: based on BLE data

Figure 16: Production and use of biofuels in Germany

The use of biofuels in Germany has not changed significantly over the last years, and has even declined slightly. Biofuels are currently only marketed in form of blends with fossil fuels (B7, E5, E10). The biodiesel market showed a notable net export of appx. 610,000 t in 2018. Since Germany does not have production facilities for HVO and HEFA fuels, all of the sold amounts have been imported in recent years. Only a small share of the biomethane produced in Germany is marketed as a renewable transport fuel blended with compressed natural gas. Although it has a very high GHG reduction potential of appx. 80%, biomethane does not have a significant share amongst the transport fuels, since the infrastructure (number of CNG cars and fuelling stations) is still not well developed.

Fossil refineries

There are 13 refineries operational in Germany with an atmospheric crude oil distillation. Their total distillation capacity amounted to 103 million tons in 2017. This is a slight increase of almost 1 million tons compared to 2016 due to technical optimizations. Different companies operate the German refineries. So far, no co-processing of biogenic oils is conducted in German refineries. However, the potential of advanced biofuels to contribute to the required emission reduction in liquid fuels is seen in the fossil refinery sector.

Fossil power

The share of renewable energies in the German electricity mix is increasing steadily. In total, the renewable energy sources solar, wind, water and biomass produced about 219 TWh in 2018. The share of public net electricity generation, i.e. the electricity mix that actually comes from the socket, was over 40% (Burger, 2019). The share of the total gross electricity generation including the power plants of the "companies in the manufacturing industry as well as in mining and quarrying" was 35%.

In parallel to the increase in renewable electricity production, coal and gas fired power plants as well as nuclear power plants have reduced their output. In 2018, lignite-fired power plants produced 131.3 TWh net for public electricity supply. The lignite-fired power plants started to react more flexibly to low exchange electricity prices than in previous years and temporarily reduced their output. However, lignite-fired power plants are still inflexible in their reaction to the high feed-in of renewable energies. Net production from hard coal-fired power plants has decreased significantly in recent years and ultimately amounted to 75.7 TWh in 2018. Gas-fired power plants produced 40 TWh net for the public electricity supply. In addition to the power plants for public electricity supply, there are also gas-fired power plants in the mining and manufacturing industries for the company's own electricity supply. They generated additional 20 to 25 TWh for industrial own consumption (Burger, 2019).

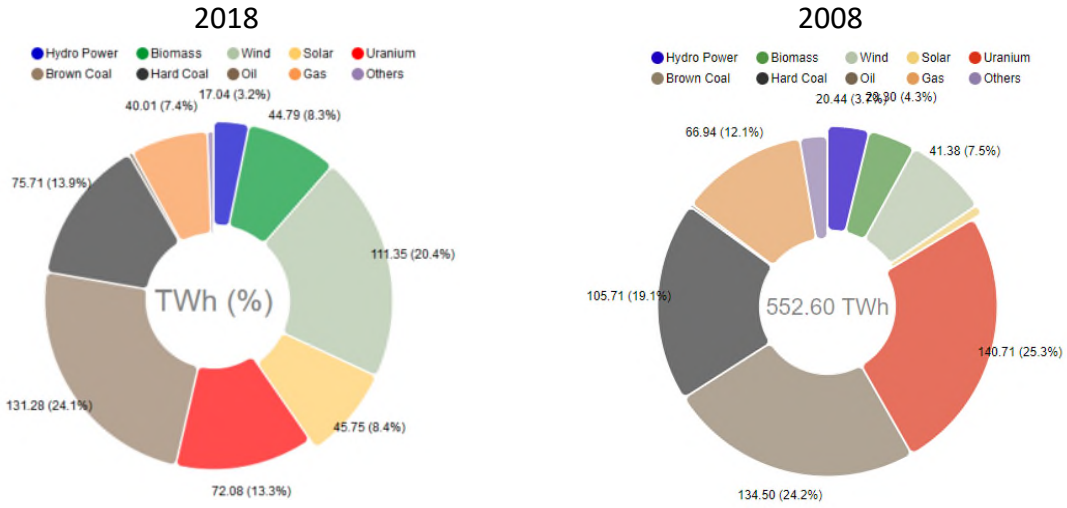


Figure 17 Comparison of the net electricity generation from power plants for the German public power supply in 2018 and 2008. (Self-generation of electricity in industry is not included) (Burger, 2019, Fraunhofer ISE)

CHP plants

After a low increase in production capacity in recent years, electricity generation from combined heat and power (CHP) plants has reached 121.8 TWh in 2018. With this amount, Germany has already exceeded its target of generating 110 TWh net electricity from CHP by 2020 (set in its Combined Heat and Power Act - KWKG) (Baten, 2017). Of the electricity from CHP plants, approx. 20% was produced from biomass and renewable waste. This share of the feedstock was relatively stable since 2013.

6.2 Policies

After a broad dialogue process, the German Federal Government has decided upon the Climate Protection Plan 2050 in November 2016. It sets a long-term goal of a largely CO_2-free economy for Germany with a target value of 80 to 95% reduction in GHG emissions in the year 2050 compared to 1990. Furthermore, it contains a plan for necessary steps with mid-term interim targets for the individual sectors and fields of action for the 2030s (Table 9). This gives an ambitious roadmap and framework for relevant upcoming bioenergy policy. However, the so far quite soft milestones in the Climate Protection Plan 2050 are still to be transferred into more specific binding legislation. Already existing policies relevant in the sectors of interest in the BIOFIT project are summarized below.

Table 9: Climate Protection Plan 2050 emissions of the fields of action included in the definition of goals

Action areas	1990 (in million tons CO2-Eq.)	2014 (in million tons CO2-Eq.)	2030 (in million tons CO2-Eq.)	2030 (Reduction in% compared to 1990)
Energy industry	466	358	175-183	62-61%
Building	209	119	70-72	67-66%
Traffic	163	160	95-98	42-40%
Industry	283	181	140-143	51-49%
Agriculture	88	72	58-61	34-31%
Subtotal	1,209	890	538-557	56-54%
Other	39	12	5	87%
Total	1,248	902	543-562	56-55%

Pulp and paper industry

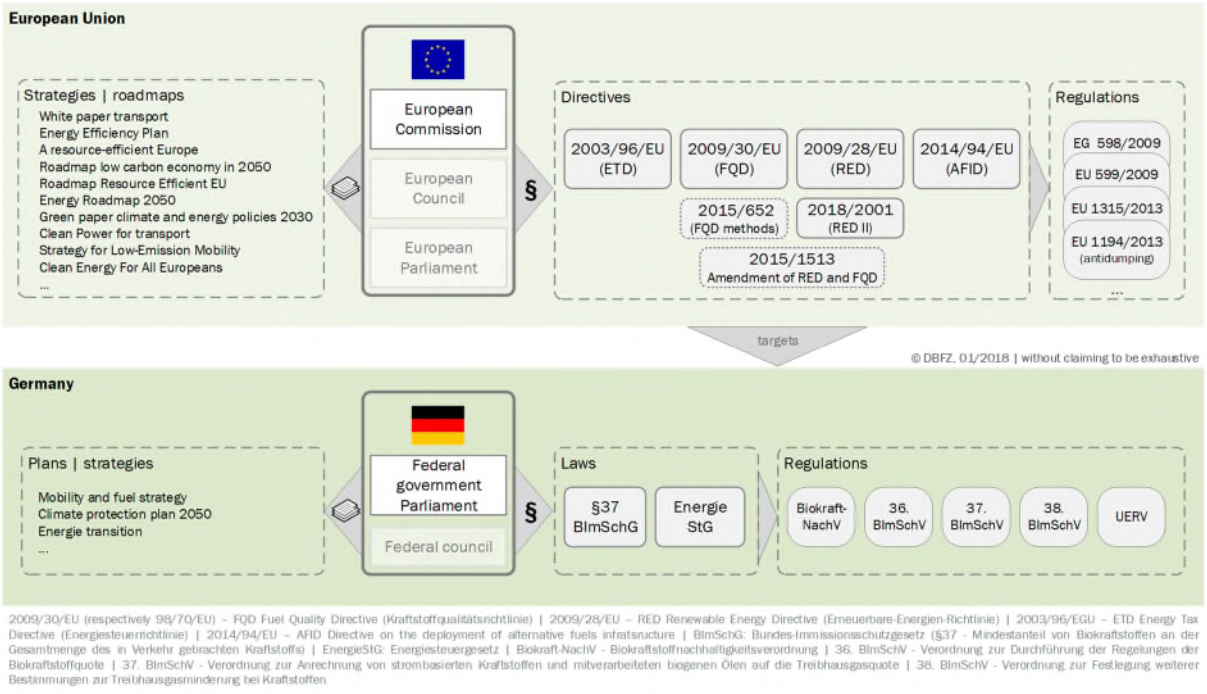
Several strategic papers of the German Federal Government promote the implementation of a bioeconomy: the “National Policy Strategy on Bioeconomy”, the “National Research Strategy BioEconomy 2030”, the “Action Plan of the Federal Government on Material Usage of Renewable Resources” and the “National Biomass Action Plan”. The pulp and paper industry plays an important role in the development of the wood-based bioeconomy. The bioenergy utilization in the pulp and paper industry is addressed rather indirectly in broader policies. Whether or not surplus electricity from byproduct combustion can be classified a renewable electricity is defined in the German Renewable Energy Sources Act (EEG). Furthermore, the Biomass Ordinance (BiomasseV) defines positive and negative lists of raw materials for electricity production within EEG. Waste liquors of pulping are on the negative list since January 2017. Since the BiomasseV is also referenced by the biofuel legislation as a definition of biomasses, waste liquors from pulping are currently excluded from the production of advanced biofuels under German policy.

First-generation biofuels industry

The use of liquid biofuels is strongly dependent on regulations in Germany. According to the Federal Immission Control Act (BImSchG), oil companies are currently required to reduce CO_2 equivalent emissions from their total sales by 4%. This commitment will increase by 6% from

2020. A sustainability certification including a GHG-balance is required for all biofuels to be accountable within this quota. The sustainability requirements for the certification are specified in the Biofuels Sustainability Ordinance (BiokraftNachV), which is the national implementation of the EU Renewable Energy Directive. This policy has increased competition for low GHG emissions amongst biofuel producers and is a driver for retrofitting measures. Since the regulation came into force in 2015, it has brought a significant improvement in the specific GHG avoidance of sustainable biofuels used in Germany.

Further regulations specify more precisely the biofuel sector: The 37th Ordinance on the Implementation of the Federal Immission Control Act specifies possible contributions of electricity-based fuels and co-processed biogenic oils to the greenhouse gas quota. The 38th Ordinance on the Implementation of the Federal Immission Control Act lays down further rules on the accountability of greenhouse gases in fuels (e.g. crediting of road vehicles with electric drive, biogenic liquid gas). The full energy tax is levied on biofuels, also in blends with fossil fuels (EnergieStG). The only exemption is a reduced energy tax for biofuels used in agriculture and forestry.



2009/30/EU (respectively 98/70/EU) – FQD Fuel Quality Directive (Kraftstoffqualitätsrichtlinie) | 2009/28/EU – RED Renewable Energy Directive (Erneuerbare-Energien-Richtlinie) | 2003/96/EGU – ETD Energy Tax Directive (Energiesteuerrichtlinie) | 2014/94/EU – AFID Directive on the deployment of alternative fuels infrastructure | BImSchG: Bundes-Immissionsschutzgesetz (§37 - Mindestanteil von Biokraftstoffen an der Gesamtmenge des in Verkehr gebrachten Kraftstoffs) | EnergieStG: Energiesteuergesetz | Biokraft-NachV - Biokraftstoffnachhaltigkeitsverordnung | 36. BImSchV - Verordnung zur Durchführung der Regelungen der Biokraftstoffquote | 37. BImSchV - Verordnung zur Anrechnung von strombasierten Kraftstoffen und mitverarbeiteten biogenen Ölen auf die Treibhausgasquote | 38. BImSchV - Verordnung zur Festlegung weiterer Bestimmungen zur Treibhausgasminderung bei Kraftstoffen

Figure 18 Overview of relevant regulations for biofuels on EU and national level for Germany (translated from Naumann, 2019)

In addition, the recently amended Renewable Energy Directive (RED II) sets the frame until 2030 on the EU level, including a limit for the share of conventional biofuels with increasing shares on advanced fuels. This framework is yet to be transferred into national regulations.

Fossil refineries

The German Government is promoting a technology agnostic approach to the implementation of renewable energy into the transport sector with its Mobility and Fuel Strategy (Mobilitäts-

und Kraftstoffstrategie, BMVI). Currently most relevant for the fossil refineries is the policy for co-processing of biogenic oils. Under the current German regulation (37th BImSchV), biogenic oils, which were co-processed in a mineral oil refinery can be recognized in the GHG quota only until the commitment year 2020. However, co-processing is an option also explicitly provided for in the EU RED II. An adaption of the German policies is thus probably needed to provide security of planning for retrofitting measures in the fossil refineries. In practice, the actual amount of renewable fuel-components in the co-processing products has to be validated by means of a C14 analysis, since the material flows in a refinery on the basis of mass balances is too inaccurate and non-transparent due to the different chemical reactions and recycling streams.

The German Government (BMU), the association of the mineral oil industry (MWV) and others are also promoting synthetic e-fuels (Power-to-X). Renewable electricity can be used to produce "green hydrogen", which can then be used for synthesis of liquid fuels with CO_2, e.g. with Fischer-Tropsch synthesis or in the hydrotreatment of biogenic oils. However, the costs of electrolysis would have to decrease significantly for an application at commercial scale (MWV 2018).

Fossil power and CHP plants

The so-called "Commission on Growth, Structural Change and Employment", created by the German federal government, has elaborated a fossil fuel phase-out plan. In January 2019 it has recommended to entirely phase out and shut down the 84 remaining coal-fired German power plants by 2038. The specific policies to implement this plan are still to be defined, but could be a strong driver for bioenergy retrofits.

So far, in the electricity sector, the Renewable Energy Sources Act (EEG) is the main policy instrument promoting the production of electricity from renewable energy sources. It has been implemented as a feed-in tariff (FIT) system in 2000. With the latest amendment in 2017, a tendering system has been introduced implying public tender procedures for onshore wind, offshore wind, solar, and biomass projects with the goal to shift from FIT support of renewable energy deployment to a market orientated price finding mechanism. With that, projects will no longer be eligible for statuary feed-in tariff remuneration but will have to bid for it in public auction organised and monitored by the Federal Network Agency (Bundesnetzagentur). For biomass installations, a quantity of 150 MW per year is the subject of tenders, applying to the period 2017–2019; for 2020–2022 the respective annual figure is 200 MW. The EEG is supplemented by the Biomass Ordinance (BiomasseV) and the Biomass Electricity Sustainability Ordinance (BioSt-NachV) defining the types of biomass that are eligible for receiving support under the EEG.

The Combined Heat and Power Act (KWKG) aims to increase electricity generation from CHP plants. The law intends to contribute to an increase in electricity generation from CHP by 25% by 2020 through the modernisation of existing and construction of new CHP plants. Since June 2018 also a tendering system is active to promote "innovative CHP systems".

6.3 Barriers and drivers for bioenergy integration

Table 10: Barriers and drivers for bioenergy integration in Germany

Industries	Barriers	Drivers
Pulp and paper	• waste liquors of pulping classified "no biomass" in BiomasseV	• Support of bioeconomy developments • Diversification of product portfolios
Biofuels	• Comparably low prices for fuels and mobility in Germany • Cap for conventional biofuels with 6.5% • Push of electro mobility and e-fuels	• GHG quota has proven to be valid instrument to achieve competition for sustainable biofuels • Recognition that conventional biofuels need to play an important role in decarbonisation. • Biomethane could become relevant as advanced biofuel
Refineries	• A strong focus on power-to-X technologies	• A possible introduction of a CO_2 tax could foster retrofitting measures in oil refineries. • National adoption of RED II may lead to clear long-term regulations for co-processing
CHP and power plants	• Tendering systems in electricity and CHP market have not yet led to significant new investments • Availability of adequate amounts of biomass may be limited	• The phase out of coal-based power plants until 2038 is political will. • A possible introduction of a CO_2 tax could foster retrofitting measures for CHP

7 Framework conditions in Greece

7.1 Markets

Pulp and paper sector

NACE[34] code 17 and its sub-sections refer to the economic activities of the pulp and paper manufacturing sector In Greece, there are 641 companies involved in the sector, which employs about 7,000 people. The total turnover is estimated at 1,200 million €, while the total production value accounted for 1,155 million €. Greek companies import pulp for further treatment, since no pulp production takes place in Greece.

The total energy consumption of the sector fell to 2 PJ in 2016 from 6.1 PJ in 2007. 37 % corresponds to electricity consumption, 39 % to various petroleum products, 17 % to natural gas and just 6 % to renewable energy sources. An example of a paper production company that has made forays into bioenergy is ELINA[35] (Komotini Paper Mill), which installed in 2012 a 8 MWth biomass boiler in order to substitute the heavy fuel oil used in its production process.

Biofuels sector

The biofuel market in Greece refers mainly to the production of biodiesel. For 2019, there were 16 producers and 5 importers of biodiesel were granted distribution quotas (Ministry of Energy and Environment, Decision 46361/1521). The producers accumulated in total for the 98 % of the annual volume, which amounts to 10 140 thousand cubic meters annually. Indicative producers are AGROINVEST S.A., PAVLOS N. PETTAS S.A., GF Energy, New Energy S.A. and Elin Verd. The raw materials used for biodiesel production are primarily oil seeds (sunflower, rapeseed and soya – 58.6 %), cotton seeds (13.6 %) and various used vegetable oils, cooking oils and animal fats (27.8 %).

The installed biodiesel production capacity in Greece is asymmetric to current local demand and underutilized, as it is employed for the domestic market. In the future, the production capacity could be used for development of export markets for biodiesel and/or for fulfilling higher blending mandates.

Refinery sector

Two company groups operate refineries in Greece: Hellenic Petroleum SA and Motor Oil Hellas SA. These two companies consist of a total of four refineries. The oil refinery capacity in Greece is about 528,000 barrels per day (ref. year 2018). The total refining capacity in Greece is sufficient to meet domestic demand. The past few years, though, there was a decline in

[34] System of classifying of economic activities in the EU (Nomenclature statistique des activités Économiques dans la Communauté Européenne)

[35] ELINA Komotini Paper Mill, https://www.komotinipaper.gr/en/page/quality-environment

domestic demand which established Greece a major net exporter of petroleum products. The total turnover of the sector accounted for about 17,700 million €, where the total production value was 17,500 million €.

Fossil power,CHP and DH sector

The electricity sector in Greece is still dominated by fossil fuels, which amount to almost 70 % of the gross power production. Coal is still the largest contributor (32 %), followed by natural gas (28 %), large hydro (11 %) wind (10 %), oil (10 %) and solar (8 %) – 2016 data (IEA Greece, 2017). However, it should be noted that the coal share has decreased significantly over the last two decades as the use of RES and natural gas has expanded.

The coal used in Greek power plants is low quality lignite Public Power Corporation S.A. (PPC) – a utility controlled by the Greek state – is currently the only operator of both lignite mines and power plants. Lignite mining and utilization takes place in two areas in Greece: primarily in Western Macedonia (location of Agios Dimitrios, Amyntaio, Kardia, Meliti and Ptolemaida power plants) and in the center of Peloponnese (location of Megalopolis power plant). The total installed capacity of lignite-fired power plants in Greece was 3.9 GW as of June 2018. The table below presents the main features of the lignite-fired power plants that were in operation – or under construction – in Greece till 2019. A number of units have already been decommissioned by 2015 (Liptol I&II, Ptolemaida I-IV, Megalopoli I, II).

Table 11 : Lignite-fired power plants in Greece

Power Plant	Unit	Gross installed capacity (MW_e)	Net installed capacity (MW_e)	Thermal Capacity for DH (MWth)	Comments
Agios Dimitrios	I	300	274	N/A	Under retrofits (dry FGD, primary measures for NOx reduction) for lifetime extensions Location for DH: Kozani city
	II	300	274	N/A	
	III	310	283	67	
	IV	310	283	67	
	V	375	342	70	Expected to remain in operation even after 2040 Location for DH: Kozani city
Amyntaio	I	300	273	25	Operating in opt-out regime since 01.01.2016 Location for DH: Amyntaio city
	II	300	273	25	
Kardia	I	300	271.1	N/A	Operating in opt-out regime since 01.01.2016. Units I and II in cold reserve since 2019 Location for DH: Ptolemais city
	II	300	270.8	N/A	
	III	306	280	50	
	IV	306	280	50	
Megalopoli	III	300	255	20	To be decommissioned by 2025. Location for DH: Megalopolis
	IV	300	256	N/A	In operation till 2032 (mine reserves will run out)
Meliti	I	330	289	70 (under construction)	Expected to remain in operation even after 2040 Location for DH: Florina city

Power Plant	Unit	Gross installed capacity (MW_e)	Net installed capacity (MW_e)	Thermal Capacity for DH (MWth)	Comments
Ptolemaida	V	660	615	140 (under construction)	Under construction. Expected commissioning in 2020 Location for DH: Ptolemais city

The net installed capacity of natural gas fired plants in Greece was almost 5 GW electrical, as of June 2018; licenses for 5 more natural gas plants with a combined capacity of around 3.5 GW have been submitted to the Regulatory Authority for Energy (RAE). The ownership of the natural gas plants is more varied; about 48.4 % is owned by PPC and the rest belong to various other private enterprises (ELPEDISON, HERON, MYTILINEOS, KORINTHOS POWER). Oil-fired power plants owned and operated by PPC are the major electricity producers in non-interconnected islands, including Crete and Rhodes.

There are several CHP plants operating in Greece, however practically all of them use natural gas as a fuel; there are also a few cases that use landfill gas. Use of other solid, liquid or gaseous solid biofuels in CHP plants is only marginal.

Currently, there are five District Heating (DH) networks in operation in Greece. With the exception of the DH system of Serres (using natural gas and oil) all other DH systems are primarily served by steam extracted from nearby lignite-fired power plants of PPC (Table 11). The DH systems usually also operate large heating oil boilers to cover peak demand and instances when the power plant waste heat is unavailable. The total installed thermal capacity of DH systems is over 450 MWth and over 660 km of network (trench length) have been developed. Approximately 125,000 citizens and more than 4,700,000 m^2 of heated building area are supplied by DH systems, while the annual turnover is about 16 million €. The average total annual heat consumption during the last years by DH end-users is about 480 GWh, while the DH heat production is approximately 600 GWh (i.e. mean network losses of about 20%).

Connection with the lignite-fired power plants is a major advantage to DH operators, since the heat has been historically purchased for very low prices by PPC. On the other hand, the decommissioning of old lignite-fired power plants is a major challenge for the operators of DH systems. The most critical case is the Amyntaio DH system, in which the connected power plant has been operated in opt-out regime and already reached the 17,500 operating hours well in advance. Even though an operational extension was granted by the Greek government, the plant is still expected to be decommissioned soon, with no refurbishment or replacement planned. Therefore, the network operator – DETEPA – is currently constructing two 15 MW thermal units, capable to be fed also with biomass. The units are expected to be operational till end of 2019.

7.2 Policies

The EU framework regarding the RES policies set the targets for minimum RES participation in the gross final energy consumption for each member state through the 3rd Energy Package.

Particularly, the targets are 40% RES participation in electricity production, 20% in heating and cooling and 10% in transport. Aiming to further enrich the diversity of the energy mix in state members through the promotion of RES in the production, policies have been developed for future applications. In particular, targets are set for 2050 that include a 60% to 70% reduction of GHG emission levels compared to the 2005 values, a total penetration of RES in both energy production and gross final energy consumption, and a high amount of 31% to 34% in oil consumption reduction replacing them with biofuels within the transportation sector, as well as the utilization of smart grids.

Premium tariff

Till 2016, Greece used a feed-in tariff (FiT) system for the financial support of different RESe technologies; this system was in place since 2006, with a major update in 2010 to bring it in line with the German EEG model. Generally, the Greek FiT system distinguished the level of the feed-in tariff received by a RES producers based on several parameters, the most important being a) the type of technology and installed capacity of the RES plant, b) whether electricity was supplied to the interconnected mainland grid or to non-interconnected islands and c) whether the investment was supported by public funds or not.

The current support framework for RES electricity in Greece is formed by Law 4414/2016 and is based on a combination of feed-in premiums (FiPs) and tenders. The Law attempts to further control fiscal expenses associated with RES support, while also being in line with European Commission's Energy and Environmental State Aid Guidelines for the period 2014-2020 (EEAG) and promoting the national targets for RES production.

A major feature of the new support scheme is that RES producers will participate directly in the wholesale electricity market, while their electricity production will be remunerated at the level of the Reference Tariffs (RTs). The FiP is calculated as the difference between the reference market price RMP and the RT for each technology and is guaranteed for a period of 20 years for most RES types.

Table 12 presents a summary of the feed-in tariff scheme and feed-in premium schemes employed in Greece for various types of biopower.

Table 12:Comparison of the feed-in tariff and feed-in premium schemes used in Greece for various types of biopower

Type of installation	Capacity	Law 4254/2014	Law 4414/2016
		Feed-in tariff (€/MWh)	Reference Tariff for 2016 (€/MWh)
Gases released from landfills	≤ 2 MW	131	129
	> 2 MW	108	106
Biogas from anaerobic digestion	≤ 3 MW	230	225
	> 3 MW	209	204

Biomass for thermal processes	≤ 1 MW	198	184 (combustion or pyrolysis) 193 (gasification)
	> 1 MW & ≤ 5 MW	170	162
	> 5 MW	148	140
Note: financial support levels indicated are without any type of public support for the investment			

The overall installed capacity of biomass-biogas project in Greece is about 83.24 MWe (ref May 2019). In specific, the installed capacity for landfill to biogas (>2MWe) is 42.008MWe, the installed capacity for biogas from anaerobic digestion units (≤ 3 MW) is 19.418 MWe, the installed capacity for biogas from anaerobic digestion units (> 3 MW) is 5.252 MWe, while the rest installed capacity corresponds to the other categories provided in Table 12 (LAGIE, 2019).

Investment Incentives Law: The updated Investment Incentives Law (4399/2016) is the main statutory framework for the establishment of Private Investments Aid Schemes for the regional and economic development of Greece. The maximum support level is 5 M€ per investment plan, 10 M€ per enterprise and 20 M€ per corporate enterprises. The support level ranges from 10 % to 55 % of the total investment, depending on the region where the investment project materializes. Special support schemes for various types of enteprises are foreseen (e.g. export-oriented SMEs).

Different types of investment supports are foreseen by the Law: 1) tax reductions, 2) grants, 3) leasing support, 4) support for new jobs creation, 5) financing support (e.g. loans, capital investment), 6) stable income tax, 7) speed-up of licensing. The investment support measures vary depending on the support regime (e.g. investments in new mechanical equipment, innovative investments for SMEs, large-investments, etc.), the type of the enterprise(s) involved and other factors.

Regarding energy production, distribution and infrastructure, the following types of investments are – indicatively – among those eligible for funding:

- Small hydropower
- High efficiency RES CHP plants
- Hybrid RES plants in non-interconnected islands
- Production of heating / cooling from RES
- Energy efficient District Heating / Cooling systems
- Production of sustainable biofuels

It should be noted that the coal sector is among those that are not eligible for funding under Law 4399/2016.

Biofuel Quota

An obligatory blending obligation of biofuels has been set for producers and distributors of petrol and diesel. This has been established with the Law3054/2002, and the mandatory blending amount is revised yearly, as explained in art. 15A par. 3 of the respective Law. The maximum FAME content allowed by EN590 diesel fuel standard is 7% v/v.

Law 4546/2018 prescribed a compulsory share of 1 % bioethanol in gasoline starting from 1st January 2019 (to be increased to 3.3 % from 2020 onwards). However, market sources mention that the measure is problematic due to the absence of a regulatory framework and the short time from the publication of the law till its implementation.

7.3 Barriers and drivers for bioenergy integration

Table 13: Barriers and drivers for bioenergy integration in Greece

Industries	Barriers	Drivers
Pulp and paper	• No raw material is being produced in Greece; paper pulp is entirely imported	• Increased energy costs make switch to bioenergy attractive • Energy Utilization of by-products/waste for covering the energy demands and decrease the energy costs
Biofuels	• No organized supply chain infrastructure in Greece to support increased production of biofuels	• Law no. 3054/2002. Mandatory biofuel proportion in petrol and diesel fuels (specific amount revised every year) • Development Law. Subsidies and tax regulation mechanism in the form of tax reliefs and supporting plans
Oil refineries	• Mandatory biofuel proportion is still low in Greece • Crude oil imports are still increasing	• Law no. 3054/2002. Mandatory biofuel proportion in petrol and diesel fuels (specific amount revised every year) • Development Law. Subsidies and tax regulation mechanism in the form of tax reliefs and supporting plans
Fossil power plants	• Co-firing is a "grey" area in the current support scheme for renewable electricity	• Phase-out of lignite-fired power plants in "transition" regions requires investigation of alternatives for maintenance of jobs\

	• Under-developed biomass supply chain networks for sourcing of significant biomass quantities • Inland location of lignite-fired power plants increases the transportation cost for imported solid biofuels • Specifications of RED II may pose limitations for large-scale biomass utilization (co-firing or repowering) in most lignite-fired power plants that will remain in operation	• Feed-in premium for biomass power. • CO_2 prices make switch to bioenergy attractive • Potential to co-fire biomass in combination with Carbon Capture and Utilization (CCU) technologies
CHP plants	• Support scheme for high-efficiency CHP only applicable for natural gas units • Lack of developed biomass supply chain networks • Warm climate and low heating demands in many areas limit the use of heat in DH systems	• Closure of lignite-fired power plants and search for alternatives in existing DH systems

8 Framework conditions in the Netherlands

8.1 Markets

Pulp and paper

The pulp and paper industry count 22 production facilities in the Netherlands with a turnover of almost 2 billion € and a production capacity of almost 3 million tonnes pulp and paper. These factories are united in the trade association VNP, the Royal Association of Dutch Paper and Cardboard Factories.

The total energy consumption of the Dutch pulp and paper industry in 2017 was 25 PJ of which 1.5 PJ renewable energy. Corrugated board and graphic paper mills have a significantly larger need for energy than the other mills. In 2015, ten paper mills used combined heat and power (CHP) installations to cover (part of) their steam demand. Most boilers and CHPs in the Dutch paper and board industry use natural gas to convert water into steam. Currently, two mills use biomass as fuel input (Eska and DS Smith). The Essity paper mill uses residual heat from a bio-power plant (VNP, 2017).

The most important sustainable energy measures for the pulp and paper industry are purchasing sustainable energy and savings by using energy from biomass and waste. In the energy efficiency plans a total of 10 measures are planned in the field of bioenergy, ambient heat, solar energy and residual heat. One factory purchases sustainable energy and the plan is that another factory will be added in the near future. A total of 241 TJ renewable energy would then be purchased by these two factories (VNP, 2015).

Biofuels

The Dutch biofuels industry is represented by the NVDB (Nederlandse Vereniging voor Duurzame Biobrandstoffen) and Platform Sustainable Biofuels (Platform duurzame biobrandstoffen). There are five companies that produce 1st generation biofuels in the Netherlands with a combined production of more than 1.5 million tonnes. In the Netherlands, 1st generation biofuels are mainly ethanol or ETBE from wheat, corn, sugarcane and sugar beet (in order of decreasing contribution). Since 2016, no palm and soy oil are used as feedstock for road transportation in the Netherlands. First-generation biofuels contribute 18.1% of the total amount of biofuels delivered. 80.3% are the biofuels that are blended into diesel (considering double counting) and 1.4% biogas. Electricity makes a small contribution (0.2%) but is on the rise. In 2017, the total amount of energy of the fuels supplied consists of 1.4% 1st generation biofuels (Nea, 2017).

Fossil refineries

There are currently six fossil refineries in the Netherlands represented by the sector association VNPI, the Dutch Petroleum Industry Association. The refineries used 85.6 PJ of energy in 2017 of which 14.9 PJ from natural gas. Biomass has not yet been used by this sector (CBS, 2017).

Figure 19: Fossil refineries in the Netherlands in 2019

In September 2011, Neste started the largest renewable biofuel plant in Europe in Rotterdam, with a capacity of 1 million tonnes biodiesel per year. With their NEXBTL technology it is possible to refine biodiesel from more than ten different renewable raw materials, mostly crude palm oil, which reduces up to 90% greenhouse gas emissions. The factory is in the port of Rotterdam, where five of the six fossil refineries are located as well (GAVE, 2019).

Fossil power and CHP

In April 2017, seven coal fired power plants remained in the Netherlands, which supplied approximately 35% of all electricity in the Netherlands and caused a CO_2 emission of 25 megatons, or more than 10% of all CO_2 emissions in the Netherlands (Ekker, 2017). In 2018, 1,827 PJ energy was produced in the Netherlands. Of this, 83% came from natural gas, 9% from renewable energy, 4% from oil, 2% nuclear energy and 2% other.

Currently, there are five coal fired power plants that produce electricity in the Netherlands (Essent, 2017). The main raw materials that these plants use, are coal, wood gas or biomass. The nominal capacity per plant ranges from 600 MW to 1,600 MW (ECN, 2005). To achieve the climate goals, the government aims to close all fossil power plants in the Netherlands before 2030. The Amer power plant in Geertruidenberg will fully run on biomass as a raw material by 2024.

In 2017 there were 19 combined heat and power plants from power stations in the Netherlands. Together these installations delivered a capacity of 4,363 MWe. The total steam and hot water production were 31,345 TJ (CBS, 2017). There are eight power stations that use a combination of a gas turbine and CHP with natural gas as raw material. Seven plants use a steam gas turbine CHP fuelled by natural gas, with one plant combining the natural gas with hydrogen. One plant uses a combustion with a CHP run on a combination of coal, biomass and wood gas.

8.2 Policies

Policies in the Netherlands focus on developing a combination of means that will encourage a feasible and reliable method to reduce greenhouse gas emissions. Planned objectives for the use of renewable energy are supervised by the Renewable Energy Directive, setting a mandatory goal for renewable energy sources of 14% of the total energy consumption in the Netherlands in 2020. The National Renewable Action Plan, National Energy Agreement, and draft climate agreement describe routes to accomplish the targets for renewable energy, energy efficiency, and greenhouse gas reduction. The share of renewable energy is expected to be 14.5% of the total energy consumption in 2020 (Pelkmans et al., 2018). NGOs, the government, and the industry, are important stakeholders that are involved in making action plans in relation to achieving the sustainable energy targets.

Bioenergy policies

In the National Renewable Action Plan, the government has decided that the largest current users of the Groningen gas (main source of natural gas in the Netherlands) must switch to another energy source. At the end of 2022, the Groningen gas production must be reduced from a maximum of 27 billion m^3 to 12 billion m^3. Besides that, the government has decided that greenhouse gas emissions should be reduced with 49% in 2030. These policy arrangements are also included in the draft climate agreement (Ebadian et al., 2019).

To achieve the set targets, the Netherlands has set up an extensive administrative and legal framework to increase the use of sustainable energy with a number of additional financial, fiscal and promotional measures, such as feed-in premium (Stimulation of Sustainable Energy production, SDE+), Energy Investment Deduction scheme (EIA) biofuel obligation, research support and green deals.

SDE+ grant

The SDE+ is an operating grant. The SDE+ scheme focuses on companies and (non-profit) institutions. Producers receive financial benefits for the renewable energy they generate. Production of renewable energy is not always profitable because the cost price of renewable energy is higher than the market price. The difference in price is called the unprofitable component. SDE+ compensates producers for this unprofitable component for a fixed number of years, depending on the technology used. The SDE+ is available for the production of renewable electricity, renewable gas, and renewable heat or CHP. For energy produced with pellets or liquid biomass, there is a system of controls in place to ensure that it meets criteria for sustainability. With the SDE +, the Ministry of Economic Affairs and Climate encourages the development of a sustainable energy supply in the Netherlands. The SDE+ will be widened from 2020 under the heading Sustainable Energy Transition Incentive Scheme (SDE ++). The SDE ++ will stimulate the roll-out of sustainable energy and CO_2-reducing technologies by compensating the unprofitable top of these technologies. This will be done through an operating grant (RVO, 2019).

Biofuels policies

The Dutch biofuels policy is closely linked to the European policy and the Paris climate agreement. The Ministry of Infrastructure and Water Management is primarily responsible for the biofuels policy in the Netherlands. However, the Dutch Emissions Authority (NEa) is responsible for monitoring the RED II targets such as the cap on crop-based fuels by 7% and the obligation of 1% of advanced biofuels in 2020. The Netherlands steadily increases its share of renewable energy sources like biogas, biofuels and using green electricity, to meet the targets in the EU Directive of 10% renewable energy in transport (36 PJ) by 2020. Other contemporary stimuli for using more renewable energy in the Netherlands are the RED II, the climate agreement, national energy agreement, and the blending obligation (Ebadian et al. 2019).

A limit on 1st generation biofuels and an obligation for advanced biofuels were introduced in 2018. The limit on 1st generation biofuels is set on 5% in 2020 and the obligation on advanced biofuels was set on 1% in 2020. Suppliers of liquid and gaseous biofuels must demonstrate European binding sustainability criteria for the entire biofuel supply chains. Sustainability of biofuels can be proven by certification through voluntary schemes recognized by the European Commission. The Dutch NTA 8080 (or Better Biomass) certification system is used for biogas certification, while ISCC EU is used for most liquid biofuels (Pelkmans et al., 2018).

In the Netherlands, fuel suppliers must produce a certain amount of biofuels on the market every year. Since 2015, they have indicated how much biofuels they have blended and how much electricity they have supplied for road transport. This is included in the Energy for Transport Register of the NEa. For this, fuel suppliers receive Renewable Fuel Units (HBEs) on their account. Companies can also buy HBEs to meet their obligation. Companies that do not meet the quantity receive a fine. This is stated in the Renewable Energy Transport Regulations. The aim of the scheme is to reach 10% alternative fuels in 2020 (Nea, 2017).

8.3 Barriers and drivers for bioenergy integration

Table 14: Barriers and drivers for bioenergy integration in the Netherlands

Industries	Barriers	Drivers
Pulp and paper [36]	• There is no sustainable energy infrastructure (for example, heat networks). • There are no transparent and stimulating allocation rules for CO_2 reduction. • There is no set yet of instruments for financial support (OPEX and CAPEX) for unprofitable CO_2 reduction measures. • No guarantee schemes to promote investments in risky groundbreaking innovations. • The processing time for granting permits for implementing innovations takes too long. • No space is created in the existing license for testing innovative technologies and raw materials. • Shareholders prefer quick profits over investing in long-term sustainability technology.	• The Dutch government wants to phase out gas production and companies must seek for another energy source [37]. • Greenhouse gas reduction by 49% in 2030 [38]. • SDE+ and EIA grant. • ETS obligation.
Biofuels	• Most combustion engines in cars are not yet suitable for the use of high blending biofuels rates [39]. • Shareholders prefer quick profits over investing in long-term sustainability technology.	• Greenhouse gas reduction by 49% in 2030. • Climate agreement. • RED II cap on crop-based fuels for 1st generation biofuels and targets for advanced biofuels [40]. • ILUC, Indirect Land Use Change[41]. • Blending of biofuels obligation [13]. • Demand for cheap raw materials and raw materials that do not compete with food production [42]. More demand for biofuels, because companies must switch from gas to another energy source
Refineries	• Existing complex processes in refineries are difficult to retrofit.	• Greenhouse gas reduction by 49% in 2030.

[36] https://vnp.nl/wp-content/uploads/2018/06/Roadmap-VNP-95-procent-CO2-besparing.pdf

[37] https://www.rijksoverheid.nl/actueel/nieuws/2018/03/29/kabinet-einde-aan-gaswinning-in-groningen

[38] (Ebadian, McMillan, Saddler, & van Dyk, 2019)

[39] https://www.nemokennislink.nl/publicaties/hybride-auto-duurzame-brandstof/

[40] (Ebadian, McMillan, Saddler, & van Dyk, 2019)

[41] http://europa.eu/rapid/press-release_MEMO-12-787_en.htm

[42] https://www.rijksoverheid.nl/onderwerpen/milieuvriendelijke-brandstoffen-voor-vervoer/biobrandstoffen

	• Shareholders prefer quick profits over investing in long-term sustainability technology	• ETS obligation. • The Dutch government wants to phase out gas production and companies must seek for another energy source [8].
CHP and power plants	• Closure of all coal-fired power plants before 2030 [43]. • Shareholders prefer quick profits over investing in long-term sustainability technology.	• Greenhouse gas reduction by 49% in 2030. • SDE+ and EIA grant. • ETS obligation. • The Dutch government wants to phase out gas production and companies must seek for another energy source [8]. • CHPs using fossil gas are less suitable for partial load, which gives more reasons to retrofit these systems[44]. • Unfavourable market conditions for CHPs using fossil gas [11].

[43] Dutch climate and energy agreement. Closure of all coal-fired power stations means no options for retrofit.

[44] https://ec.europa.eu/energy/sites/ener/files/documents/Toekomst%20warmtekrachtkoppeling%20en%20warmtevoorziening%20industrie%20en%20glastuinbouw.pdf

9 Framework conditions in Spain

9.1 Markets

Pulp and paper industries

Spain is one of the biggest pulp and paper producers in Europe with 10 pulp mills and 68 paper mills. According to ASPAPEL ("Asociación Española de Fabricantes de Pasta, Papel y Cartón", Spanish Association of Pulp, Paper and Cardboard Manufacturers) the total Spanish production was 7.9 million tons in 2017 (8.6% of total European production), divided by 1.7 million of pulp and 6.2 million of paper.

Since the pulp and paper industry presents high consumption of electricity and steam, the use of biomass and cogeneration are the main measures to increase the energy efficiency and to reduce greenhouse gases in the sector.

Currently, 81% of the organic wastes from the pulp and paper industry are revalued as follows: fuel in the plant itself (39%), raw material in cement or ceramics industries (9.1%), agricultural use (8.8%), and composting (7.3%). In this industry, the residual biomass generated (bark, lignin, sludge, etc.) is increasingly being used as a fuel in the plants themselves, which makes the paper industry the largest producer and industrial consumer of biomass in Spain. In 2017, around 33% of the fuel used by this sector is renewable (biomass and biogas) and the rest is natural gas. Moreover, about 20,600 TJ of electricity was produced by cogeneration in 2017, of which 60% was used to fulfil the industry energy requirements.

Nowadays, there is a great interest in the development of high-valued bioproducts in this sector. In fact, according to the report, "The Cellulose Era: The most innovative Pulp and Paper industry products"[45] (an initiative of the CEPI), the latest lines of innovation in the pulp and paper sector point to the use of cellulose fibres from new natural sources, bio-composites, printed electronics, microfibrillated cellulose and new packaging concepts.

Biofuels

In Spain as in the rest of Europe, biodiesel production is much higher than bioethanol. In fact, biodiesel production represents around 70% of total production. In 2018, Spanish biofuels production increased by 16.2%, reaching 2,236 ktoe distributed in 1,582 ktoe of biodiesel, 393 ktoe of HVO and 262 ktoe of bioethanol (16.6%, 3.7%, and 38.3% higher than previous year, respectively). This increase in biofuels production could be attributed to both the increase in exports (26.7%) and the consumption growth.

In 2018, Spain increased its consumption of biofuels by 26.4%. Although most of this growth is due to the increase in the use of biodiesel (41.3%), the consumption of bioethanol also rose significantly by 15%. This increase is attributed to the rates of energy content for fuel blend regulated in Spain, 4.3% in 2016, 5% in 2017 and 6% in 2018. RD 1085/2015 establishes

[45] La Era de la Celulosa: Los productos más innovadores de la industria de la Celulosa y el Papel

mandatory minimum annual targets for the sale or consumption of biofuels in 7% and 8.5%, for 2019 and 2020 respectively.

Fossil refineries

Nowadays, there are 10 refineries in Spain with a daily capacity of 1.56 million barrels representing 1.6% of the world's total daily capacity. In 2017, fossil fuels are still the main transportation fuel, reaching 95% of consumption. Between 2008 and 2012, approximately 8 million € were invested to improve Iberian refineries in the following aspects: market adaptation, environmental improvements, energy efficiency and security supply.

As it is discussed in section 2.1, one of the main challenges of fossil refineries is the transition to a low-carbon economy. To meet this challenge is important to develop new environmentally friendly processes and products and, in this respect, retrofitting is a good approach to achieve this objective. In Spain, there are already some initiatives to implement retrofitting in fossil refineries. The following projects fulfil with these retrofitting initiatives:

- PYROFUELS (**Repsol)**: it is focused on the production of 2nd generation fuels or advanced biofuels, obtained from biomass in refinery process units.
- HVO (**Repsol)**: it is focused on the co-processing of vegetable oils. Co-funded by the European Regional Development Fund (ERDF), it was part of the National Plan for Scientific Research, Development and Technological Innovation 2008-2011.
- Obtaining advanced biofuels by co-processing non-food fatty materials (**Cepsa)**. Co-funded by the European Regional Development Fund (ERDF), within the Operational Program Smart Growth 2014-2020.

Fossil power and CHP industries

Figure 20 shows the breakdown of Spanish installed power capacity in 2017. It can be noted that 43% of power production is still coming from fossil fired power (5.6% cogeneration, 25.6% combined cycle, 2.4% Fuel+gas and 9.6% coal) while renewable energy represents a significant contribution to the power generation (46.2%). In addition, it is important to note that 9 of 14 total coal plants located in Spain are planned to be closed in 2020 due to no-compliance on denitrification and desulphurisation European Union Regulations.

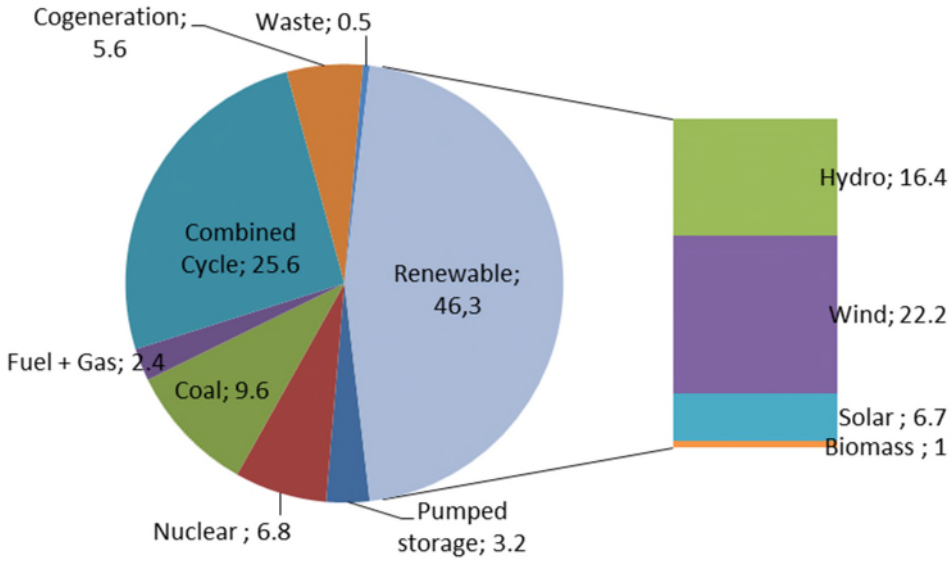


Figure 20: Breakdown of installed power capacity in Spain in 2017 (Source: REE 2017)

Power generation from biomass includes the following sources: biomass from energy crops and industrial facilities, biogas and biowaste (municipal solid waste and animal manure). In 2017, the total installed biopower capacity was 1,015 MW, distributed in 547 MW of biomass, 270 MW of biogas and 162 MW of biowaste. In the same year 4,365 GWh of electrical energy was generated, representing 1.7% of the total electricity production.

Figure 21 points out the power generation from biomass per region in 2017. The communities of Andalusia, Galicia, the Basque Country and Catalonia are those that present a greater use of biomass for power generation.

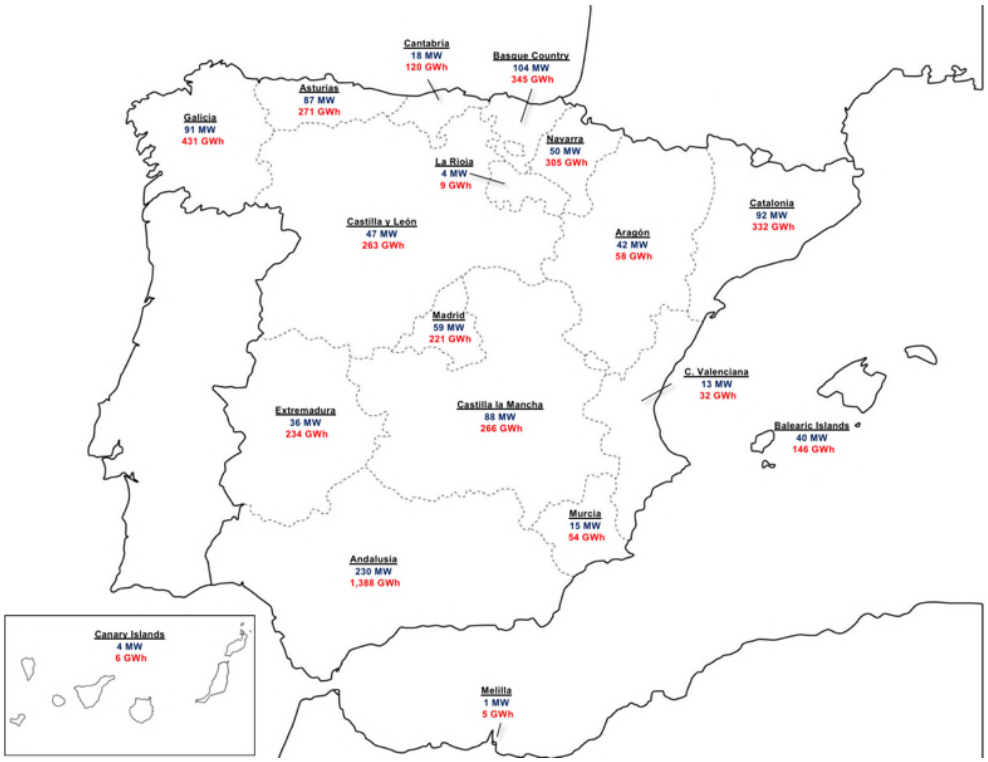


Figure 21: Power generation from biomass in Spain in 2017 (Source: REE 2017)

9.2 Policies

The Spanish regulatory framework of bioenergy has been developed according to the European Union Directives on the promotion of the use of energy from renewable resources.The incorporation of these Directives into Spanish law framework has resulted in the following regulations.

- **Royal Decree 1085/2015, of December 4th**. Its aim is the promotion of the use of biofuels and other renewable fuels for transport purposes as well as the partial incorporation into Spanish law of the Directive 2015/1513, by which the Directive 98/70/EC on the quality of gasoline and diesel and the Directive 2009/28/EC on the promotion of the use of renewable energy coming from renewable sources, are amended. In this Royal Decree, a mandatory minimum annual global goal of sales or consumption of biofuels of 4.3% is established for 2016, and for the years 2017, 2018, 2019 and 2020, targets in energy content of 5%, 6%, 7% and 8.5% respectively. Moreover, it is established that the percentage of biofuels produced from cereals and other starch- and sugar-rich crops, oilseeds and other crops cultivated on agricultural land dedicated for energy purposes, may not exceed 7% of the renewable energies in the transport sector in 2020.

- **Royal Decree 235/2018, of April 27th**: in this Royal Decree calculation methods and information requirements are established in relation to the intensity of greenhouse

gas emissions from fuels and energy in transport sector. Moreover, Royal Decree 1597/2011 that regulates the sustainability criteria of biofuels and bioliquids, the National System of Verification of Sustainability and the double value of some biofuels for the purpose of computing them is modified. Furthermore; an objective indicative of sale or consumption of advanced biofuels is established.

- **Circular 1/2016, of March 30th**, of the National Commission of the Markets and the Competition: regulates the management of the mechanism of promotion of the use of biofuels and other renewable fuels for transport purposes.

- **Order IET / 2786/2015**, of December 17th: it modifies the Order ITC / 2877/2008, of October 9, which establishes a mechanism to promote the use of biofuels and other renewable fuels for the purposes of transport.

- **Resolution of April 2nd, 2014**, of the Secretary of state for Energy: this approves the list of raw materials for the manufacture of biofuels for double counting purposes.

- **Royal Decree 1597/2011, of November 4th**: it regulates the sustainability criteria of biofuels and bioliquids, the National System of Verification of Sustainability and the double value of some biofuels.

- **Royal Decree 413/2014, of June 6th**: it regulates the activity of power production from renewable energy sources, cogeneration and waste.

- **Royal Decree 947/2015, of October 16th**: it establishes a call for the granting of the specific remuneration regime to new installations for the production of electricity from biomass.

- **Order IET / 2212/2015, of October 23th**: it regulates the procedure for assigning the specific remuneration regime in the call for new facilities for the production of electricity from biomass. The number of equivalent hours of the biomass and biogas plants production untitled to receive compensation for the operation is limited to 6,500 per year.

- **Spanish Strategy for the development of the energy use of residual forest** biomass: it has been elaborated following the fourth additional provision of the Law 43/2003, of September 21st, and its amendment in the Law 10/2006, of April 28th.

Moreover, the draft of the National Integrated Energy and Climate Plan 2021-2030 (PNIEC, "Plan Nacional Integrado de Energía y Clima 2021-2030) has been sent to the European Commission. This plan, which must be submitted by all the Member States, defines the national objectives for the reduction of greenhouse gas emissions (GHG), the incorporation of renewable energies and energy efficiency measures, among other issues. The PNIEC aims to achieve the following results: 21% reduction in GHG emissions (from 1990 levels), 42% of renewables on total final energy consumption and 39.6% improvement in energy efficiency.

9.3 Barriers and drivers for bioenergy integration

Table 15: Barriers and drivers for bioenergy integration in the 5 BIOFIT industries in Spain

Industries	Barriers	Drivers
Pulp and paper	• Technological adaptations in the industry.	• In pulp and paper industries, the revalorization of the generated waste is already carried out. • There are initiatives in this industry for the development of high-valued bioproducts.
Biofuels	• Feedstock cost still supposes a high contribution to the total cost. • Lack of maturity of advanced biofuels technologies. • Difficult fit of the directives in the Spanish legislative framework.	• Food crops versus energy crops. • The ILUC directive and the RED promote advanced biofuels.
Refineries	• Lack of support of the petrochemical sector.	• The RED specifies that each MS shall set an obligation on fuel suppliers to ensure that the share of renewable energy within the final consumption of energy in the transport sector is at least 14% by 2030
CHP and power plants	• Lack of support of the fossil heat and power generation sector.	• GHG mitigation strategies of the EU include targets for decarbonizing the power sector.

10 Framework conditions in Sweden

Sweden has gone through an important transformation from the early 1970´s regarding the use of biomass for energy purposes. The introduction of a number of policies and access to wood are two important explanations for the transformation. Nowadays, biomass accounts for 38% of energy use. Historically, increases in the use of bioenergy has been due primarily to increasing use for electricity production and district heating. This trend continues, but the increases in recent years are increasingly explained by increases in the use of biofuels.

10.1 Markets

Pulp and paper

Sweden has more than 50 pulp and paper mills. It is the second largest pulp and paper exporter in Europe, after Germany. Its pulp production is the largest in Europe, 4th in the worl). Its paper production is the second largest in Europe, after Germany.

Pulp production in Sweden has been stable since the 1980's. Total pulp production in 2018 was 11.9 million tons, of which about 65 % is used for internal production of paper and board at the various mills. The rest, about 35 %, is sold to the pulp market. The amount of pulp exported increased during 2018 to 4.2 million tons and accounted for 76 % of the pulp is delivered within Europe.[46]

Swedish paper production in 2018 was 10.1 million tons, of which 9.2 million tons was exported. The paper market in Sweden increased up to 2008 but has been stable since 2013.

The pulp and paper industry is a large energy consumer. It is also a large energy producer and the largest bioenergy producer in Sweden. Many pulp mills are net producers of electricty. In many places, excess heat from the pulp mills is used for district heating for nearby municipalities. The pulp mills are also large exporters of wood chips, bark and saw dust to the heat and power sector.

Swedish pulp and paper mills have steadily decreased their use of fossil fuels. They use mainly bioenergy from the by-products of their own processes and only 5 % of energy consumption is from fossil fuels. Currently, most of the fossil fuel used is in sulphate pulp production with a small portion in paper production.

Fossil refineries and biofuels

Sweden has three oil refineries, two in Gothenburg and one in Lysekil. The crude oil capacity is approx. 23 million m^3 per year in total. Swedish refineries are among the most energy efficient, in Europe. One of the reasons for this is the delivery of excess heat from the refinery

[46] https://www.skogsindustrierna.se/skogsindustrin/branschstatistik/massa-produktion-och-handel/

process to the city of Gothenburg. It is used to provide district heating to nearby industry and the local inhabitants, warming around 100,000 households.

The production of biofuels in Sweden consists of 1st generation ethanol and biodiesel (FAME and HVO). Since 2011, there has been a rapid decline in ethanol demand and instead a rapid increase of biodiesel. There are two commercial producers of ethanol in Sweden. Lantmännen Agroetanol in Norrköping is the only full-scale producer and supplier of ethanol from starch crops, with a capacity of 230,000 m^3 (1.3 TWh). The second ethanol plant is located in Örnsköldsvik, where ethanol is generated in the sulphite pulp mill (Domsjö Fabriker) and then upgraded in SEKAB´s plant to fuel specification ethanol. The production capacity of ethanol at SEKAB is 15,000 m^3 (62 GWh).

FAME is produced in both small and large scale facilities. The largest production plants are Perstorp Bioproducts with a capacity of 180,000 m^3 (1.7 TWh) and Ecobränsle with a production capacity of 50,000 m^3.

HVO is produced by the SunPine and Preem refineries. The HVO is produced from a by-product from the pulp mill process, unrefined tall oil. This unrefined tall oil is refined into tall oil by the SunPines process, then processed at Preems' refinery in Gothenburg into HVO. Preem started their production of HVO from tall oil in 2010. The ST1 refinery in Gothenburg has started to build a production line for renewable diesel (HVO) production mainly from fat residues, which will start in 2019/2020.

Fossil power and CHP industries

Sweden has only a few fossil fuel power plants and these are used as national back-up for electricity production. Electrity generation is mainly from nuclear energy and hydro power. In 2017, 15 TWh/ year of electricity was produced in CHP facilities, contributing to around 9 % of total power generation in Sweden (Figure 22). 6 TWh/y of electricity is generated in the industry, of which the pulp mill industry is the largest power producer. Most of the electricity from CHPs is generated by biomass, but small parts of fossil fuels exist as well. The use of fossil fuel for electricity production accounts in total (some CHPs and back-up facilities) for approximately 1 %. The largest coal fired CHP plant in Sweden was converted from coal to biomass in 2016. The last coal fired CHP plant will be converted by 2022 according to exisiting strategic plans.

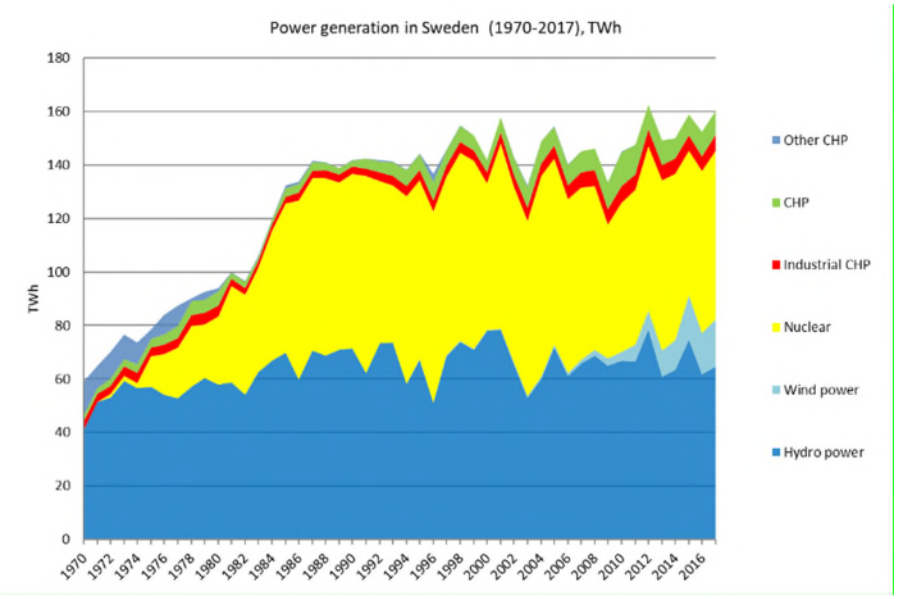


Figure 22: Power generation in Sweden[47]

There is an increased interest in converting small heating boilers (< 10 MW) to CHP plants in Sweden. There are around 500 district heating networks, of which 94 include power generation. There is a potential to increase the power generation from small scale CHP in Sweden by 2 – 6 % of total power generation. The district heating company in Ronneby Miljö & Teknik AB was the first in Sweden to invest in two different technologies, an Organic Rankine Cycle (ORC) and a wet steam technology. The company is a forerunner, but today five companies have followed and installed an ORC in addition to the existing heat plant.

10.2 Policies

Apart from the targets set by the EU Directive, Sweden has no specific targets for bioenergy. However, general policy stated an aim of a Fossil Free Society 2050, and the new government in 2014 declared that Sweden shall be a "fossil free welfare state". In 2016 the framework agreement on energy with five out of eight in the parliament stated that "At the latest in the year 2045, Sweden shall have no net emissions of greenhouse gases to the atmosphere, and will thereafter achieve negative emissions". In addition, The Swedish parliament decided in 2009 that Sweden shall have a fossil independent vehicle fleet by 2030.[48]

Sweden`s policies regarding bioenergy have been rather stable for a long period of time. The development of biomass as a renewable energy source for heat was promoted from the late 1970s to decrease Sweden's dependence on imported oil, mainly by taxation of oil, and investment grants for heat plants using biomass. In 1991, a carbon tax was introduced, and this tax has since then been raised multiple times, mainly on the heating and service sector, and lately also on industries which are not part of emission trading scheme (ETS). Besides the

[47] http://www.energimyndigheten.se/nyhetsarkiv/2019/Nu-finns-siffror-pa-energilaget-i-Sverige/

[48] https://www.ieabioenergy.com/iea-publications/country-reports/2018-country-reports/

carbon tax there are also variable energy taxes and fees on sulphur and nitrous oxide emissions. The most important incentives and tax measures have been:[8]

- 1970s to present: energy taxes to diversify energy use and decrease dependence on oil
- 1977: Law on municipal energy planning
- 1991: introduction of a carbon tax, high on heat, lower on industry.
- 1991 – 1995, 1997 – 2003: investment grants to build biomass fuelled CHPs.
- 2000 – 2004: green tax shift. The carbon tax was increased while labour taxes were lowered.
- 1998-2012 LIP & KLIMP: Local investment programmes for municipalities
- 2002: landfill ban for combustible waste
- 2003: Green certificate scheme to promote new renewable electricity production,
- 2005: landfill ban for organic waste
- 2007: Tax exemptions for biofuels for transport to be used up to 2013. Annual prolongation since then with some major adjustments
- 2012: Electricity Certificates Act. Together with Norway, a common electricity certificate market was installed in order to increase the production of renewable electricity by 26.4 TWh by 2020. In 2016 the goal was raised to 30 TWh.
- 2016: Framework agreement on energy and climate: Net zero emissions to the atmosphere by 2045

However, the higher oil prices during the last few years in combination with reduced prices of traditional biofuels has resulted in an "overcompensation" of biofuels relative to fossil transport fuels, which is not allowed by EU state aid regulations. Moreover, the revision of the EU state aid regulation for energy 2014-2020 also limits Sweden's possibilities to exempt biofuels from energy and CO_2 tax, since it contains limitations on giving tax exemptions to "food-crop based" biofuels. Therefore, the Swedish government launched a proposal. In brief, the structure of the system builds on a gradual increase in reduction of greenhouse gas emissions by addition of biofuels in gasoline and diesel. The system shall reduce emissions from diesel by 19.2 % and 2.6 % in gasoline. The decrease shall than increase over time with specific control stations with the goal of a 40 % decrease in greenhouse gas emissions by 2030. The system aims at creating a more stable long-term policy for producers and distributors.[8]

The new directive for medium combustion plants (MCPD) came into force in 2018 for new plants and in 2025 for existing plants. Criticism and concern in Sweden are that the new limits will act as a barrier for the continued expansion of nearby district heating production and the phasing out of fossil fuels in the industry due to increased costs for flue gas cleaning

equipment. For existing boilers, there is a concern that the costs for reducing emissions of particles may cause plants to close.

The Swedish support scheme for renewables has mainly been based on general incentives and technology neutrality, like the carbon tax and the green certificates. The carbon tax is based on PPP, the polluter pays principle, whereby the fossil fuels pay for their long-term environmental damage and cost and direct subsidies for any renewable alternative have in general been avoided. Bioenergy has thus not had any direct subsidies but has been benefited because its greenhouse gas emissions are estimated to zero.[8]

On January 1, 2018, the Swedish Climate Act came into force. The Climate Act is the law that regulates the government's climate policy framework. This means, among other things, that the government will produce a climate policy action plan every four years.

An investigation is underway into obstacles to energy efficiency and small-scale electricity production and storage for small actors. The investigation is to identify, among other things, measures that can stimulate technology development and development of new services in small-scale electricity production and energy efficiency on a market basis, such as white certificates. The investigation will also highlight the challenge of lack of power supply in parts of south Sweden.

10.3 Barriers and drivers for bioenergy integration

Table 16: Barriers and drivers for bioenergy integration in Sweden

Industries	Barriers	Drivers
Pulp and paper	• Bioenergy is already the dominating source of energy. The Swedish pulp – and paper mills are normally net suppliers of energy. • High costs for investments (CAPEX).	• Access to raw material. • A business model which includes a variety of production of possible biomass-based products. • Proven and established technologies.
Biofuels	• High costs for investments (CAPEX). • Competition for feedstocks from other sectors.	• National and EU-wide directives provide support. • Flagship projects such as the decision on new investment (Production of HVO at ST1 in Gothenburg, which starts 2019). • Successful demonstrations such as the positive results from the woody biomass gasifier demonstration plant (Gobi gas) in Gothenburg. The demonstration was successful from a technical point of view. However,

		the demonstration plant is closed down, due to political decision.
Refineries	• Limited access to feedstocks	• National and EU-wide directives provide support. • Flagship projects such as the 2019 increase in production of HVO in the PREEM refinery in Gothenburg.
CHP and power plants	• Bioenergy and renewables is already the dominating source for combined heat and electricity production. • Competition for feedstocks from other sectors. • Increased use of waste, including e.g. plastics, for combustion purposes.	• Access to raw material. • Proven and established technologies. • Technologies accepted by society.

11 Conclusion

The markets and framework conditions for bioenergy use in the industries pulp and paper, fossil power generation, combined heat and power (CHP), fossil refineries, and biofuels in Europe are as diverse as the industries themselves are. In Europe, there exist about 150 pulp mills and 750 paper mills. More than 600 coal fired power plants produce electricity and about 90 operational refineries convert crude oil into the various products. The number of combined heat and power plants are very large, as they range from micro CHP unity to large-scale CHP units. The biofuels sector is generally still small, whereby mainly 1st generation biodiesel is produced, but the amount of 2nd generation biofuels is still negligible. However, the role of biomass and waste and a feedstock source are clear: biomass accounted for about two thirds of all renewable energy consumption in the EU in 2012.

Besides the technologies, also the markets of the BIOFIT target countries in Austria, Bosnia and Herzegovina, Finland, Germany, Greece, The Netherlands, Spain, and in Sweden are very diverse; influenced by the size of the country, its location, and the agricultural and forestry sectors. Finland, Sweden, Spain, and Germany are characterized by the large potential of biomass from forests. By-products from agriculture are especially relevant in Germany, Spain, Greece, and The Netherlands. Furthermore, Bosnia and Herzegovina, as a relatively small country which is not yet member of the EU, has both agricultural and forestry biomass. A key challenge of this small country is to find solutions for the substitution of coal-based electricity. Also, for most of the other countries the phasing out of coal – Both Finland and the Netherlands have already decided to close coal-fired plants by 2029 - is a key element of today's political debate, as it would have a huge impact on mitigating climate change. An overview on national coal phase-out announcements in Europe[49] is provided by the Beyond Coal Europe initiative.

Most important drivers and barriers for the various sectors are:

- The **Pulp and paper** industry is concentrated in countries with large shares of forested areas, such as Finland and Sweden. In countries with smaller wood resources, imported pulp or recycled paper and board are used as the feedstock in paper mills. There, without sustainable feedstock and due to high capital costs associated with the bioenergy retrofits, increasing bioenergy use is challenging. A key driver in the pulp and paper sector is the emergence of opportunities to produce new bio-based materials and products such as biofuels. Several countries report positive impulses because of that development.

[49] https://beyond-coal.eu/wp-content/uploads/2018/11/Overview-of-national-coal-phase-out-announcements-Europe-Beyond-Coal-November-2018.pdf

- **CHP and power plants** are well-known and widely used to provide renewable energy, which creates sometimes problems with biomass availability. Competition from other renewable heat sources and competition for biomass resources, as well as sustainability and image all play a role.

- Progress on 2nd generation **biofuels** is made especially in Finland, Germany, Austria and Spain, and the conversion from 1st to 2nd generation biofuels is an important driver for the sector. Key barriers against retrofitting are high capital expenditure, and the emergence of electromobility.

- Due to the usually large size, the number of **oil refineries** in Europe is limited, though all BIOFIT countries have at least one refinery. An important barrier with respect to oil refineries is the general low interest of the industry in biofuel integration as their core business is on fossil fuels. Furthermore, biomass logistics is a challenge as oil refineries usually require significant quantities, due to their centralized structure. Main drivers are EU and national mandates.

All target countries have introduced different policies and legislations that positively or negatively affect biomass integration into the considered industries. These are based on EU legislation, notably the RED II. Even the non-EU country Bosnia and Herzegovina is stepwise adapting its legislation with the consideration of EU rules. The obligations related to the RED II, and the substituted national targets and policy framework act as a powerful driver for all sectors, but need to be transferred into powerful national legislations in the Member States. However, without summarizing all legal aspects, it must be noted that the ambitions of most policies need to be much higher in order to reach the goals of the Paris Agreement on Climate Change mitigation.

Besides legislation, frequently mentioned barriers against biomass integration in the industries include high CAPEX for new installations, but also for retrofitting measures, missing carbon taxes or low carbon emission prices, as well as low prices of coal, fossil fuels and natural gas. Furthermore, it must be considered that the use of biomass is always depended on its local availability as costs for logistics increase with larger supply distances.

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