Status report on gasification in member countries

IEA Bioenergy: Task 33

September 2025

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Abstract

The gasification status report is published at the end of each triennium, providing a comprehensive overview of gasification activities across member countries. It summarizes the information exchanged during regular Task meetings, where representatives from each country update on the latest developments in gasification.

This report is essential for tracking progress, challenges, and innovations in gasification technology. The current edition highlights not only the status of gasification within Task 33-member countries but also focuses on biomass gasification products, reflecting the subtasks defined in the previous triennium. These subtasks focus on key product streams such as:

- Heat and combined heat and power production (CHP)
- Synthetic natural gas (SNG)
- Hydrogen production
- Biofuels production
- Biochemicals production

A core objective of Task 33 is to continuously monitor global gasification advancements. To facilitate this, a dedicated and regularly updated database has been developed on the Task 33 website. This resource offers detailed, up-to-date information on gasification facilities worldwide – covering operational, planned, under construction, non-operational, and paused projects.

The database is maintained through ongoing contributions from Task 33 members, ensuring it accurately reflects the status of gasification efforts across member countries.[1]

[1] https://task33.ieabioenergy.com/database/

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LIST OF ACRONYMS

Acronym	Definition	Acronym	Definition
2G	Second Generation	ABSL	Advanced Biofuel Solutions Ltd
ASTM	American Society for Testing and Materials	BECCUS	Bioenergy with Carbon Capture, Utilization, and Storage
BEST	Bioenergy and Sustainable Technologies	BLRE	Beaver Lake Renewable Energy
BOKU	University of Natural Resources and Life Sciences, Vienna	CAPEX	Capital Expenditure
CCS	Carbon Capture and Storage	CCU	Carbon Capture and Utilization
CCUS	Carbon Capture, Utilization, and Storage	CFB	Circulating Fluidized Bed
CHP	Combined Heat and Power	CI	Carbon Intensity

CO	Carbon Monoxide
CO_2	Carbon Dioxide
DAC	Direct Air Capture
DME	Dimethyl Ether
EFG	Entrained Flow Gasifier
EPA	Environmental Protection Agency
FHT	Ferro-Hy-Tunnel
FOAK	First-of-a-Kind
FT	Fischer-Tropsch
GHG	Greenhouse Gas
GTI	Gas Technology Institute
H_2	Hydrogen
H_2O	Water
H_2S	Hydrogen Sulphide
HCl	Hydrogen Chloride
HRSG	Heat Recovery Steam Generator
HTW	High Temperature Winkler
IEA	International Energy Agency
IOCL	Indian Oil Corporation Limited
ISCC	International Sustainability and Carbon Certification
KIT	Karlsruhe Institute of Technology
KLPD	Kilolitres Per Day
LPG	Liquified Petroleum Gas
MSW	Municipal Solid Waste
NOx	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
OPEX	Operating Expenditure
PEM	Proton Exchange Membrane / Polymer Electrolyte Membrane
PNNL	Pacific Northwest National Laboratory
PSA	Pressure Swing Adsorption
RDF	Refuse-Derived Fuels
RNG	Renewable Natural Gas
SAF	Sustainable Aviation Fuel
SMUD	Sacramento Municipal Utility District
SNG	Synthetic Natural Gas / Substitute Natural Gas
SOx	Sulphur Oxides
TCP	Technology Collaboration Programme
TNO	Netherlands Organization for Applied Scientific Research
TRL	Technology Readiness Level
vPSA	Vacuum Pressure Swing Absorption
WGS	Water-Gas-Shift

INTRODUCTION

Thermochemical gasification is a process that converts various carbon-based feedstocks - such as coal, biomass, and waste – into combustible gas. Historically, coal gasification was widely applied, particularly in countries with abundant coal reserves, and in some regions, it continues to play a role today.

However, as the global energy sector moves toward greater sustainability and seeks to reduce dependence on fossil fuels, the gasification of biomass and waste materials is gaining increasing importance. These renewable feedstocks offer a viable pathway to produce renewable energy and energy carriers. Consequently, biomass and waste gasification are emerging as key technologies in the development of a cleaner, more resilient, and decentralized energy infrastructure. Biochemical production is also receiving attention

A more detailed overview of the gasification process principle can be found in the IEA Bioenergy Task 33 Status Report 2016[2].

The gas produced through gasification – often referred to as producer or product gas – can be utilized directly for combustion or co-combustion in boilers to generate heat. With moderate cleaning, it can also be used in gas engines or turbines for combined heat and power (CHP) production.

Furthermore, through more advanced cleaning and conditioning processes, this gas can be upgraded to syngas, a refined mixture primarily composed of carbon monoxide (CO) and hydrogen (H_2). Syngas serves as a versatile building block for a wide array of energy and chemical applications.

In the last triennium, IEA Bioenergy Task 33 developed a series of fact sheets focused on the various application pathways for gas via gasification of biomass and waste. These include:

Gasification for

- Production of Heat and Power
- Production of Substitute Natural Gas
- Production of Chemicals
- Production of Fuels
- Production of Hydrogen

Each fact sheet is accompanied by a one-page summary graphic, providing a concise visual representation of the respective application pathway. The next chapter outlines the main applications and products resulting from the gasification process.

[2] https://task33.ieabioenergy.com/wp-content/uploads/sites/33/2022/07/Status_report.pdf

BRIEF OVERVIEW ON APPLICATIONS OF GAS FROM GASIFICATION

A comprehensive review on biomass gasification for synthesis gas (syngas) production, along with an overview of its various applications, was published previously[3], therefore, this section will provide a summary, drawing primarily on the fact sheets developed within IEA Bioenergy Task 33.

Subtask: Gasification for heat and combined heat and power production

(by Jitka Hrbek, BOKU Vienna)

The major benefit of using gasification for heat production, especially at elevated temperatures, lies in its ability to provide a flexible and sustainable heat source. Gasification systems can be designed to handle a variety of feedstocks, such as biomass residues, municipal solid waste, and carbon containing industrial byproducts. This allows them to offer an attractive solution for industries seeking to reduce their reliance on fossil fuels, lower carbon emissions, and integrate renewable energy into their operations.

A key advantage is the ability to use the producer gas as a clean and efficient heat source, with emissions being controllable and reduced compared to direct combustion of biomass or fossil fuels.

Biomass gasification for combined heat and power (CHP) production is a highly advanced and increasingly widespread technology. Only in Europe, there are more than 1700 operational units there. These systems are part of a broader shift toward renewable energy and decentralized power generation, driven by the need for greater energy efficiency and reductions in carbon emissions. Biomass gasification offers a versatile and sustainable way to produce both electricity and heat from renewable resources, making it an attractive option for industries, municipalities, and energy providers looking to optimize energy production and use locally available biomass.

The primary advantage of biomass gasification for CHP lies in its ability to maximize energy utilization. Traditional power generation methods, whether fossil-fuel-based or biomass-fired, are often characterized by significant thermal losses - up to 50-60 % of the input energy can be wasted as heat. In contrast, gasification-based CHP systems capture this waste heat for productive use, achieving combined efficiencies between 70-90 %, depending on system design and scale. This significantly outperforms the typical 30-40 % electrical efficiency of standalone gasification power plants.

This level of efficiency stems from the combined use of both the producer gas (for electricity generation) and the recovered heat (for district heating or industrial applications), which traditional power plants often fail to utilize.

CHP configurations allow the gas produced during gasification to drive gas engines or turbines for electricity generation, while the waste heat from the process can be harnessed for district heating, industrial processes, or biomass drying. This integrated approach not only reduces fuel consumption per unit of energy output but also stabilizes operational costs by providing both power and heat from a single energy input.

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[3] Rauch, R., Hrbek, J., & Hofbauer, H. (2014). *Biomass gasification for synthesis gas production and applications of the syngas. Wiley Interdisciplinary Reviews: Energy and Environment, 3*(4), 343–362.

Despite the clear efficiency benefits, the integration of gasification into CHP systems presents several technical challenges, particularly in terms of feedstock variability, producer gas quality, and plant scalability. Biomass characteristics, such as moisture content, ash composition, and particle size, play a critical role in determining gasifier performance and the quality of syngas produced. These factors can affect engine performance, especially when producer gas is used in internal combustion engines or combined cycle systems.

Syngas cleaning and conditioning are essential to maintaining CHP system reliability. Tars, particulates, and other impurities in the syngas can lead to operational issues such as fouling, corrosion, and reduced engine life. Advances in gas cleanup technologies, including high-temperature filtration, catalytic tar reforming, and improved gas conditioning systems, are crucial to ensuring long-term, stable CHP operation. For larger-scale systems, integrating gas turbines with heat recovery steam generators (HRSGs) has proven effective in handling the lower calorific value of biomass-derived syngas while optimizing heat recovery. To meet the growing demand for electricity, the CHP sector associated with gasification has recently been exploring the possibility of coupling with solid oxide fuel cells (SOFCs). Although not yet fully mature and commercial, these systems appear promising in achieving a significant increase in electrical output. In fact, compared to more conventional internal combustion engines, the latter could have the potential to double.

Biomass gasification-based CHP systems are well-suited for decentralized energy generation, particularly in regions with abundant biomass resources but limited grid infrastructure. By deploying small to medium-sized CHP plants, industries and municipalities can achieve energy self-sufficiency while reducing transmission losses associated with centralized power generation. Moreover, CHP plants provide flexibility to the grid by offering dispatchable power, an advantage over intermittent renewable energy sources like wind and solar.

From an environmental perspective, biomass gasification CHP systems offer substantial carbon reduction potential. The use of biomass, a carbon-neutral resource, in CHP plants aligns with global decarbonization goals. When biomass is sourced sustainably, the CO_2 emitted during combustion is offset by the CO_2 absorbed during the biomass growth cycle, creating a closed carbon loop. Additionally, modern gasifiers produce lower emissions of particulates, NOx, and SOx compared to direct biomass combustion systems, further improving their environmental profile.

Biomass gasification in CHP applications represents a powerful tool for enhancing energy efficiency and sustainability. By capturing and utilizing waste heat, these systems dramatically improve energy conversion efficiency and offer reliable, decentralized power and heat generation. Although challenges related to feedstock variability and syngas cleaning remain, continued technological advancements are making biomass gasification CHP an increasingly attractive option for industries and communities seeking to reduce carbon footprints while maintaining energy security. The future of CHP, particularly in decentralized energy systems, is closely tied to the evolution of gasification technologies, which promise to deliver both environmental and economic benefits on a global scale.

REFERENCE FACILITIES

The Kymijärvi II Gasification Plant is an advanced energy facility operated by Lahti Energia in Lahti, Finland. Located in the Kymijärvi area, this plant uses biomass and refuse-derived fuels (RDF) to generate combined heat and power (CHP) through a fluidized bed gasification process. Kymijärvi II was commissioned to meet Finland's ambitious renewable energy and carbon reduction goals, providing both electricity and district heating to the surrounding region.

Kymijärvi II is a key part of Lahti Energia's strategy to replace fossil fuels with renewable sources. The plant's gasification process allows for the efficient conversion of biomass into syngas, which is then burned in a gas turbine to generate electricity, while the excess heat is used for district heating. The total capacity of the Kymijärvi II plant is around 50 MW for electricity and 90 MW for district heating.

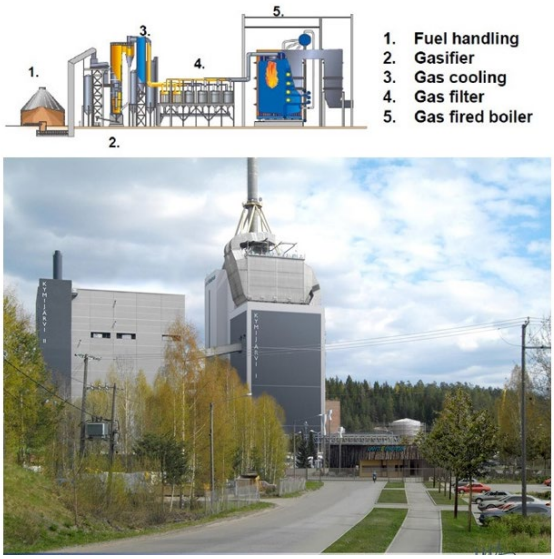

Figure 1: Kymijärvi II gasification plant (source: Database Task 33)

The Eska Gasification Plant in the Netherlands, primarily serving the pulp and paper industry, has a biomass gasification system designed to convert waste materials into gas for heat and steam production. The plant, CFB, typically operates with a paper reject as a fuel, input is 10-13 MWth. The produced gas is burned in a boiler, which produces 5-16 t/h steam (196 °C, 13,6 bar). The operation is fully automatic; the plant was built in 2016 and started its operation in late 2016.

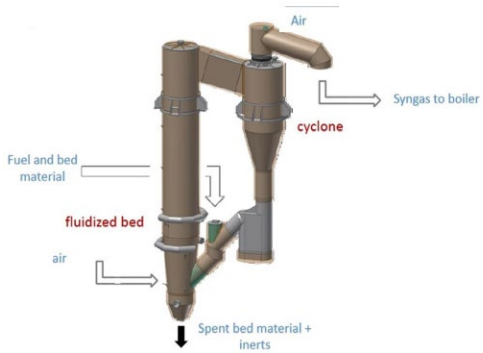

Figure 2: Circulating fluidized bed gasifier ESKA

The Skive Gasification Plant, located in Skive, Denmark, plays a crucial role in the local energy infrastructure by providing combined heat and power (CHP) to the surrounding region. The plant uses biomass, such as wood chips, as its primary feedstock, converting it into gas through a gasification process. This gas is then utilized to generate both electricity and heat, which are distributed through Skive's district heating system. The plant operates with a bubbling fluidized bed gasifier, and it has an electricity generation capacity of around 6 MW, while providing up to 12 MW of thermal energy for district heating. This significantly reduces the area's reliance on fossil fuels, helping to support Denmark's renewable energy goals and reduce carbon emissions. The facility is in operation since 2008.

There are several other gasification plants, mostly situated in Germany, Austria or in Italy. The detailed information can be found in the Task 33 database.[4] A the list of selected companies active in producing biomass gasification facilities for Combined Heat and Power (CHP) applications is provided below:

- **Valmet** (Finland) offers advanced biomass gasification technology for CHP applications, focusing on large-scale plants for energy production, especially in pulp and paper industries.
- **Metso** (Finland) has developed biomass gasification technologies that can be integrated into CHP plants, focusing on sustainability and efficiency.
- **ANDRITZ** (Austria) provides biomass gasification systems integrated with CHP solutions, especially for industrial applications. Their gasifiers are designed for use with a variety of biomass types.
- **SynCraft** (Austria) specializes in the production of floating fixed-bed gasifiers designed for the generation of heat and power from wood residues. A valuable by-product of this process is high-quality biochar, which enhances the plant's sustainability and offers additional commercial value.
- **Spanner Re² GmbH** (Germany) develops small/medium-scale wood gasification CHP units, primarily used for decentralized heat and power generation from woody biomass.
- The **Burkhardt** (Germany) gasification system converts wood pellets into syngas for efficient combined heat and power (CHP) generation. Its compact, modular design is ideal for small-scale renewable energy applications.
- CMD SpA (Italy) produces containerized modules designed to operate in the range of Micro Combined Heat & Power segment (mCHP; 20 kWel/40 kWth) and with biomass feedstocks from a wide range of products and by-products.
- ESPE (Italy) proposes a modular 50 kWe co-generator equipped with proprietary software for controlling processes both locally and remotely. The unit is designed for small and medium-sized enterprises requiring both heat and electricity.
- **Eqtec** (Ireland) specializes in gasification technology for converting biomass and waste into gas, which is used in CHP plants to generate electricity and heat efficiently.
- **HoSt Bioenergy Systems** (Netherlands) provides biomass gasification solutions for CHP plants, offering both small- and medium-scale systems with high efficiency in power and heat production.

These companies represent a wide spectrum of capabilities, from small-scale modular solutions to large industrial systems, catering to various sectors seeking sustainable CHP solutions through biomass gasification.

[4] https://task33.ieabioenergy.com/database/

Subtask: Gasification for hydrogen production

(by Joakim Lundgren, Luleå University of Technology)

Upgraded and conditioned producer gas from biomass gasification, may after the Water-Gas-Shift-reactor contain in the range of 65–70 vol% of hydrogen. Further purification to hydrogen can be done via pressure swing adsorption (PSA), resulting in a high purity hydrogen stream (99.9 %). The formed CO_2 is separated into a concentrated residual stream as an integral part of the gasification system, thus providing a favourable source for CO_2 capture and storage. This consequently leads to that the hydrogen can be produced with negative CO_2-emissions. Some biomass gasification technologies can also simultaneously produce biochar as a value-added co-product.

There is currently no commercial biomass gasification plant for hydrogen production in operation. However, several commercial technology providers exist, and there is an increasing number of projects announced world-wide, see examples in Figure 3. In the following, a selection of ongoing activities is briefly described. This is an excerpt from the forthcoming IEA Bioenergy Task 33 report "*Biomass gasification for hydrogen production – State-of-the art technology*"[5]

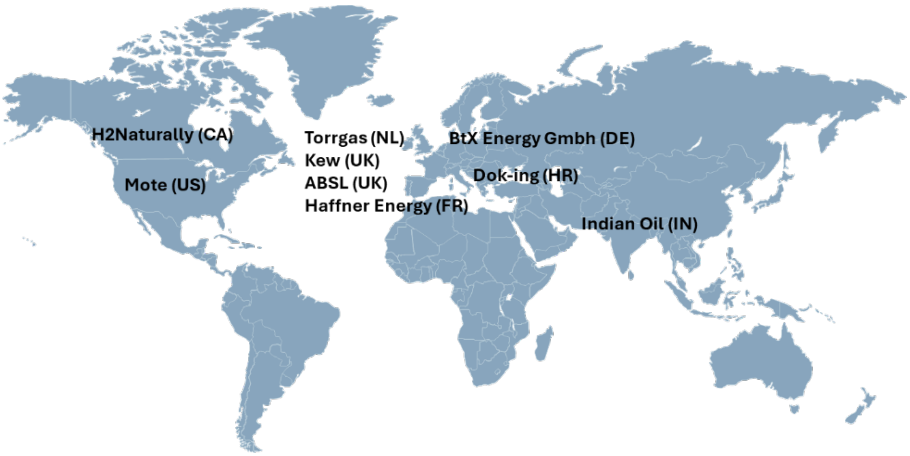

Figure 3: Examples of technology providers and projects on gasification based biohydrogen production.

Selected Initiatives in North America

- *H2Naturally (Canada)*

The Canadian company H2Naturally plans to build three gasification-based bio-hydrogen plants with CCS in British Columbia, Canada. They have chosen CFB gasifiers from SunGas Renewables, which are as previously mentioned based on GTI's U-Gas® technology. For the synthesis gas upgrading, H2Naturally are using conventional water gas shift catalyst and amine absorption.[6]

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[5] Lundgren J., Vreugdenhil, B., Ganjkhanlou, Y., Blanco-Sanchez P., Baldwin RM. 2024. *Biomass gasification for hydrogen production – State-of-the art technology*. IEA Bioenergy Task 33

[6] Robinson T. 2024. CANADA Country Update. IEA Bioenergy Task 33 meeting, Karlsruhe, 2024.

- *Mote (US)*

The US company Mote was awarded funding to deploy a first-of- a-kind (FOAK) biomass gasification facility for hydrogen production with integrated carbon capture and geological sequestration as illustrated in Figure 4. Annually, the project will process at least 300 000 tons of wood waste producing more than 20 000 tons of hydrogen for use in transportation and energy storage and geologically sequester more than 450 000 tons of CO2. The gasification technology is an oxygen-blown, fluidized bed.[7]

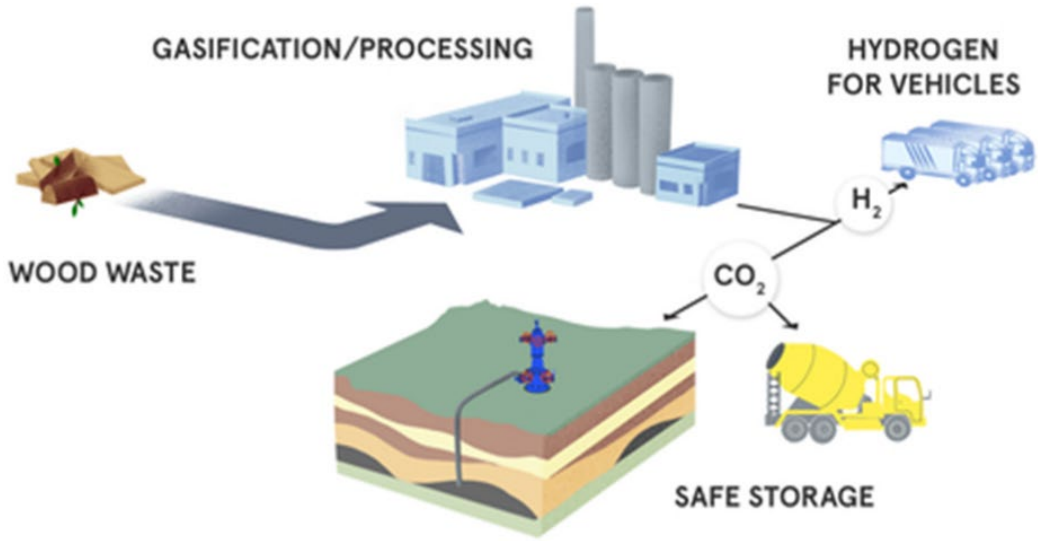

Figure 4: Mote's carbon-negative hydrogen solution based on biomass gasification and CCS

Selected Initiatives in Asia

- *Indian Institute of Science (IIS) & Indian Oil*

IIS has in collaboration with Indian Oil demonstrated the production of fuel-cell quality biohydrogen produced in a small-scale woody-biomass gasifier and Vacuum Pressure Swing Absorption (vPSA). The production capacity is 5 kg of hydrogen per hour and an average yield of 100-105 g hydrogen per dry kg biomass was reported. The hydrogen recovery in the vPSA was in the range of 70-72 %. The fuel-cell system was operated in more than 250 hours using the produced biohydrogen. A scaled-up plant to 2 tons of hydrogen per day is planned at one of the Indian Oil refineries.[8]

[7] https://www.motehydrogen.com/

[8] Mohana R. Badhe R. INDIA Country Update. IEA Bioenergy Task 33 meeting, Karlsruhe, June 2024.

Selected initiatives in Europe

- *Novéa (France)*

The French engineering company Novéa has announced plans to develop local hydrogen production units based on industrial pyro-gasification. The first demonstration project, called *Cappyro H2*, started operation in November 2024. It will be progressively optimized through iterative testing with a pilot and the demonstrator itself, rather than a single test phase. This project will take place over a period of 64 months in two main phases. The first phase, lasting 20 months, will focus on construction, commissioning, and hydrogen production from the demonstrator, including extensive testing and optimization of the process with different types of feedstocks. The second phase will involve the construction of a full-scale industrial unit. Several sites are planned in Nouvelle-Aquitaine, with a particular focus on rural areas and the valorisation of local resources.

The main objective of the Novéa project is to develop decentralized green gas production units to strengthen energy autonomy at the local level. The process is designed to be flexible and consists of four main steps, including the treatment of incoming organic matter and a pyrolysis stage followed by gasification. The project will be carried out in collaboration with local authorities, farmers, and other territorial stakeholders to ensure its success.

Figure 5 : Demonstrator "Cappyro H2" of Novéa's sustainable gas production plant, located in Le Barp[9]

[9] https://www.sudouest.fr/economie/avec-novea-jean-paul-cales-parie-sur-les-usines-a-gaz-verts-et-locaux-23136173.php

- *Haffner Energy (France)*

The French technology provider Haffner Energy has announced plans to establish three biohydrogen producing plants in Europe, one in Gloveller in Switzerland, one in Alkmaar in the Netherlands and one in Montbélliard in France. The first two will have a production capacity of 720 kg per day of hydrogen with planned start of operation in the year 2026, while the third plant in France may become a bit larger, above 1000 kg of hydrogen per day with planned start-up in the beginning of 2027.[10]

- *Torrgas Technology BV (the Netherlands)*

The Dutch company Torrgas Technology BV provides a concept for converting torrefied biomass residues in a patented two-stage gasification technology for production of biochar, tar, and nitrogen-free syngas for production of hydrogen (as well as other green commodities like methanol and SNG), see Figure 6. A 50 MW demonstration plant is being planned on the Brightlands Chemelot Campus in the Netherlands to produce hydrogen by gasifying torrefied biomass, based on technology developed by Torrgas (project BrigH2).

HyCarb is a development company owned by Torrgas that presently is planning a similar plant at the Brightlands Chemelot, but with a plant capacity of 100 MW_{th} gasification input and its own on-site torrefaction plant. The feedstock comes from residual flows such as demolition wood and prunings. The plant production capacity is approximately 15,000 tons of green hydrogen annually. Figure 6 shows an illustration of the planned plant.[11]

Figure 6: Illustration of the planned HyCarb-plant[12]

[10] Nait Saidi C. 2024. FRANCE Country Report. IEA Bioenergy Task 33 meeting, Sao Paulo, 2024.

[11] https://www.torrgas.nl/

[12] https://www.processcontrol.nl/

- *BtX energy GmbH (GER) (BtX energy, 2024)*

In a joint project in between A.H.T. Syngas Technology N.V. and BtX energy GmbH, a container system for decentralized production of hydrogen from pelletized biogenic residues will be developed.

Figure 7: Picture of the BtX Energy test facility

The project is based on the gasification technology provided by BtX energy and the technology of Ferro-Hy-Tunnel (FHT) for the separation of pure hydrogen from mixed gases. The latter has been tested in laboratory scale but has not yet been applied in larger scale.

The project aims to maximise the hydrogen yield with a high purity from pelletised waste wood. Depending on the gas quality, one kilogram of pure hydrogen can then be obtained from 12 – 15 kg of wood. The project has a total budget of €630,800.[13]

- *Advanced Biofuel Solutions Ltd (UK)*

The ABSL gasification plant in Swindon, UK, converts household waste into bio-substitute natural gas (BioSNG) that is injected into the local gas grid. In this plant, a slipstream of syngas was taken after the WGS and further purified in a PSA (Xebec) to meet the specification for proton electron membrane (PEM) fuel cells.[14]

[13] https://btx-energy.de/projekte/bidrogen/

[14] Blanco-Sanchez P. 2023. UK Country Update. IEA Bioenergy Task 33 meeting, Lyon, October 2023.

Subtask: Gasification for production of substitute natural gas

(by Berend Vreugdenhil, TNO)

Natural gas plays a major role in global energy, accounting for about 22 % of total energy production and imports in 2020 (IEA data). However, synthetic natural gas (SNG), also called biomethane or renewable natural gas, offers a sustainable alternative derived from biogenic carbon.

SNG can be produced through three main pathways:

1. Anaerobic digestion of wet biomass with biogas upgrading.
2. Gasification of various feedstocks, followed by gas cleaning, conditioning, and catalysis to maximize methane output.
3. Synthetic production from captured CO_2 combined with renewable hydrogen.

Gasification is particularly flexible, allowing diverse feedstocks - such as forest residues, agricultural waste, or municipal solid waste - to be converted into SNG. Key steps include thorough gas cleaning to remove impurities like tar, sulphur, and particulates, which are critical for reliable methanation.

Two commercial methanation technologies illustrate these processes: Wood PLC's **VESTA**, optimized for low-temperature gasification product gas, and Topsoe's **TREMP**, designed for high-temperature syngas conversion. Both use catalytic reactors with careful gas composition control to efficiently convert cleaned gas into pipeline-quality methane.

SNG production offers important benefits:

- Energy security through local feedstock uses and supply diversification.
- Negative carbon footprint potential, especially when biochar is co-produced and sequestered.
- Grid flexibility by acting as an energy buffer when paired with renewable hydrogen.
- Versatility, since the gasification platform can be adapted for fuels, chemicals, or hydrogen production.

Europe aims for 35 billion m^3 of SNG by 2030, with countries like the Netherlands already setting blending mandates. With ongoing technological advances and growing market demand, biomass gasification-based SNG is becoming a key component in the transition to renewable, low-carbon energy systems.

Subtask: Gasification for fuels production

(by Sabine Fleck, KIT)

First-generation biofuels are produced mainly from sugar or starch crops (e.g., wheat straw, corn stover) (ethanol) and oilseeds (biodiesel).

Second-generation biofuel technologies have been developed to utilize the whole plant as well as biogenic residues, expanding the volume and variety of sources available for biofuel production. Municipal waste and waste products from agriculture, forestry, and manufacturing industries, as well as new energy crops such as fast-growing trees and grass, can potentially be used, reducing land competition with food and feed production.

Gasification is an efficient technology to produce second-generation biofuels. The gasification process converts biomass or waste into a gaseous chemical energy carrier, the synthesis gas, which can be further used for synthesis of a variety of fuels such as synthetic long-chain hydrocarbons like Fischer-Tropsch (FT) diesel, gasoline, and kerosene or oxygenates like methanol, ethanol, and dimethyl ether (DME). The production of biomethane (SNG) (Subtask 2.2), hydrogen (Subtask 2.5), and chemicals (Subtask 2.4) via gasification are dealt with in other subtasks.[15]

Production Pathways

The main process steps to produce fuels from biogenic and anthropogenic waste streams are pretreatment, gasification, gas cleaning, conditioning, and the synthesis to biofuels. A wide range of carbon-containing feedstock from dry biomass to mixed waste streams can be used, which undergo a physical pretreatment in a first step, whereby the feedstock is dried and grinded. Fluidized bed or Entrained Flow Gasifiers (EFGs) are especially suitable to produce biofuels, converting the fuel to syngas at temperatures ranging from 800–900°C for fluidized bed gasifiers and up to 1,200 °C for EFGs. Only the EFG is operated under pressurized conditions. Air, oxygen, or steam is used as the gasification agent. Fluidized bed gasifiers can be operated with solid feedstock in the size range up to 50 mm, such as wood chips. EFGs require solid feedstock pulverized to a size below 200 µm, but they can also be operated with liquid or suspension fuels produced from the original feedstock by pyrolysis. Depending on feedstock composition and operating conditions, varying amounts of undesirable by-products like methane, higher hydrocarbons, tar, soot, H_2S, and HCl are formed in addition to the main syngas components CO, CO_2, and H_2. If air is used as the gasification agent, the syngas also contains nitrogen.

For an efficient synthesis process, the syngas must fulfil several requirements. Most synthesis processes require an H_2:CO ratio of 2, which can be adjusted in a separate catalytic reactor, shifting some CO to H_2 by the WGS reaction. The concentration of inert gases like nitrogen should be as low as possible, as they reduce the partial pressure and thus conversion. Methane and higher hydrocarbons are also normally inert in the synthesis reactor. However, even in low concentrations they reduce the overall conversion from the feedstock to the final product. These species are mainly produced in fluidized bed gasifiers and are generally converted to H_2 and CO in an additional reformer. Species containing sulphur act as a catalyst poison and thus must be removed to very low levels.[16]

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[15] R. Rauch, J. Hrbek, and H. Hofbauer. 2013. "Biomass gasification for synthesis gas production and applications of the syngas." *WIREs Energy and Environment* 3 (4).
[16] D. Chafia. 2022. "High Quality Syngas from Non-Recyclable Waste: A Pilot-Scale Study

The purified and conditioned syngas consisting of CO and H_2 can be converted to liquid hydrocarbons applying FT synthesis. By adjusting temperature, the product can be shifted from a higher fraction of higher-boiling hydrocarbons (above 360°C) to products with shorter chains and methane, olefin, and aromatic production. Conversion rates and formation of the desired long-chained alkanes can also be improved by increasing the pressure. Methanol can be produced from the syngas by hydrogenation of CO applying a suitable catalyst. Gasoline, olefins, or DME can be produced from methanol, and DME can replace fossil gasoline or diesel fuels.

Opportunities

After passenger transport has been fully electrified, there will remain a large demand for molecule-bound fuels for aviation, shipping, and long-distance truck transport, as well as the stock fleet of older vehicles with combustion engines. For these applications, a fuel with high energy density is mandatory.

The syngas produced by gasification also contains CO_2, which can be captured and either stored (i.e., carbon capture and storage [CCS]) or used in chemical processes to produce materials (i.e., carbon capture and utilization [CCU]). Thus, by avoiding emission of CO_2 to the atmosphere, bioenergy with CCS or CCU contributes to reduce the carbon footprint of the process. Integrating the gasification process into chemical production sites enhances the efficiency of the process, as synergies between the different plants can be directly used. Carbon efficiency can be increased by adding green hydrogen produced by electrolysis, shifting the water–gas equilibrium to CO and H_2O.

Current Commercial Developments

The following sections summarize projects and plants in operation, on hold and planned, or under construction. There are multiple processes in operation, of which eight apply fluidized bed gasifiers and four entrained flow gasifiers. Four processes are under construction or planned.

Operational Processes

- ***Entrained Flow Gasification***

BioTfueL (France) (technology readiness level (TRL 7–8) developed an innovative process for converting lignocellulosic biomass into biofuel. The raw biomass first undergoes a pretreatment step (drying and torrefaction), which is demonstrated at Avril's Venette site in northern France. After grinding the biomass is fed to a PRENFLO® direct quench gasifier. The produced syngas is then cleaned to remove gaseous impurities by solvent and catalytic processes, and H_2/CO ratio is adjusted for the FT synthesis. Afterward, biodiesel and biojet fuels are produced using GASEL® technology—a combination of FT synthesis, hydrotreatment and hydrocracking. Gasification, purification, and synthesis demonstration units are situated at TotalEnergies Etablissement des Flandres near Dunkirk (north France). The project finished in 2021, and the process chain is now industrial and commercialized.

The bioliq® plant (KIT, Germany, Karlsruhe) (TRL 6–7) operated at KIT consists of the complete process steps to convert dry lignocellulosic residues into customized fuels. A 5-MW high-pressure slagging entrained gasifier is operated at 40 to 80 bar with biosyncrude, a suspension of pyrolysis oil and char produced by fast pyrolysis. The produced syngas is cleaned

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Based on HTW 2.0 Gasification Technology." Presentation at TC biomass, 2022.

from particles and gaseous by- products like HCl and H_2S via hot gas cleaning. After CO_2 and water separation, the purified syngas is first converted to DME and then to gasoline. The gasifier has been operated for more than 2,300 hours in test campaigns feeding model and technical fuel suspensions.

LTU Green Fuels Pitea (Sweden, CHEMREC) (TRL 6–7)

In Pitea, Sweden, a 3-MW high-pressure refractory-lined EFG was operated for more than 25,000 hours using Kraft black liquor as feedstock. The produced syngas is first cooled down in a quench, where droplets and particles are separated, and then purified from H_2S. The clean gas is either used as fuel or further synthesized to DME.

- ***Fluidized Bed Gasification***

In the **Advanced methanol Amsterdam project (Gidara Energy, Netherlands, (TRL 8))**, a high-temperature Winkler (HTW) 2.0 gasifier produces syngas from non-recyclable pelletized waste, which is currently landfilled or incinerated. The syngas is partly synthesized to methanol used for fuel blending. The CO_2 produced during gasification is separated from the syngas and fed to greenhouses. The plant has been in operation since 2021, and production capacity averages 87,500 t of methanol per year. A second plant will be built at Rotterdam starting in 2025, which will produce 90,000 t methanol/year.[16]

Waste2Value (Austria, Vienna, BEST) (TRL 6–7)

Within the project **Waste2Value (TRL 6-7)** a plant demonstrating the conversion of waste materials into eco-friendly and carbon-neutral fuels is under construction and startup. At the site of a hazardous waste incineration plant in the urban area of Vienna, Bioenergy and Sustainable Technologies (BEST) will operate a novel process chain to generate and utilize a hydrogen-rich synthesis gas on an industrial scale. The plant was built by the SMS Group. Biogenic residues and waste are converted to syngas in a 1-MW pilot fluidized bed gasifier. After syngas cleaning and conditioning, fuels are produced via FT synthesis.[17]

Processes Under Construction or Planned, all TRL 8–9

Ametis/LanzaTech has worked to develop commercialization of biomass-derived syngas fermentation based on the Sekisui (Japan) gasifier. More information is provided in Section V: Biomass and Waste Gasification to produce Chemicals.

In the process developed by **JV controlled by ENI (NextChem)**, waste is fed to a high temperature melting gasifier. The ash fraction is collected as inert granulate. The producer gas is cleaned, purified, conditioned, and finally synthesized to methanol.

Within the process planned by **Värmlandsmetanol AB** forest residues will first be chipped, dried, and pelletized. The wood pellets will then be converted to syngas in an HTW gasifier under pressurized conditions with oxygen as the gasification medium. After purification and adjusting the CO-to-H_2 ratio, fuel-grade biomethanol will be synthesized.

[17] https://www.best-research.eu/en/competence_areas/all_projects/view/611

Subtask: Gasification for chemicals production

(by Robert Baldwin, NREL)

Production of renewable chemicals from biomass-derived syngas is a technology pathway that is just now emerging as a result of world-wide efforts to decarbonize the chemicals industry. Many opportunities exist, including:

- **Ethanol**: produced through syngas fermentation, a hybrid thermochemical/biochemical process
- **Hydrogen**: one of the most important industrial chemicals
- **Fischer-Tropsch Liquids**: Including hydrocarbons and oxygenates
- **Methanol**: widely used industrial chemical
- **Acetic acid**: important basic platform chemical
- **Long-chain fatty acids and higher alcohols**: Including caproic acid, butanol, hexanol, and 1,2-butanediol.
- **Mixed alcohols**: C1 and C2 alcohol mixture from thermochemical conversion of syngas
- **Olefins**: ethylene and propylene from renewable methanol
- **Aldehydes and oxo-synthesis products**: tremendous potential to pivot to biomass-derived syngas

Low-carbon chemicals from biomass-derived syngas

An opportunity exists for developing a new paradigm for production of chemicals with low carbon intensity (CI) from syngas. This involves switching to a renewable carbon source - such as biomass - and employing carbon capture, utilization, and storage (CCUS) to greatly reduce or even eliminate GHG emissions. A general schematic showing biomass gasification coupled with CCUS for production of low-carbon chemicals is shown in Figure 8. Capture and either sequestration or recycle/re-use of CO2 enables this transition from our current high CI chemicals to low/zero/negative CI chemicals produced from renewable resources.

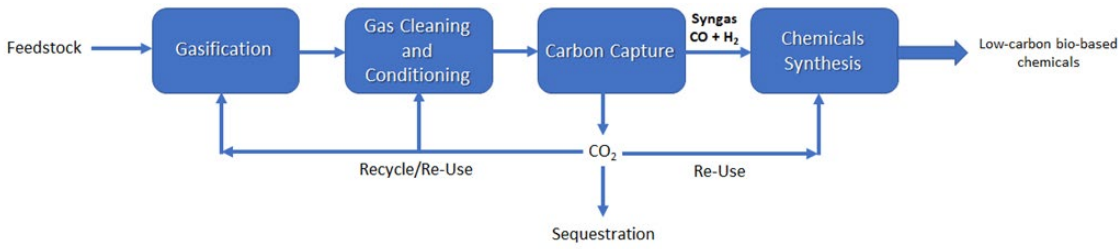

Figure 8: Production of low-carbon bio-based chemicals from biomass.

Selected Initiatives

- *Enerkem (Canada)*

Enerkem is a Canadian company that is commercializing production of bio-methanol and bioethanol from gasification of biomass and municipal solid waste. Enerkem is currently planning to open a facility in Varennes, Canada which employs Enerkem's innovative process, coupled with one of the world's largest PEM electrolysers, to produce 125M litres per year of bio-methanol and bioethanol from non-recyclable waste and residual biomass.

- *Braskem (Brazil)*

Braskem is a Brazilian petrochemical company that operates the world's first large-scale green ethylene plant, producing 200,000 tons per year of bioethylene from sugarcane ethanol. Ethylene is produced by dehydration of ethanol at Braskem's Triunfo Petrochemical Complex, in Triunfo, Rio Grande do Sul, Brazil.

- *LanzaTech (Japan)*

LanzaTech has worked to develop commercialization of biomass-derived syngas fermentation based on the Sekisui (Japan) gasifier to produce ethanol and other specialty chemicals (2,3-butanediol, acetone). As of 2022, several major commercialization projects have been announced using gasification from a variety of different technology providers.

- *Synova/TNO/Tecnip*

Synova and Technip Energies recently announced that they had entered into a joint development and cooperation agreement to commercialize Synova's advanced plastic waste-to-olefins technology, in conjunction with Technip Energies' steam cracking technology. Synova's patented thermochemical recycling technology is based on the Milena gasifier and takes mixed plastic waste and breaks it down to olefin monomers and co-products to produce circular plastics. The technology was invented by the Netherlands Organization for Applied Scientific Research (TNO).

STATUS OF THERMOCHEMICAL GASIFICATION OF BIOMASS AND WASTE: CURRENT TRENDS AND FUTURE PROSPECTS

This chapter provides an updated overview of gasification as of March 2025 in Europe, the USA, Canada, China, and India. Gasification technology has advanced notably across these regions, each showing distinct trends in biofuel production, hydrogen generation, biochemical applications, and integrated carbon management. Thermochemical gasification is a flexible and efficient process that converts biomass and other carbon-rich feedstocks into valuable products such as biofuels, hydrogen, synthetic natural gas (SNG), and biochemicals. It also plays a key role in Bioenergy with Carbon Capture, Utilization, and Storage (BECCUS) technologies, enabling significant carbon reduction or even negative emissions. This report aims to summarize the status of biomass and waste gasification within IEA Bioenergy Task 33-member countries, focusing on pilot, demonstration, commercial-scale facilities, and upcoming projects.

EUROPE

Small scale combined heat and power facilities are well established in Europe. There are about 1700 facilities currently in operation. The bulk of facilities are in Germany, Italy, and Austria. The reference facilities are listed in the IEA Bioenergy Task 33 database[18].

Although biomass and waste gasification technologies for CHP are well-established, they continue to evolve. One of the most promising developments is the increasing focus on co-producing biochar. Biochar's growing applications, particularly in agriculture, construction, and water filtration, offer new revenue streams and enhanced economic viability of gasification plants. By utilizing biochar, plants can improve their CAPEX and OPEX efficiency, adding value to the overall process. Biochar applications as a long-term storage medium reduce carbon emissions to the atmosphere. This makes gasification even more sustainable and cost-effective.

Europe is also home to numerous larger scale gasification facilities and projects. These are often aimed at the production of renewable biofuels and chemicals or the direct displacement of fossil fuel at existing industrial facilities. This aligns with the European Green Deal's goal of climate neutrality by 2050 and a 55 % emissions reduction by 2030.[19] Advanced biofuels and biochemicals from gasification can play a crucial role in sectors like transportation and industry while promoting a circular economy and reducing dependence on fossil-based products.

Status of selected gasification plants in Europe

- *Gaya (France)*

The Gaya platform for SNG production was a key project demonstrating the technical, economic, and environmental viability of producing bio-SNG through gasification. With the collaboration of 11 partners, the project covered the entire process chain. The facility was operational since 2018 and able to generate up to 0.5 MW of SNG, despite meeting specifications the produced gas was not injected into the grid due to regulatory barriers.[20]

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[18] https://task33.ieabioenergy.com/database/
[19] https://eur-lex.europa.eu/resource.html?uri=cellar:b828d165-1c22-11ea-8c1f-01aa75ed71a1.0002.02/DOC_1&format=PDF
[20] https://www.engie.com/en/news/gaya-energy-waste-gas-renewable

- *Salamandre (France)*

The Salamandre project was developed to scale up and commercialize the technology that was successfully demonstrated by GAYA. The aim was to convert 70,000 tonnes/year of non-recyclable waste to SNG for grid injection or to liquified SNG to serve as a fuel for the trucking or maritime applications. Expected output was 170 GWh/year of SNG or 11,000 tonnes/year of liquefied SNG. The project would have been capable of delivering 40 GWh/year of renewable heat to local networks. Both the Gaya and Salamandre projects were halted in 2025 for economic reasons.

- *BioTfuel® (France)*

In France, the BioTfueL® project has attracted significant attention[21] for demonstrating the conversion of lignocellulosic biomass into biofuels in a pressurised entrained flow gasification. The process begins with a pretreatment stage, where raw biomass is dried and torrefied at Avril's Venette site in northern France. After grinding, the torrefied biomass is fed into a PRENFLO® direct quench gasifier, which converts it into gas. To produces syngas, the gas is cleaned of impurities through solvent and catalytic processes, with the H_2/CO ratio adjusted to optimize it for Fischer-Tropsch (FT) synthesis. The resulting products include biodiesel and biojet fuels, produced using GASEL® technology – a combination of FT synthesis, hydrotreatment, and hydrocracking. Demonstration units for gasification, purification, and synthesis are located at TotalEnergies' Etablissement des Flandres facility near Dunkirk, further showcasing the project's industrial scale. The BioTfueL® project, completed in 2021, has demonstrated the entire process chain, which is now fully industrialized and commercialized.

- *BioTJet (France)*

The BioTJet project was launched in 2022. The board consists of Elyse Energy, Avril, Axens, Bionext, and IFP Investissements (the investment arm of IFP Energies Nouvelles). Two thirds of the capital is held by IFP, and the remainder is divided equally among the other partners. The project aims to build on the success of the BioTfueL project, by constructing and operating Europe's largest gasification-based sustainable aviation fuel (SAF) facility. The project combines biomass gasification with hydrogen produced by electrolysis and aims to produce 75,000 tonnes/year of e-biokerosene, which is equivalent to 30 % of the annual fuel consumption at the Mérignac Airport in Bordeaux. In addition to aviation fuel the project expects to co-produce other fuel components for transportation and shipping. The latest news[22] are from the 20th of March and inform about the selected technology.[23]

- *ABSL (UK)*

In the UK, the ABSL plant in Swindon located in the Protos energy park near Ellesmere Port, Cheshire. has been operating a substantial demonstration facility. The plant was designed to process 8,000 tonnes of waste annually, producing 22 GWh per year of SNG (2.2 million Nm^3) while capturing 6,000 tonnes of CO_2. The waste was first fed into an oxy-steam fluidized bed

[21] https://elyse.energy/en/our-projects/biotjet
[22] https://www.bioenergy-news.com/news/elyse-energy-selects-biotfuel-technology-for-waste-wood-to-saf-project/
[23] https://elyse.energy/en/our-projects/biotjet

gasifier, generating producer gas. The producer gas was processed in a plasma reformer to convert tars and melt ashes. The carbon dioxide was liquefied for industrial use, and 400 tonnes of vitrified ash was used as an aggregate. The plant has been fully operational since 2024. After 15 years of development, ABSL is ending its activities. The Swindon demonstration plant, designed to develop the skills required for operation, failed to secure the necessary funding for its completion despite more than £75M invested.

- *KEW (UK)*

The KEW Plant in Wednesbury, UK, has demonstrated a complete waste (MSW) to X pathway. Its pressurized (7bar) bubbling fluidized bed gasifier was designed to process 15,000 tonnes/year MSW into dimethyl ether (DME), hydrogen, or electricity.

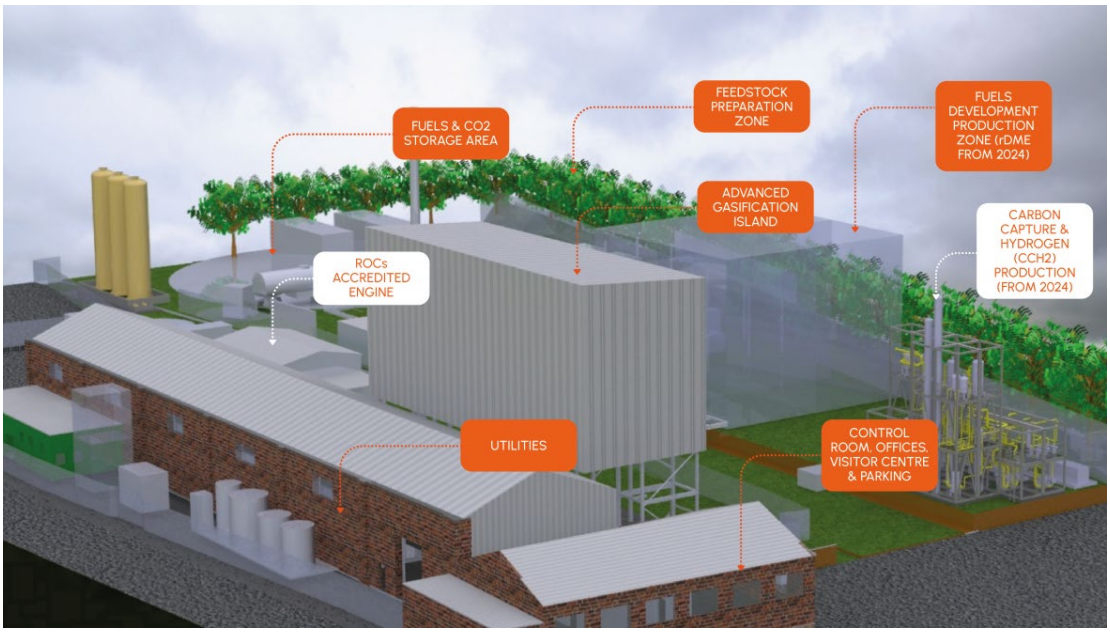

Figure 9: KEW plant[24]

Figure 9 outlines the process, which proceeds through feed preparation, gasification, gas cleaning and conditioning. Once the gas is cleaned and conditioned it may be converted to hydrogen or DME via catalytic processes. It may also be converted to electricity in a gas engine.[25] Nowadays, KEW Technology is facing financial difficulties. The company is under administration, and its sustainable energy centre is up for sale. Initially intended for commercial deployment, the £35 million Wednesbury gasification plant is now being marketed by Hilco after incurring losses.[26]

[24] https://kew-tech.com/our-commercial-plant/
[25] https://kew-tech.com/our-commercial-plant/
[26] https://www.endswasteandbioenergy.com/article/1907825/kew-hits-financial-woes-stalled-waste-gasification-project-put-sale

- *MEVA Energy (Sweden)*

The Swedish gasification company MEVA Energy[27] has installed a gasification plant for production of renewable gas replacing fossil LPG for tissue drying at Sofidel mill in Kisa, Sweden. The entrained flow cyclone gasifier converts 1300 kg/hour of wood pellets into a gas that is used to displace liquified petroleum gas from a tissue drying process. This installation produces biochar as a co-product. A recent study has concluded that with co-production of biochar this facility can produce net negative emissions, so long as the biochar is utilized in an application where it is permanently sequestered. The Kisa plant has been operating since 2024.

- *Biorefinery Östrand (Sweden)*

The production of Sustainable Aviation Fuel (SAF) and naptha is also the primary goal of the **Biorefinery Östrand** project in Sweden. In this project, hydrogen produced via water electrolysis is added to the syngas generated from gasification, effectively doubling the final SAF output. The entire technology process is planned to be integrated into an existing pulp mill plant, optimizing both resource use and efficiency.

This gas is then cleaned and conditioned before hydrogen is added to enhance the SAF-production. This integration not only maximizes SAF production but also advances the transition to cleaner, more sustainable energy solutions in the aviation sector. By combining electrolysis-based hydrogen production with biomass gasification, the project optimizes the use of renewable resources in a circular economy framework. Anyway, which gasification technology, especially a reactor design will be employed was not decided yet.

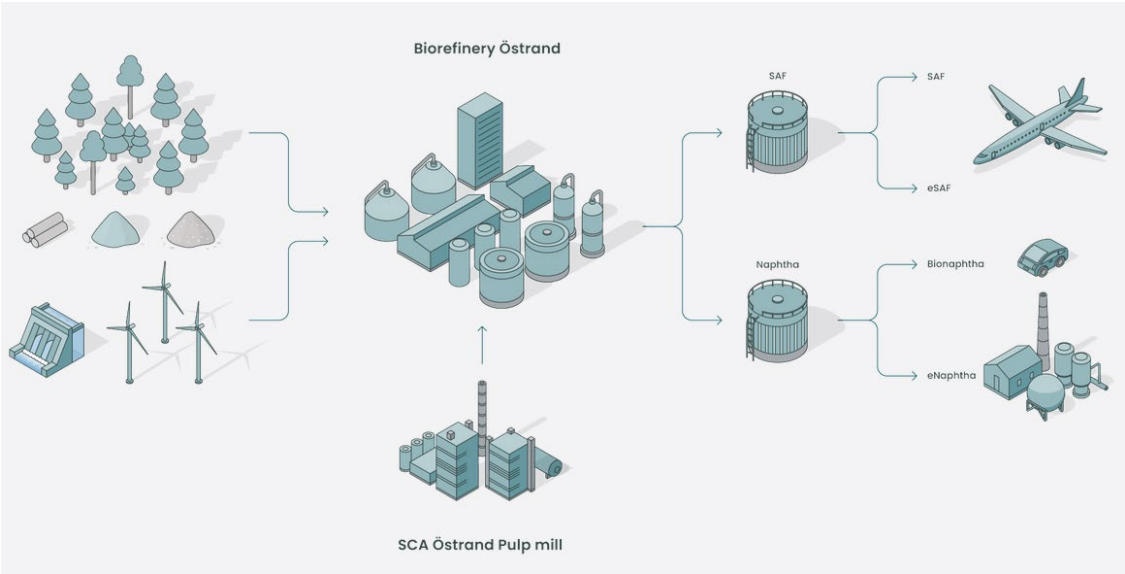

Figure 10: Biorefinery Östrand, Sweden[28]

[27] https://mevaenergy.com/
[28] https://www.biorefineryostrand.com/en/about-us/from-forest-to-future/

- *FUREC (Netherlands)*

While a few projects in Europe have been targeting the production of e-biofuels by combining gasification, FT synthesis, and electrolysis other projects aim to produce renewable hydrogen from biomass gasification.

One example is the FUREC-project, (FUse REuse reCycle), in which hydrogen will be produced via gasification of municipal solid waste (MSW) in Limburg (Netherlands). The idea is that the company RWE uses non-recyclable municipal residual waste to produce renewable and circular hydrogen (about 50 % renewable and 50 % circular) (54 000 t/y) and carbon. The intention is to use the hydrogen and carbon in chemical plants at the Chemelot industrial park, thus reducing their consumption of natural gas by 280 Nm3/year.

Figure 11: Project FUREC[29]

- *Bioliq® (Germany)*

Another European key project is the Bioliq® demonstration facility, at KIT in Karlsruhe, Germany, which ceased operations at the end of 2024. The concept behind Bioliq® was the decentralized pre-treatment of biomass to create a high-energy-density intermediate carrier, known as bioliq-Syncrude, which could be economically transported over long distances to supply an industrial-scale plant for synthetic fuel production. Using chemical synthesis, the facility aimed to produce fuels that could either be used as drop-in fuels or as standalone products fully compatible with existing diesel or gasoline systems. The process could utilize nearly any type of dry biomass, with a particular focus on by-products and residues from agriculture, forestry, or landscaping. The core of the process was a pressurized entrained flow

[29] https://www.rwe.com/en/research-and-development/hydrogen-projects/furec/

(EF) gasifier, operating at high temperatures (1200°C) and pressures (40–80 bar), with an input capacity of 5 MW (1 ton/hour) of syncrude. The cleaned gas produced from the gasification process was then converted to dimethyl ether (DME), demonstrating the potential for advanced biofuels to support sustainable energy transitions. The Bioliq® facility operated from 2014 until its closure at the end of 2024. During this time, it tested various feedstocks under different process conditions and successfully demonstrated the technical feasibility of the process. Now no further projects based on experience with Bioliq® are planned in Germany.

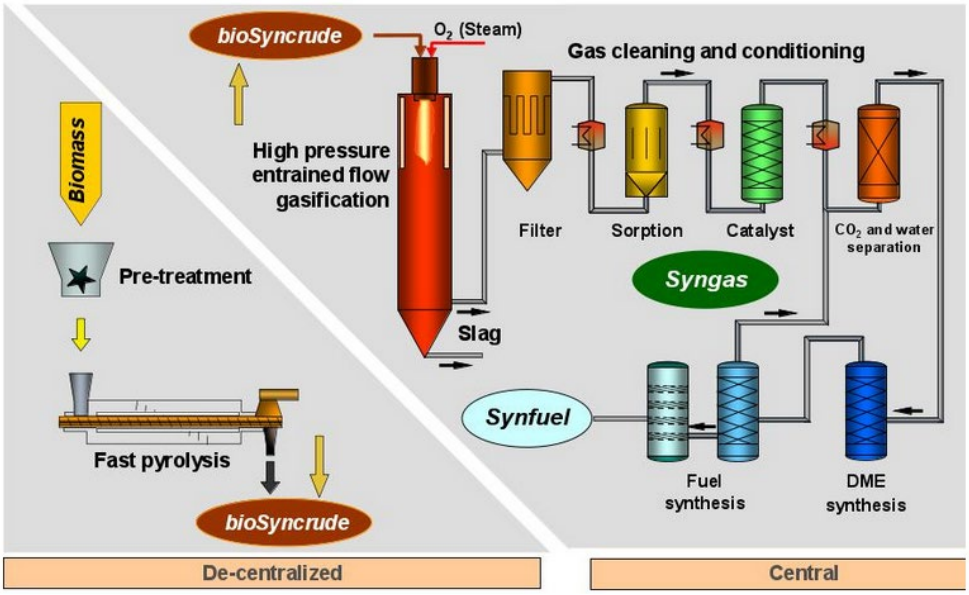

Figure 12: Bioliq® process chain

Figure 13: Photo of the Bioliq® plant[30]

[30] https://www.bioliq.de/english/index.php

- *Enerkem (Netherlands)*

Enerkem, a Canadian company, has been working on a potential project at the port of Rotterdam for several years. The project was originally termed waste-to-chemistry. The planned facility would use Enerkem's fluid bed gasification technology to convert mixed and non-recyclable plastic wastes to new raw materials. In June 2021, the project proponents announced a strategic shift towards producing sustainable aviation fuel at the facility utilizing a proprietary FT technology provided by Shell. In 2024, Shell paused the project citing technical difficulties. The nature of those technical difficulties is unclear. Shell has also recently cancelled an SAF project in Singapore. The project in Singapore was not based on gasification and appears to have been shuttered due to a lack of regulation supporting SAF (Argus Media 31/03/23).

- *Enerkem (Spain)*

Enerkem along with Repsol has also been developing the Ecoplanta project in Tarragona, Spain. The project titled Ecoplanta will be the first plant in Spain to produce circular methanol from treated urban waste that comes mainly from the surrounding ecoparks.

The project targets the conversion of up to 400,000 tonnes/year of MSW into renewable methanol. The project refers to both renewable and circular methanol. Methanol resulting from conversion of the biogenic component of the MSW is renewable, while the methanol that results from the petrogenic component of the waste would be circular. In practice the different components of the MSW would not be separated and the renewability or circularity of the methanol would be determined by analysis of carbon isotopes.

The future plant in Spain will have a treatment capacity of about 363,000 metric tonnes of MSW and will generate up to 237,000 metric tonnes of methanol.[31, 32]

NORTH AMERICA (Canada and US)

- *Enerkem (Canada)*

Enerkem is a Canadian gasification technology developer. **Enerkem Alberta Biofuels**, a partnership between Enerkem, Alberta Innovates, the city of Edmonton, and the Alberta government, had operated a 40,000 tonnes per year waste-to-alcohol facility in Edmonton, Alberta since 2014. This facility was the world's first to obtain International Sustainability and Carbon Certification (ISCC), allowing it to export its bio-methanol to Europe. The facility was also the first waste-to-biofuel plant to receive approval to sell ethanol under the US EPA's renewable fuel standard.

The Edmonton facility was equipped to produce both ethanol and methanol. Initial operations demonstrated the company's ethanol production process, but after proving their ability to meet EPA standards, they shifted their focus to producing ISCC certified methanol for the European

[31] https://www.repsol.com/en/press-room/press-releases/2025/repsol-will-invest-more-than-800-million-ecoplant/index.cshtml
[32] https://www.ecoplanta.net/?lang=en

market. In 2023, the facility received ISCC+ certification, reaffirming its dedication to sustainable practices. During operation from 2014 to 2024, the facility ran for over 15,000 hours and produced five million liters of biofuels.[33] In January 2024, Enerkem announced the closure of the Edmonton facility, stating that it had achieved its goal of completing commercial scale-up of Enerkem's technology.

Enerkem had been building a larger facility in Varennes, Quebec, drawing on its extensive knowledge and experience from Edmonton. **Recyclage Carbone Varennes** is a joint venture involving Shell, Suncor, Proman, and the governments of Canada and Quebec. The heart of the project was to be a bubbling fluidized bed gasifier coupled to one of the world's largest PEM electrolyzers. The planned facility was designed to convert 200,000 tonnes per year of non-recyclable waste and residual biomass into 125 million litres of biofuels and circular chemicals annually, utilizing a 90 MW polymer electrolyte membrane (PEM) electrolyser supplied by Cummins[34]. This would have resulted in an emission reduction of 170,000 tonnes of CO2 equivalents each year.

Construction of the Varennes facility was ongoing until recently, with operations originally planned to commence in 2026. However, in March 2025, it was announced that Recyclage Carbone Quebec was unable to pay creditors and had applied to the courts for creditor protection while seeking approval to search for potential buyers or investors. According to media reports, the biofuels plant is 75 % complete, and the electrolyser is 45 % complete. [35] In its application to the court, the company cited insufficient liquidity, cost overruns, and volatility in the biofuels market to explain its current difficulties. Now, the situation is unresolved, and the fate of the venture and the partially completed facility remain uncertain.

Figure 14: Construction of Enerkem facility in Varennes

[33] https://enerkem.com/projects/edmonton
[34] https://enerkem.com/projects/varennes
[35] https://www.lapresse.ca/affaires/entreprises/2025-03-11/projet-de-1-5-milliard-finance-par-l-etat/recyclage-carbone-varennes-a-l-abri-de-ses-creanciers.php

- *Hydrogen Naturally (Canada)*

Hydrogen Naturally is a Canadian venture founded by Peak Renewables and Northwest Capital, developing biomass-to-hydrogen projects based on gasification of forestry residues coupled with carbon capture and storage (CCS). Northwest Capital brings significant experience with carbon capture and storage through involvement with numerous projects in Alberta, with team members intimately involved in standing up the vacuum bottoms gasification unit at the Sturgeon refinery in Alberta. Peak Renewables is a forestry services company with extensive experience processing residues and making pellets.

The proposed facility is to be situated at the site of a former oriented strand board plant in Fort Nelson. While the company seeks to produce hydrogen, they position themselves as providing carbon removal services, competing with direct air capture (DAC) ventures. The company estimates an input of 600,000 tonnes per year of wood pellets to the first phase of a four-phase facility, to produce 40,000 tonnes of hydrogen per year while permanently removing one million tonnes of CO2 from the atmosphere. [36]

- *SunGas Renewables (USA)*

SunGas Renewables is an American gasification technology provider incorporated in 2019, though development of their gasification technologies stretches back to the 1980s and includes the operation of several substantial gasification facilities converting coal or biomass. They are developing the Beaver Lake Renewable Energy (BLRE) facility in Pineville, Louisiana, on the site of a former International Paper facility. The project entails an investment of over $2 billion and will be operated by Beaver Lake Renewable Energy LLC, a wholly owned subsidiary of SunGas Renewables Inc.

The facility aims to produce 500,000 tonnes per year of green methanol, serving as both marine fuel and chemical feedstock. The project is expected to create over 1,150 construction jobs and more than 100 operational positions.

SunGas is also part of a major Australian development - the $1.4 billion Bell Bay Powerfuels Project in Northern Tasmania, where they have been selected by ABEL Energy to supply their SunGas System 1000™ gasifier technology for a facility expected to produce 300,000 tonnes of green methanol annually starting in 2027.

In May 2024, SunGas Renewables and C2X LLC announced a strategic partnership, including an investment by C2X in convertible preferred stock issued by SunGas, which seeks to accelerate the development of renewable methanol production facilities across North America. They also announced that Johnson Matthey had been selected to provide catalyst technology.[37]

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[36] https://www.canadianbiomassmagazine.ca/fibre-fuel-canadian-company-looks-to-create-hydrogen-from-marginalized-wood/
[37] https://biomassmagazine.com/articles/sungas-renewables-c2x-announce-strategic-partnership

- *Sierra BioFuels (USA)*

Fulcrum BioEnergy's Sierra BioFuels facility was in Sparks, Nevada, about 20 miles east of Reno. Construction began in 2008, with operations commencing in 2022. The plant was designed to consume 170,000 tonnes/year of MSW sourced from nearby landfill facilities to produce 42 million litres of sustainable aviation fuel (SAF) annually, initially employing about 120 people.

The facility employed the FastOx gasification technology originally developed by Sierra Energy with support from the US Department of Defence. As of 2018, the company had licensed the FT CANS technology developed by Johnson Matthey and BP for SAF synthesis. However, the plant faced significant operational difficulties, including media reports of cement - like deposits accumulating in the gasifier and the release of nitric acid on startup. Additionally, issues with undersized boilers and generators led to stop-work orders in March 2024. [38]

After a shutdown in May 2024, the company was unable to restart operations and defaulted on bonds used to finance the project, ultimately filing for Chapter 11 bankruptcy protection in September 2024. In November 2024, a judge approved the sale of Sierra's waste processing facility to Refuse Inc., a subsidiary of WM, located next to WM's Lockwood Regional Landfill. Switch, a data centre operator, bid $15 million for the production facility in Sparks, though it is unclear if this bid has been accepted by the court. The future of the Sierra BioFuels facility remains uncertain, with both Fulcrum and Sierra currently having significant negative net values. [39]

Figure 15: Sierra Biofuels – plant construction activities (May 2022)

[38] https://cen.acs.org/energy/Fulcrum-BioEnergy-abandons-trashfuel-plant/102/web/2024/06
[39] https://www.businesswire.com/news/home/20240918647885/en/Solicitation-for-Bids-of-the-Assets-of-Fulcrum-Sierra-BioFuels-LLC-and-Fulcrum-BioEnergy-Inc.

- *Aemetis (USA)*

Aemetis, based in Cupertino, California, is actively involved in the development of various gasification and biogas projects across the U.S. Their initiatives focus on converting agricultural waste, particularly dairy manure, into renewable natural gas (RNG) and sustainable aviation fuels. In 2017, Aemetis licensed InEnTec's Plasma Enhanced Melter (PEM) gasification technology, originally planning to produce cellulosic ethanol using LanzaTech's syngas-to-ethanol technology. InEnTec was spun out of MIT in 1995, with their plasma gasification technology developed in partnership with PNNL (Battelle) and General Electric, receiving significant funding from the United States Department of Energy. InEnTec has operated several waste management facilities, including a 25 tons per day plant in Arlington, Oregon, in partnership with Waste Management Inc.

Aemetis is also planning a SAF production facility at the site of a former munitions plant in Riverbank, California. The planned facility is designed to produce 90 million gallons annually, split evenly between SAF and renewable diesel, targeting the aviation and trucking markets with low-carbon alternatives to conventional petroleum-based fuels. In September 2022, Aemetis finalized $7 billion in supply contracts, ensuring offtake agreements for the plant's entire production for up to 10 years.[40] As of March 2024, Aemetis had received the permits required to start construction at the Riverbank site, though it remains unclear which specific gasification and syngas conversion technologies will be employed.[41]

- *DG Fuels (USA)*

DG Fuels is actively advancing the development of SAF through integrated FT-synthesis and water electrolysis, with a key feature being the ability to leverage green hydrogen to create more green hydrocarbons from a given amount of feedstock. The company has several significant projects underway, with the most developed being a SAF plant in Louisiana projected to produce 13,000 barrels per day of SAF blend stock.

In April 2024, DG Fuels announced their intention to use the FT CANS technology co-developed by BP and Johnson Matthey at the planned facility in Louisiana. In June 2024, they partnered with NEXTCHEM to license their NX Circular gasification technology for the facility, which is projected to produce up to 450 million litres (approximately 119 million gallons) of SAF annually, utilizing residual biomass and municipal waste as feedstocks. HydrogenPro of Norway was selected to supply at least 839 MW of high-pressure alkaline electrolyser capacity for the planned facility. While originally planned for operation by 2028, more recent reports indicate an investment decision in 2025 with potential production planned for 2030.[42]

In October 2024, DG Fuels also selected Moorhead, Minnesota, for a new SAF production facility serving the Great Lakes region, designed to produce 193 million gallons of SAF per year meeting ASTM fuel standards, with production slated to begin in 2030. These projects appear to be less developed than the Louisiana facility.[43]

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[40] https://www.globenewswire.com/news-release/2022/09/07/2511464/0/en/Aemetis-Finalizes-7-Billion-of-Supply-Contracts-for-100-of-Riverbank-Plant-Production-of-Sustainable-Aviation-Fuel-and-Renewable-Diesel-for-up-to-10-Years.html
[41] https://www.aemetis.com/aemetis-reports-2024-fourth-quarter-and-year-end-results/
[42] https://dgfuels.com/2024/06/26/dg-fuels-and-nextchem-sign-licensing-agreement-for-2028-louisiana-saf-facility/
[43] https://dgfuels.com/2024/10/30/dg-fuels-to-launch-saf-plant-in-moorhead-minnesota-

- *Mote (USA)*

Mote is a climate technology company currently focused on removing carbon from the atmosphere by coupling biomass gasification with carbon capture and sequestration. Their proprietary process involves the conversion of agricultural and forestry residues to hydrogen, with the resulting carbon dioxide captured and stored underground, providing a carbon-negative solution that addresses both clean energy production and climate change mitigation.

Mote is pursuing multiple projects in California. In Kern County, the company is developing a $100 million gasification project to convert agricultural and forestry residues into hydrogen. Mote has selected SunGas Renewables to provide gasification technology and engaged Fluor for preliminary design of this project, which is designed to produce 7,000 tonnes per year of hydrogen while sequestering 140,000 tonnes per year of carbon dioxide. As of 2022, they had completed FEL-2 engineering and were targeting startup sometime in 2025.

In addition to the Kern County project, Mote has announced a second project in Sacramento, developed in partnership with the Sacramento Municipal Utility District (SMUD). This larger project would produce 21,000 tonnes per year of hydrogen and sequester 450,000 tonnes per year of carbon dioxide. Mote has received $1.2 million in grant funding from the US Forest Service, the California Department of Conservation, and the California Department of Forestry for preliminary development of this project. Recently, Mote secured $7 million in Series A funding to accelerate development of their carbon removal technology.

- *Arbor Renewable Gas (USA)*

Arbor Renewable Gas, based in Houston, Texas, was developing a renewable gasoline project at their Spindletop site in Beaumont, Texas. The project aimed to convert wood wastes from the forests of east Texas into 1,000 barrels per day of renewable gasoline. [44, 45] The project was strategically located on a 53-acre site at the border of Beaumont and Nederland, chosen for its access to critical infrastructure, feedstock availability, and community support.

In 2021, it was announced that the **Spindletop** project would utilize the Topsoe Improved Gasoline Synthesis (Tigas) technology to convert synthesis gas to gasoline. However, in 2022, it was announced that SunGas Renewables would supply their System 1000 gasification technology to the Spindletop project instead. The Tigas process had previously been employed in an extensive wood-to-gasoline pilot project conducted at GTI, which utilized Andritz's Carbona fluidized bed technology.[46] However, recent information about the Arbor Renewable Gas project appears limited, with no significant updates found after 2022, raising questions about the status of the development.

Note: In the USA, there were several gasification projects under development till the end of 2024. Anyway, as of March 2025, the United States' energy and technological landscape reflects a complex interplay of policy decisions, industry shifts, and public sentiment. The Trump administration has maintained a strong focus on fossil fuels, aligning with its "America First"

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[44] https://globalenergyinfrastructure.com/news/2021/11-november/arbor-renewable-gas-picks-beaumont-for-renewable-plant-location/

[45] https://www.opportunitylouisiana.gov/news/clean-energy-start-up-reveals-plan-for-800-million-renewable-fuels-facility-in-port-allen

[46] https://www.hydrocarbonprocessing.com/news/2022/10/sungas-renewables-inc-announces-agreement-with-arbor-renewable-gas/

agenda. In January 2025, the administration released an energy policy emphasizing the utilization of America's natural resources to restore prosperity and enhance national security. This policy has led to actions such as a moratorium on offshore wind energy leasing and reduced federal support for renewable infrastructure, aiming to prioritize traditional energy sources.[47, 48] Currently, the future of renewable energy developments in the USA, including the production of biofuels and biochemicals through gasification, appears uncertain. However, we must remain hopeful for a brighter future and trust that many will recognize the urgent need for the transition to renewable energy — not only for ourselves but especially for the well-being of future generations.

ASIA (India and China)

In India, several research institutions, industries and implementing agencies actively involved in development and deployment of biomass gasification during 1990-2010. Since 2010, focus on biomass gasification-based power generation was reduced significantly. Currently, about 10-12 biomass gasifiers manufacturers are active in India.[49]

The Indian Oil Corporation Limited (IOCL) has successfully commissioned India's first second-generation **(2G) ethanol plant** at its Panipat refinery in Haryana. The plant, inaugurated in August 2022, has a production capacity of 100 kilolitres per day (KLPD) of bioethanol, utilizing approximately 200,000 tonnes of paddy straw annually as feedstock. This initiative is a significant step towards achieving India's goal of blending 20 % ethanol with gasoline by 2025, aiming to enhance energy security and reduce carbon emissions.[50] IndianOil's 2G ethanol plant in Panipat uses enzymatic hydrolysis and gasification technology as part of the process to convert agricultural waste, primarily paddy straw, into biofuels. After gasification, the resulting syngas is subjected to further processing.

Figure 16: 2G ethanol plant in Panipat, India.

[47] https://www.whitehouse.gov/presidential-actions/2025/01/unleashing-american-energy/
[48] https://lewisbrisbois.com/newsroom/legal-alerts/trump-administrations-2025-energy-
[49] https://task33.ieabioenergy.com/wp-content/uploads/sites/33/2022/06/India-1.pdf
[50] https://www.icis.com/explore/resources/news/2022/08/11/10794279/indian-oil-commissions-first-2g-ethanol-plant-in-panipat/

Historically, the gasification of coal has been a significant area of development in China, particularly in recent decades as the country has sought to diversify its energy mix and reduce its reliance on imported fuels.

Nowadays, China has significantly advanced its biomass gasification sector, integrating it into national energy strategies to enhance energy security and environmental sustainability. Now, more than 80 large-scale operational biomass gasification plants can be found in China. As a feedstock, agricultural and forestry waste, industrial organic waste, MSW, hazardous waste or biomass-coal mixtures are used. The gasifiers in China are mostly in scale of 500 t/y to 100,000 t/y of input. The gasification facilities are mainly fixed bed and fluidized bed ones.

The reference gasification plants in China, listed in the Table 1 below, highlight the gasification facilities in three different areas of China. Notably, one of the key co-products of these processes is biochar, which has gained significant attention due to its value in various industries.

Table 1: Reference gasification plants in China.

No.	Location	Company	Description
1	Jingmen, Hubei	Debo Bio-energy technology., Ltd.	• **Rice husk** gasification coupled with coal combustion for power generation (10.8 MW). • **CFB** with the feedstock of 8 t/h. • Bio-char is utilized as a fertilizer.
2	Anji, Zhejiang	Debo Bio-energy technology., Ltd.	• **Bamboo** gasification for poly-generation of steam and bio-char. • **CFB** (7 t/h) + steam boiler (10 t/h). • Char is sold for production of activated carbon.
3	Heze, Shandong	Baichuan Tongchuang Energy., Ltd.	• **Chinese medical residue** (as received, 250 t/d) gasification producing heat and steam. • **CFB** (10 t/h) + combustion of syngas + heat recovery boiler • The steam and heat are recycled to medicine production process.
4	Jingning, Zhejiang	Litian Environmental technology., Ltd	• **MSW** gasification • Four **Fixed bed gasifiers** (200 t/d in total) • Gasified gas is combusted and clean treatment of MSW is achieved.

Biomass gasification is being utilized to produce syngas, which can then be used to generate electricity in gas turbines or internal combustion engines (CHP). This is particularly important for rural areas where agricultural residues (such as straw, rice husks, and corn stover) are abundant and underutilized.

In line with China's growing interest in hydrogen as a clean energy carrier, biomass gasification is being explored as a method to produce renewable hydrogen. Several demonstrations were built. For example, China Wuhuan Engineering Corporation Ltd. constructed a MSW high-temperature gasification plant in Fangshan, Beijing, and hydrogen yield is 0.03 t_{H2}/t_{MSW}. China Datang Corporation Ltd. built a biomass chemical looping gasification plant for hydrogen production in Maanshan, Anhui. The purity of produced hydrogen can be higher than 99.99 %, and the annual production of hydrogen is 110 000 m^3.

Figure 17: MSW high-temperature gasification for hydrogen production (Fangshan Beijing).

Even more attention than to green hydrogen is put to production of green methanol in China. By the end of 2024, more than 90 green methanol projects are in planning or under construction in China, most of them applies biomass gasification. According to a report by the China Petroleum Society[51], by 2028, China's green methanol production is projected to reach approximately 12 million tonnes. This aligns with other industry forecasts, which suggest that China's share of global green methanol production could exceed 60 % by 2025.[52]

In Table 2 below, the projects to methanol production through gasification can be found. As you can see, also here, synergies between gasification and electrolysis can be found. Additionally, the route of anaerobic digestion coupled with gasification can be employed, as seen in Figure 18.

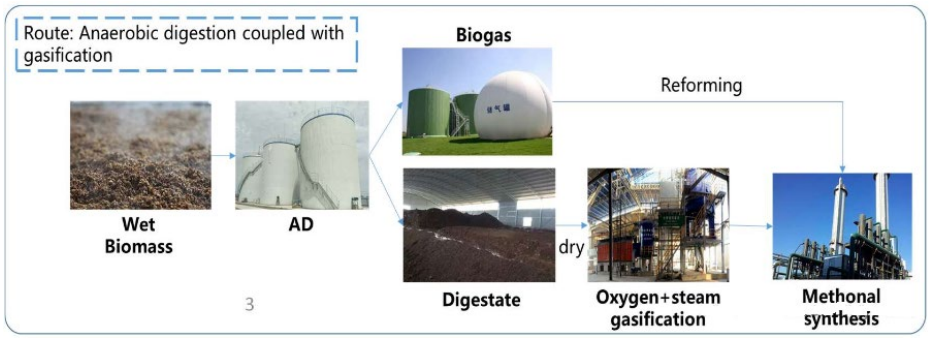

Figure 18: Anaerobic gasification coupled to gasification for production of green methanol.

[51] https://www.rivieramm.com/news-content-hub/news-content-hub/as-china-green-lights-green-fuel-production-ports-prepare-for-uncertain-fuels-future-82607
[52] https://assets.bbhub.io/media/sites/25/2024/06/BNEF-Methanol-Report_to-publish.pdf

Table 2: Representative Biomass to green methanol production

Serial No.	Project Name	Major Investors	Main Technical Parties	Location and Size	Current Progress and Contact Status
1	Goldwind Technology Xing'an League Wind Power Coupling 500,000 Tons of Green Methanol Project	Goldwind Green Energy Chemical Technology (Jiangsu) Co., Ltd.	Sai Ding Engineering (EPC Contractor), Yangmei Chemical Machinery Group Co., Ltd. (Gasifier Manufacturer)	Xing'an League, Inner Mongolia. Planned Investment: 13.665 billion yuan. Annual Production: 500,000 tons of green methanol, 2 million kilowatt wind power plant, 92,200 tons hydrogen production, 118-ton hydrogen storage facility, 160,000-kilowatt/2-hour energy storage facility, biomass power and gasification equipment.	Civil engineering completed, gasifier installed, methanol synthesis section's desulfurization tank hoisted. Expected production start: **Q4 2025.**
2	Zhongsheng Inner Mongolia Pilot Project	Jiangsu Zhongsheng New Energy Holdings Co., Ltd.	Shanghai Puhe Green Carbon Clean Energy Technology Co., Ltd. (Pure Oxygen Pressurized Fluidized Bed Gasification Technology)	Inner Mongolia, exact location unknown. Daily Processing: 100 tons of biomass, Annual Output: 10,000 tons/year of green synthesis gas.	Project debugging ongoing, pilot test expected completion: **June 2024**.
3	Shanghai Electric Taonan Wind Power Coupling Biomass Green Methanol Integration Project	Shanghai Electric Group	Shanghai Boiler Factory Co., Ltd., Shanghai Hydrogen Era Technology Co., Ltd.	Taonan, Jilin Province. Total Investment: 5.6 billion yuan. Project Scale: 250,000 tons of green methanol annually coupled with 680,000 kilowatts of new energy.	Phase 1 (50,000 tons/year green methanol) underway, trial production expected by **end of June 2025**.

Regarding the future perspectives in gasification in China it could be posted that [53]

- Carbon tax will significantly promote development of gasification in particular for shipping.
- The average carbon price in the national carbon market in 2022 is expected to be 59 RMB/ton (i.e., 7.11€/ton), by 2025, it is expected to rise to 87 RMB/ton (i.e., 10.48 €/ton), and by 2030 will reach 130 RMB/ton (i.e., 15.67 €/ton).
- Carbon tax should be calculated based on products instead of feedstocks, which can evaluate the carbon reduction benefits accurately.
- Biomass gasification will be more often combined with industrial processes, where biomass coke can replace coal coke for metallurgy industry and waste heat from industrial process can be used for enhancing gasification to prepare coke.

[53] https://task33.ieabioenergy.com/wp-content/uploads/sites/33/2023/11/China.pdf

CONCLUSIONS

Thermochemical gasification of biomass and waste has great potential to be a key pathway for producing renewable fuels, hydrogen, and chemicals while enabling carbon-negative solutions when paired with biochar production or carbon capture. Across Europe, North America, and Asia, gasification projects reflect varying degrees of technical maturity, policy support, and commercial viability. This report provides an overview of regional developments, major projects, and prospects.

Europe

Small-scale gasification is well established in Europe, with around 1,700 CHP plants - primarily in Germany, Italy, and Austria - forming the backbone of the sector. In recent years, however, attention has increasingly shifted toward larger-scale, high-value applications such as the production of renewable hydrogen, sustainable aviation fuels (SAF), and biochar as a valuable by-product.

Biochar, in particular, is attracting growing interest as a valuable co-product. It not only provides economic benefits in sectors like agriculture, construction, and filtration, but also serves as a durable form of carbon storage, supporting negative-emission pathways and enhancing the climate value of gasification systems.

Despite technical successes, several high-profile European projects have faced financial or regulatory obstacles. In the UK, ABSL's Swindon facility and KEW's Wednesbury plant failed to reach commercial operation due to funding challenges. In France, the Gaya and planned Salamandre projects were halted in 2025 despite demonstrating technical feasibility, while the Bioliq® facility in Germany ceased operations at the end of 2024.

France's BioTfueL® project has successfully demonstrated the production of biojet fuel through integrated gasification and FT synthesis. The BioTJet project now aims to scale this up into Europe's largest SAF production facility, with a projected annual output of 75,000 tonnes of e-biokerosene. Sweden's Biorefinery Östrand project also combines electrolysis and gasification to optimize SAF output, showcasing integration into existing pulp mill infrastructure.

Hydrogen production is another area of innovation. The FUREC project in the Netherlands converts municipal waste into renewable and circular hydrogen, feeding chemical industries and reducing fossil dependency. Projects like Ecoplanta in Spain aim to convert up to 363,000 tonnes of MSW annually into renewable and circular methanol, integrating carbon analysis to determine sustainability outcomes.

North America

Canada's Enerkem played a leading role with its Edmonton facility, the first ISCC-certified waste-to-biofuel plant. Although operations ceased in 2024, Enerkem's technology is now being scaled up at the Varennes Carbon Recycling project in Quebec. However, as of March 2025, the project is under creditor protection due to cost overruns and liquidity issues, leaving its future uncertain.

Meanwhile, Canada's Hydrogen Naturally and Mote (USA) are pursuing carbon-negative hydrogen from biomass via gasification and CCS. These projects aim to remove up to 1 million tonnes of CO_2 per year while producing tens of thousands of tonnes of clean hydrogen.

In the U.S., Fulcrum BioEnergy's Sierra BioFuels plant in Nevada collapsed in 2024 following technical and financial setbacks, including unanticipated reactor issues. Aemetis and DG Fuels are now among the key players attempting to scale SAF production through gasification. DG Fuels is developing a major SAF facility in Louisiana (projected capacity: 119 million gallons/year), with additional sites planned in Minnesota and Nebraska.

SunGas Renewables is leading a $2 billion project in Louisiana to produce 500,000 tonnes/year of green methanol, while smaller firms like Arbor Renewable Gas aim to supply renewable gasoline using forest waste. However, many U.S. projects face regulatory uncertainty under the current administration's pro-fossil fuel energy policy, which has reduced federal support for renewable technologies.

Asia (China and India)

China hosts more than 80 large-scale gasification plants, using feedstocks ranging from agricultural waste to municipal solid waste (MSW) and hazardous materials. Projects emphasize synergies with industrial processes, such as metallurgical applications, and capitalize on biochar production for both economic and environmental benefits.

Renewable methanol through gasification is the dominant growth area: over 90 projects are under planning or construction, and by 2028, China is expected to produce 12 million tonnes of renewable methanol annually, representing over 60 % of global output.

Hydrogen is also a key focus area, with demonstration facilities like the Wuhuan MSW plant in Beijing

India's gasification sector, once more active, has slowed but still shows potential. The IndianOil 2G ethanol plant in Panipat, inaugurated in 2022, uses agricultural waste gasification integrated with enzymatic hydrolysis to produce bioethanol, contributing to India's ethanol blending targets and carbon reduction goals.

Overall, biomass gasification is a well-established technology that is becoming increasingly important for producing sustainable fuels and chemicals and enabling long time carbon storage. However, its widespread adoption hinges on securing adequate investment, support for scaling up, and the presence of stable policy frameworks. Expanding gasification on a large scale will require significant funding for research, development, and commercial demonstration projects aimed at enhancing efficiency, lowering costs, and integrating the technology into existing industrial systems.

Furthermore, long-term success depends on creating and maintaining supportive policy environments that offer clear incentives, regulatory stability, and strong market signals for renewable energy and carbon management solutions.

In summary, biomass gasification holds a vital role in the global shift toward cleaner energy. Yet, its full potential will only be unlocked through a coordinated approach that combines technological innovation, financial backing, and consistent policy support at both regional and international levels.

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Appendices

Appendices can be found separately on the website.

https://task33.ieabioenergy.com/projects/

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Technology Collaboration Programme