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Report Highlights:

In an effort to address global warming, the European Union (EU) and its Member States have established targets for reducing carbon dioxide emissions. Sweden, Finland, and Denmark have already cut their emissions by 25 to 45 percent since 1990. Their technology for refining woody biomass, a sustainable and renewable feedstock, could play a key role in a fossil-free bioeconomy, such as to produce sustainable marine fuels and sustainable aviation fuels. Moreover, seaports in the Netherlands are a viable location for biorefineries and advanced biofuel plants to produce such advanced fuels in Europe.

Introduction - Sustainable Marine and Aviation Fuels

International actions to prevent global warming are shifting from renewable energy goals towards targets to reduce carbon dioxide (CO_2) emissions. While the United States and the Netherlands have reduced CO_2 emissions by roughly one percent since 1990, Sweden, Finland, and Denmark have reduced their CO_2 emissions by 25 to 45 percent during the same period (see table below). Woody biomass plays an important role in their successes. Because of an ample supply, the Nordic countries made use of biomass for their energy needs (both power and heat) and have the technology to apply woody biomass as a feedstock for producing transport fuels and high-value products. In this report an overview is given of the energy transition policy path and subsequent de-carbonization in the European Union (EU), with a focus on Sweden, Finland, Denmark, and the Netherlands.

Energy Supply & CO_2 Emissions
United States, the Netherlands, Sweden, Finland, and Denmark

	Total Energy Supply (TJ)	Share non-fossil (a)	Share Biomass (b)	Total CO_2 Emissions (MT)	Share Industry (c)	**Reduction since 1990**
United States	84,997	19.3%	5%	4,744	50.5%	**-1.22%**
The Netherlands	2,906	12.0%	8%	146	59.3%	**-0.98%**
Sweden	1,979	73.0%	30%	34	42.4%	**-35.4%**
Finland	1,251	59.7%	35%	40	62.5%	**-25.5%**
Denmark	620	43.5%	30%	28	44.8%	**-44.4%**

Source: International Energy Agency (a) Includes nuclear energy (b) Includes waste (c) Includes energy sector

The EU - Biomass is Essential for the Transition Towards a Fossil-Free Economy

In 2018, the EU adopted the Renewable Energy Directive II (REDII). The REDII includes a set of renewable energy targets and targets for the transportation sector.[1] In 2019, the European Commission (EC) presented its European Green Deal which laid out the blueprint for the EU's transformation to a zero-emission and climate neutral economy by 2050. One of the EC's most recent climate policy proposals, in line with the Green Deal, is the "Fit-for-55 package" (the FF55 package). The FF55 package proposes new legislation and updates current legislation for the EU to reach a 55 percent reduction of greenhouse gas (GHG) emissions by 2030. The proposal underlines the current[2] and future importance of bioenergy but also notes Member States must design support schemes for bioenergy which respect the cascading principle of uses for woody biomass. The proposals are currently going through the legislative process within the European Parliament and the Member States. In 2022 and 2023, it is expected these proposals will be amended and adopted.

As a data point for the development of EU climate and energy policies, the Joint Research Center (JRC) of the EC published the report "The use of woody biomass for energy". The JRC concludes that wood-

[1] The updated 2030 renewable target for the energy sector is 32 percent and for the transportation sector 14 percent.
[2] According the FF55 package, 60 percent of the renewable energy production in the EU.

based bioenergy, when produced sustainably and used efficiently, can be an integral part of the solution to the climate change and biodiversity loss crisis.

In June 2020, the EC adopted the Taxonomy Regulation to classify economic activities as "sustainable activities," "transitional activities," and "enabling activities." The goal is to steer private investments to meet the EU's climate targets for 2030 and reach the objectives of the Green Deal. On April 21, 2021, the EC adopted a first delegated act which includes bioenergy as a sustainable activity if it follows the technical criteria listed in the text and the sustainability criteria laid down by the REDII. For more information please see the FAS GAIN Report: EU Green Deal - July 2021 Update.

Shipping and Aviation – EC policies Call for Cellulosic Fuels.

The Green Deal aims to reduce transportation emissions by 90 percent by 2050 (compared to 1990), and to ramp up the production and deployment of sustainable alternative transportation fuels. Accordingly, the FF55 package identifies how the shipping and aviation industries could become more sustainable, as shipping and aviation are responsible for a significant volume of GHG emissions (in total 7.4 percent).

In this context, the EC proposed to include shipping in the existing EU Emissions Trading System (EU ETS)[3] and proposed to phase out free emission allowances for aviation -- aligning with the global Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Sustainable marine fuels (SMF) and sustainable aviation fuels (SAF) are regarded as key factors in de-carbonizing the shipping and air sectors. The EC has proposed a limit on the GHG content of energy used by ships visiting EU ports, and for a minimum share of SAF used by airplanes, which would gradually increase over time. While alternative sustainable options are available for SMF in the long term (e.g., green ammonia), fossil-free alternatives are limited for aviation. For more information see the following webpages: European Green Deal, FuelEU Maritime and ReFuelEU Aviation.

According to the EC, the availability of feedstock is currently a limiting factor for increasing SMF and SAF production. Food and feed crops are considered to have limited potential for de-carbonization, notably due to their indirect impact on land use. The EU policy (REDII) is structured to limit further expansion of "conventional or feed and food-based" biofuels and incentivizes the expanding use of "advanced waste and cellulosic-based" biofuels. For more information, see the FAS GAIN reports: EU Biofuels Annual 2021 and Biofuel Mandates in the EU by Member State and the UK.

The Nordics - Utilizing Woody Biomass for De-carbonization

Sweden

Sweden is a global leader in de-carbonization and aims to reduce GHG emissions by 59 percent by 2030 (compared to 2005), and to have a net-zero carbon economy by 2045. The Swedish government aims to reduce transport emissions by 70 percent from 2010 to 2030, and is supporting transport de-carbonization through electrification and advanced biofuels (source IEA). Sweden is also a frontrunner in the production of advanced waste and cellulosic-based biofuels, with a projected capacity of 950 million liters in 2024. The production of advanced biofuels in Sweden is led by Preem, Setra, SunPine,

[3] This would cover CO_2 emissions from large ships (above 5,000 gross tonnage) and emissions that occur when ships are at berth in EU ports. The proposal is for the policy to phase in over the period 2023 to 2025.

Pyrocell, among others. Notably, Preem has indicated its intention to begin producing of up to 300 million liters of SAF in 2022.

Finland

Finland is fast-tracking the de-carbonization of its economy with a net zero target for 2035 -- with transport and industry the key sectors to make further progress on its ambitious national climate targets. Like Sweden, Finland is a global leader in second-generation (advanced) biofuels produced from wood (source IEA). The production of Finnish advanced biofuels is led by Neste, UPM, St1, Green Fuel Nordic Oy, Nordfuel, BioEnergo, and Fintoil. The current Finnish advanced biofuel capacity is estimated at 500 million liters. In addition, Neste has two plants, each 1.2 billion liters, in Singapore and Rotterdam. Neste is also planning to build another plant in the port of Rotterdam with a capacity of roughly 2 billion liters, and plans to increase its global SAF capacity to 1.9 billion liters in 2023. UPM is also planning to open a biorefinery in Rotterdam.

Denmark

Denmark aims to cut GHG emissions by 70 percent by 2030 (from 1990 levels) and for renewables to account for at least half of the country's total energy consumption by 2030. The country also has a political agreement in place that aims for renewable energy to account for 100 percent of electricity and 55 percent of overall energy consumption by 2030 (source IEA). Denmark is a world leader in wind energy, but also opted to fulfill its renewable energy obligations by using biomass for the generation of power and heat. Denmark is examining the option to capture and store the CO_2 output of bioenergy installations, also known as Bioenergy Carbon Capture and Storage (BECCS), to achieve negative emissions. A Danish company active in the advanced biofuels sector is Novozymes.

The Netherlands – A Hub for Feedstocks and Biofuels

The Dutch 2019 Climate Act sets legally binding targets to reduce GHG emissions by 49 percent by 2030 and by 95 percent by 2050 (compared to 1990 levels). It also aims for 100 percent of electricity to come from renewables by 2050. Despite successful decoupling of economic growth from GHG emissions, the Netherlands remains reliant on fossil fuels (source IEA). The energy, chemical, and petrochemical industries produce almost sixty percent of Dutch CO_2 emissions (see table above). Most of the industrial clusters are located in the Dutch seaports, such as Rotterdam, Amsterdam, Delfzijl, IJmuiden, and Terneuzen.

The Finnish company, Neste, and the Dutch companies, BioMCN, DSM, and SkyNRG, lead the production of Dutch advanced biofuels. SkyNRG is planning to produce SAF for Schiphol Airport in Delfzijl, a seaport in the Northern part of the country. With the technical expertise of Shell Aviation, the plant will convert waste fats and oils with a capacity of nearly 125 million liters. Additionally, SkyNRG, in cooperation with Lanzatech, is planning to build a plant which converts waste-based ethanol into SAF. The plant will produce roughly 38 million liters annually and is scheduled to become operational in 2024. Recently, Shell announced a final investment decision to build a one billion liter biofuels facility in Rotterdam. SAF could account for more than half of the capacity. For more information see the FAS GAIN EU Biofuels Annual 2021.

Shipping and Aviation

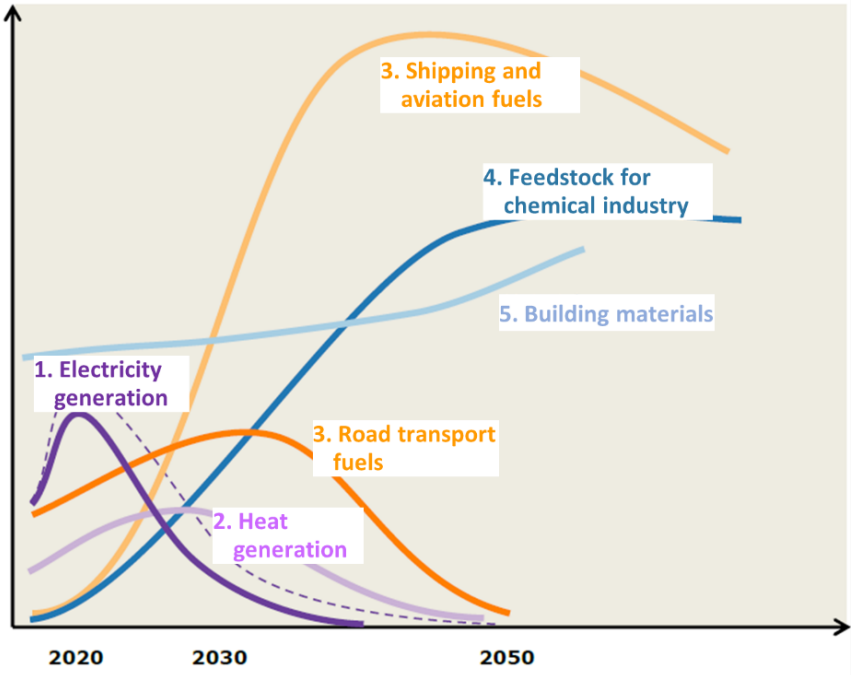
According to Statistics Netherlands (CBS) and the Dutch Environment Assessment Agency (PBL), the Netherlands is the largest supplier of bunker fuels for maritime and aviation fuels in the EU. Nearly a quarter of all deliveries are made via the Netherlands. The Netherlands is also one of the major 'fuels stations' in the EU, partly due to the presence of several large refineries in the seaports of the Netherlands.

Currently, the GHG emissions associated with the consumption of bunker fuels must be reported in accordance with the guidelines of the IPCC and are not included in the national emission total. However, the introduction of shipping and aviation emissions to the ETS would make the country where the emissions take place responsible for the output.

These developments and the presence of the large refinery capacity in the Netherlands makes it clear that Dutch seaports are a viable location for EU production of advanced biofuels. Several Dutch ports have the expertise and infrastructure to facilitate the production of renewable fuels for the shipping and aviation industry.

Following the findings and policy of the EC, the Dutch government asked the Dutch Social Economic Council (SER) to provide information about the application of biomass for the Dutch economy. On July 8, 2020, the SER published its report: Biomass in Balance (Dutch language). The main conclusion of the SER is that sustainable bio-feedstocks are a necessary and valuable tool for a CO_2 neutral and circular economy, are needed to reach the Netherlands' climate goals, and must be used for the highest value applications. Below is a graphic representation of the tentative development of the demand for biomass in the Dutch economy (volume versus time).

Tentative Development of Demand for Biomass in the Dutch Economy (Volume vs. Time)



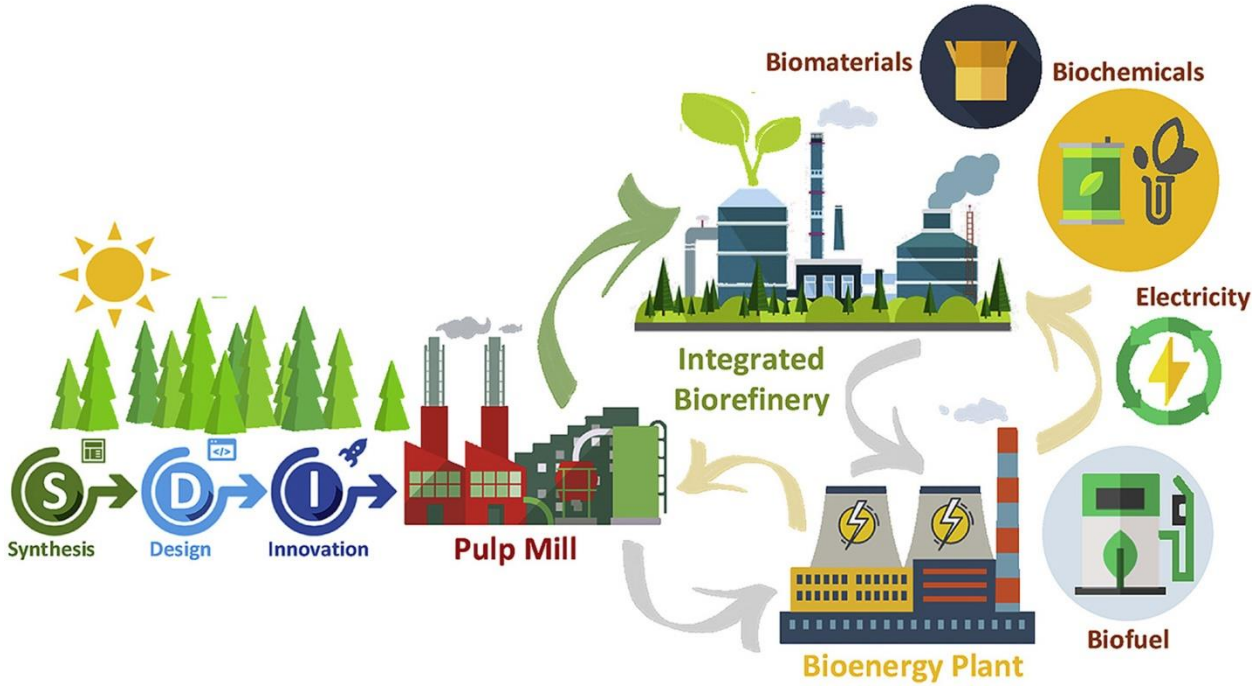
Source: Biomass in Balance

The SER's advised that electricity and heat challenges can be addressed at the national level. While the other categories (biofuels, feedstocks, and materials), based on the limited domestic availability, must be addressed with international partners (including those outside of the EU). Accordingly, there is a role for international partnerships to accelerate and develop infrastructure for these applications.

The SER also recommended the Dutch government ask the Netherlands Environmental Assessment Agency (known by its Dutch acronym of PBL) to investigate the available supply and economically viable applications of biomass for the Dutch economy. In its report, published on May 8, 2020, the PBL advised the government to develop an agenda for the realization of biorefinery projects on an industrial scale. For more information, see the FAS GAIN Report - Dutch Government Advised to Cascade Biomass, published July 14, 2020.

Refinery of Woody Biomass – Building the Infrastructure.

In summary, one way to reduce CO_2 emissions is by replacing fossil inputs with biomass, as its regrowth captures the released CO_2 (i.e., through the replanting of trees and crops). The most beneficial use of the biomass would be to first extract the valuable components which can be used as an input for the production of bio-chemicals, bio-plastics, and liquid biofuels, and only use the remainder as an input for generating heat and power (see graphic below).



Source: Journal of Cleaner Production

Sweden, Finland, and Denmark have been able to reduce CO_2 emission mainly based on the use of woody biomass. Private companies in the Nordics have the technology to refine wood, which can be utilized by a pulp mill or a biorefinery (see picture above). There are two approaches that can be implemented, and they are not mutually exclusive (depending on the feedstock and other factors):

- A decentralized approach: Collection of raw feedstocks (such as tall oil and lignin) from a pulp mill. These intermediate products can then be converted by a biorefinery and a bioenergy plant. Advanced refining technologies will improve the extraction efficiency and refining capacity of the pulp mill and could change the mill into a primary wood refining plant. Such a plant is typically located near the source of woody biomass.

- A centralized approach: The three plants (see picture above) wcanill be co-located or even integrated at one location, including at a hub like a seaport.

For more information about the infrastructure for the location of a biorefinery see the FAS GAIN - Case Studies for a Biorefinery, published May 14, 2018.

The United States as a Biomass Supplier and Technology Provider.

The United States has an oversupply of woody biomass, mainly available in the Southeast (known as the wood basket) of the United States, and a large share of this wood complies with the stringent EU and Dutch sustainability requirements. U.S. forests are a sustainable asset, and the harvested woody biomass is a sustainable alternative feedstock for producing fuels and substitutes for fossil fuel-intensive products. For more information see the Biomass & Bioenergy webpage of the U.S. Forest Service of the U.S. Department of Agriculture (USDA).

In 2017, the USDA and other federal agencies released the Federal Activities Report on the Bioeconomy (FARB) documenting federal agency activities aimed at helping to develop and support the bioeconomy – as an emerging part of the overall U.S. economy. Emphasis was specifically placed on the production and use of biofuels, bioproducts, and biopower.

On September 13, 2021, the U.S. Department of Agriculture (USDA), the Department of Transportation (DOT), and the Department of Energy (DOE) announced a "Grand Challenge" to support the production of 35 billion gallons (130 billion liters) of SAF per year by 2050. The USDA has a crucial role in SAF research. However, one challenge is sustainably producing enough biomass feedstock at the right price for conversion to SAF.

Additional Information

If you are a U.S. interested party and have questions about this report, please do not hesitate to contact FAS/The Hague at: AgTheHague@usda.gov.

Attachments:

No Attachments.