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What are possible technology pathways to convert renewable feedstocks?

Hello shipper, many sustainable maritime fuel production pathways exist*

*There are multiple market-ready conversion technology pathways, that are possible to produce renewable fuels, using renewable sources as input either in the form of sustainable biomass or renewable electricity.[1] Table 1 provides an overview of the different technology pathways. The choice of the technology pathway depends on the availability of the feedstock in the region close to the decentral production facility and the fuel type which is required.

Technology pathway	Feedstock	Products
Fermentation	Starch, sugars	Alcohols, which can be upgraded to fuels
Anaerobic digestion	Wet biomass	Biogas, which can be upgraded to bio-LNG, producing CO_2 as by-product
Hydrothermal liquefaction	Wet biomass	Bio oil, which can be used directly as marine fuel or upgraded towards a diverse range of fuels
Gasification	Dry biomass	Syngas, which can be upgraded to methanol or via Fischer-Tropsch towards a diverse range of fuels
Pyrolysis	Dry biomass	Bio oil, which can be upgraded towards a diverse range of fuels
Power-to-X	Electricity	CO_2 and/or H_2, which can be further processed into methanol, syngas, alcohols, or towards a diverse range of fuels

Figure 1 Overview of different technology pathways to produce renewable fuels using renewable feedstocks.

Fermentation

Sugars and starch can be fermented into biofuels, such as ethanol, using microorganisms. Ethanol can directly be used as a fuel and is already blended in with gasoline. Furthermore, the alcohols produced can be further processed through alcohol-to-fuel technology pathways.

[1] IEA 2025, *Delivering Sustainable Fuels, pathways tot 2035*

Anaerobic Digestion

Wet biomass, such as manure and wet organic waste, can be converted by anaerobic digestion into biogas, a mixture of mainly methane and CO_2. By removing the CO_2, the biogas can be upgraded towards green gas or bio-LNG, which can be injected into the existing natural gas grid. The removed CO_2 can be used in other process to produce multiple renewable fuels (see Power-to-X section below). Transporting wet biomass is relatively inefficient, because of the large amount of water present. Therefore, short supply chains are essential. Regions with large amounts of dairy farms are very attractive for local anaerobic digestion.

Hydrothermal Liquefaction

During hydrothermal liquefaction (HTL), wet biomass is thermo-chemically converted into a low oxygen bio-oil. The process operates at a medium temperature and high pressure. Due to the low oxygen and water content in the bio-oil, it can directly be used a marine fuel to replace fossil based maritime gas oil. Further processing of the oil through hydrotreatment can upgrade the oil into a diverse range of renewable fuels. The technology developments of HTL are well underway to being a mature technology and has a large potential.[2]

Gasification

High temperature gasification is a process that breaks down carbon-based materials under limited oxygen supply into a synthetic gas called syngas. A dry biomass feedstock is required, such as woody biomass, agricultural residuals, or municipal solid waste containing carbon. Syngas is an intermediary platform gas, a basic building block, which can be used to form a wide range of chemical compounds, including renewable fuels.[3] Syngas is a mixture of different gases, mainly consisting of carbon monoxide (CO) and hydrogen (H_2), and with a smaller share of carbon dioxide (CO_2) and methane. Fischer-Tropsch is a well-established conversion technology, used in the chemical industry for the refining of fossil-based fuels. Feeding this process with a syngas from renewable feedstocks can produce renewable fuels in the form of drop-in fuels.

Pyrolysis

Similarly to HTL, pyrolysis is a thermochemical conversion technology that converts dry biomass into bio-oils. However, resulting oil has a higher oxygen concentration compared to the bio-oil generated with HTL. Therefore, hydrodeoxygenation is typically applied to convert the raw bio-oil into a diverse range of fuels. The high energy density of the oils makes them easy for transportation. Furthermore, the infrastructure for oil transport already exists, which could provide a large potential to accelerate its deployment.

Power-to-X

Next to biomass as feedstock, electricity can also be used as feedstock in a power-to-x conversion process. The most well-known power-to-x technology is the production of hydrogen (H_2) through electrochemical conversion. Furthermore, electricity can also be used to capture CO_2, either directly from the air or from flue gases in industrial processes. Both H_2 and CO_2 are elemental building blocks for renewable fuels. Combining these two can produce methanol, which can be further processed using methanol-to-jet or diesel. Furthermore, they can be combined to form a syngas, using the reverse water gas shift reaction (RWGS). This syngas can then again be converted using Fischer-Tropsch towards a wide range of drop-in fuels.

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[2] Li et al 2026. Techno-economic and life cycle assessment of wet waste hydrothermal liquefaction with different biocrude upgrading strategies. *RSC Sustainability*, 4 (3): 1356–1366.

[3] Expert advice 2025. The future of sustainable carbon chemistry in the Netherlands

Moreover, CO_2 can also be directly converted into other chemical compounds using CO_2 electrolysis. This innovative technology is currently going through rapid developments and could potentially be a novel pathway towards a wide range of chemicals.

Design workshop to assess renewable fuel production pathways

The choice of the technology pathway depends on the availability of the feedstock in the region close to the decentral production facility. Specific areas in the Netherlands have large numbers of livestock farms, producing manure which can be used in anaerobic digesters. Other regions have large amounts of dry biomass available, or a surplus of renewable electricity, of which not all can be transported over the grid due to congestion.

As part of the Design Workshop, developed by the Platform Renewable Fuels [you can have a look at the workshop factsheet to know more about what we are offering], we evaluate the different technology options based on the locally available resources and fuel demand.

Do you want to organize a design workshop in your region? Do you want to evaluate how a demand for renewable energy for transportation can be met locally? Get in touch via contact@hernieuwbarebrandstoffen.nl to discuss how we can organize a workshop to open the conversation.