Scalable, modular and affordable biomethanol production

Agenda:

1. Introduction
2. Torrefaction
2. Gasification
3. Potential methanol

Biomass is not a fuel but a feedstock.

Torrefaction improves the physical properties. Torrefaction is preferred conversion for efficient logistics and downstream processing

- Torrefaction is a thermochemical treatment of biomass at 250 to 280 °C. It is carried out under atmospheric pressure and in the absence of oxygen, i.e. with no air.
- The final product is the remaining solid, dry, blackened material that is referred to as torrefied biomass or bio-coal.
- Torrefaction changes biomass properties to provide a much better fuel quality for combustion and gasification applications.

Y	Tough	N
Y	Fibrous	N
Y	Hydrophylic	N
Y	Biodegradable	N
Y	Heterogeneous	N
Y	Poor energy density	N

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Clean biosyngas Reserves Upgrading Innovative technology Results Hub
Torrefied biomass bioSNG Efficient bioMeOH Syngas Value chain
Biomass Energy Gasification bioFischer-Tropsch Torrefaction

Torrefaction and gasification

Innovative and scalable technology that produces a sustainable synthetic gas

In addition to sustainable electricity, the energy transition also requires more and more renewable gas. The Torrgas process converts waste streams into synthetic gas (syngas), more sustainable and efficient than combustion. The resulting syngas is a good alternative for fossil fuels and feedstocks. Besides, it enables the sustainable synthesis of a wide range of base chemicals.

Waste streams as feedstock

Scrap wood and wood processing residues

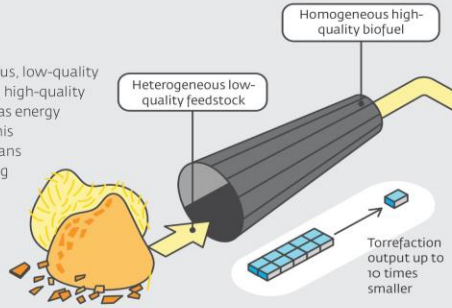
Grass, straw and agri-cultural residues

Wet waste streams such as manure and sewage sludge for wet torrefaction

Torrefaction processes use a wide range of waste streams that would otherwise be burned or left to perish. This greatly increases the amount of waste that can be reused.

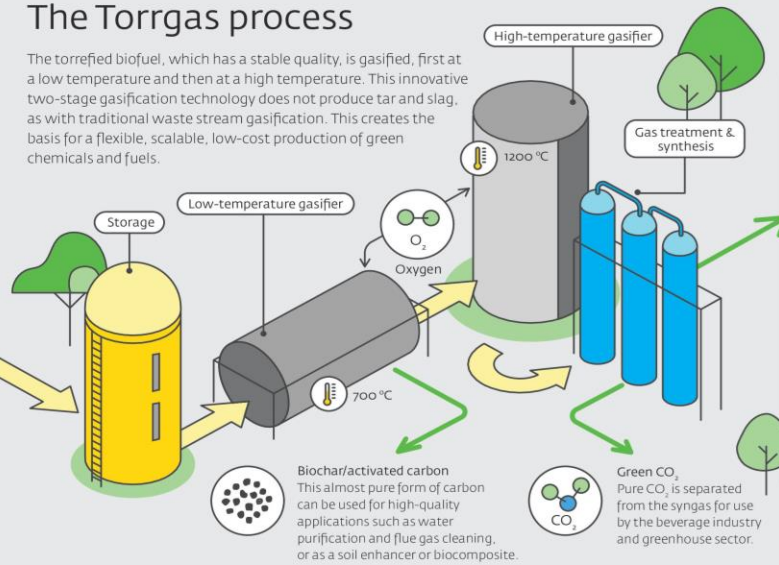
Torrefaction

Torrefaction converts heterogeneous, low-quality waste streams into homogeneous, high-quality biofuels that are around ten times as energy dense as the original feedstocks. This enables efficient transport and means torrefaction is a vital link in enabling large-scale reuse of problematic waste streams.



The Torrgas process

The torrefied biofuel, which has a stable quality, is gasified, first at a low temperature and then at a high temperature. This innovative two-stage gasification technology does not produce tar and slag, as with traditional waste stream gasification. This creates the basis for a flexible, scalable, low-cost production of green chemicals and fuels.



Product

Sustainable molecules

- CH_4 Green gas
- H_2 Green hydrogen
- Methanol
- DME
- Plastics

Uses of green gas

The Torrgas process produces green gas from syngas. This gas is transported through gas infrastructure to users in the industrial domain (for use as a feedstock and for process heating) and to the built environment.

Industry & chemistry

Built environment

Transport & mobility

Benefits of the Torrgas process

Scalable
A Torrgas plant can be scaled up to 100 MW.

Affordable
Activities such as the scaling up and marketing of biochar and green CO_2 make it increasingly cheaper to produce syngas. So much so, in fact, that it can even compete with fossil alternatives on price.

Fully circular
Low-quality waste streams are fully converted into high-value molecules (syngas and green CO_2) and products (biochar).

CO_2 reduction
Waste streams are converted into usable products. This prevents combustion and carbon emissions, effectively removing CO_2 from the atmosphere.

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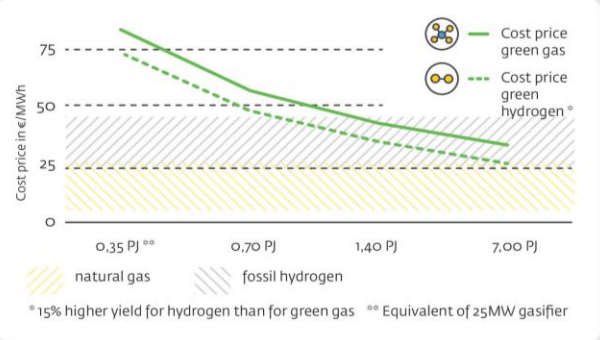
Torrgas Outlook 2030: scalable, affordable and CO_2 negative green gas and hydrogen production

More than 25PJ of green gas capacity by 2030

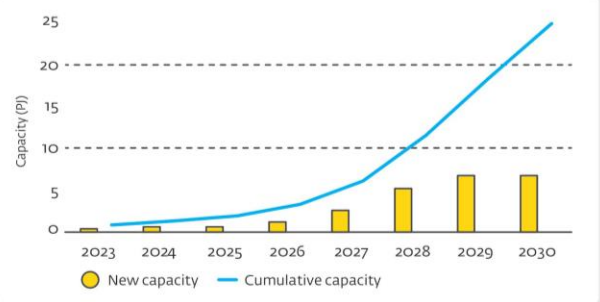
Torrgas technology is scalable to 100 MW (1,4 PJ green gas) per gasifier, which is an essential element to low cost green gas and green hydrogen production. By using high (volumetric) energy density torrefied pellets, Torrgas plants ensure there is no dependence on locally available biowaste and enable efficient supply for upscaling. The conversion of waste streams into high value products (green gas or green hydrogen and biochar) significantly reduces the carbon footprint.

Scale up and lower costs

Torrgas technology can be scaled up to 100MW per gasifier.



Scaling up results in dramatic cost reductions in both Capex and Opex, allowing green gas and hydrogen to be produced at competitive price levels compared to fossil by 2030.

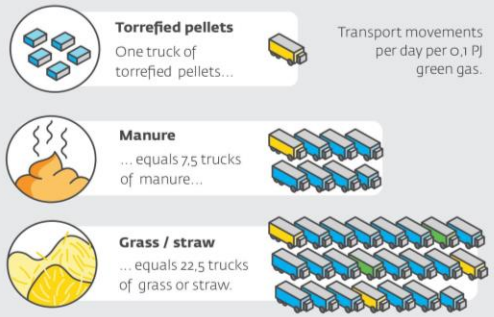


Torrgas plants are aimed to scale up to 3 PJ+ per location by building plants with multiple gasifiers.

Efficient and low cost transport

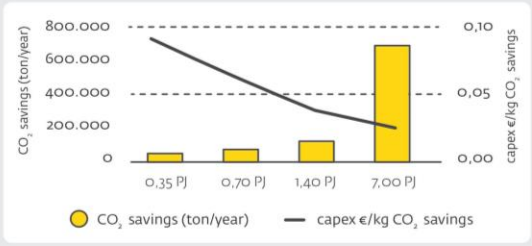
Torrefaction converts heterogeneous, low-quality waste streams into homogeneous, high-quality biofuels.

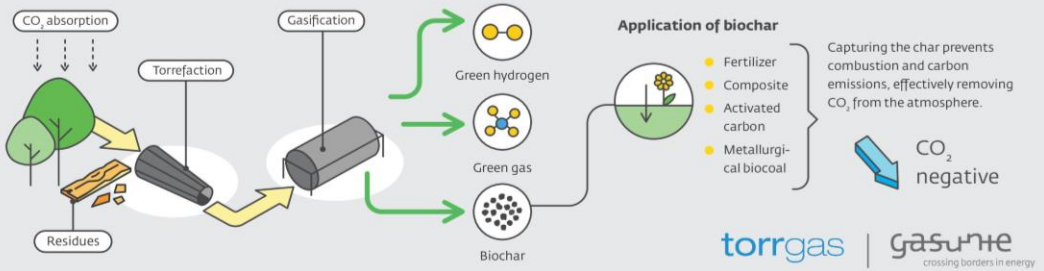
- Torrefaction increases energy density and thus dramatically decreases the number of transport movements.
- Less and simpler handling transactions, also enabling efficient supply by barge or vessel.
- Significantly lower carbon emissions as a result (LCA comparison to untreated biomass supply); typical carbon efficiency of 85-90%.



Significant CO_2 savings

- Each operational 1,4 PJ Torrgas location saves minimally 130.000 MT of CO_2 emissions per year.
- CO_2 captured in biochar can be locked into long lifecycle products (composites, fertilizer). This creates a permanent carbon reduction of another 60.000 MT per 1,4 PJ green gas.
- A CO_2 price of €50 per MT results in a €15-20 per MWh lowering of green gas or green hydrogen costs, enabling fossil parity at relatively low CO_2 prices.





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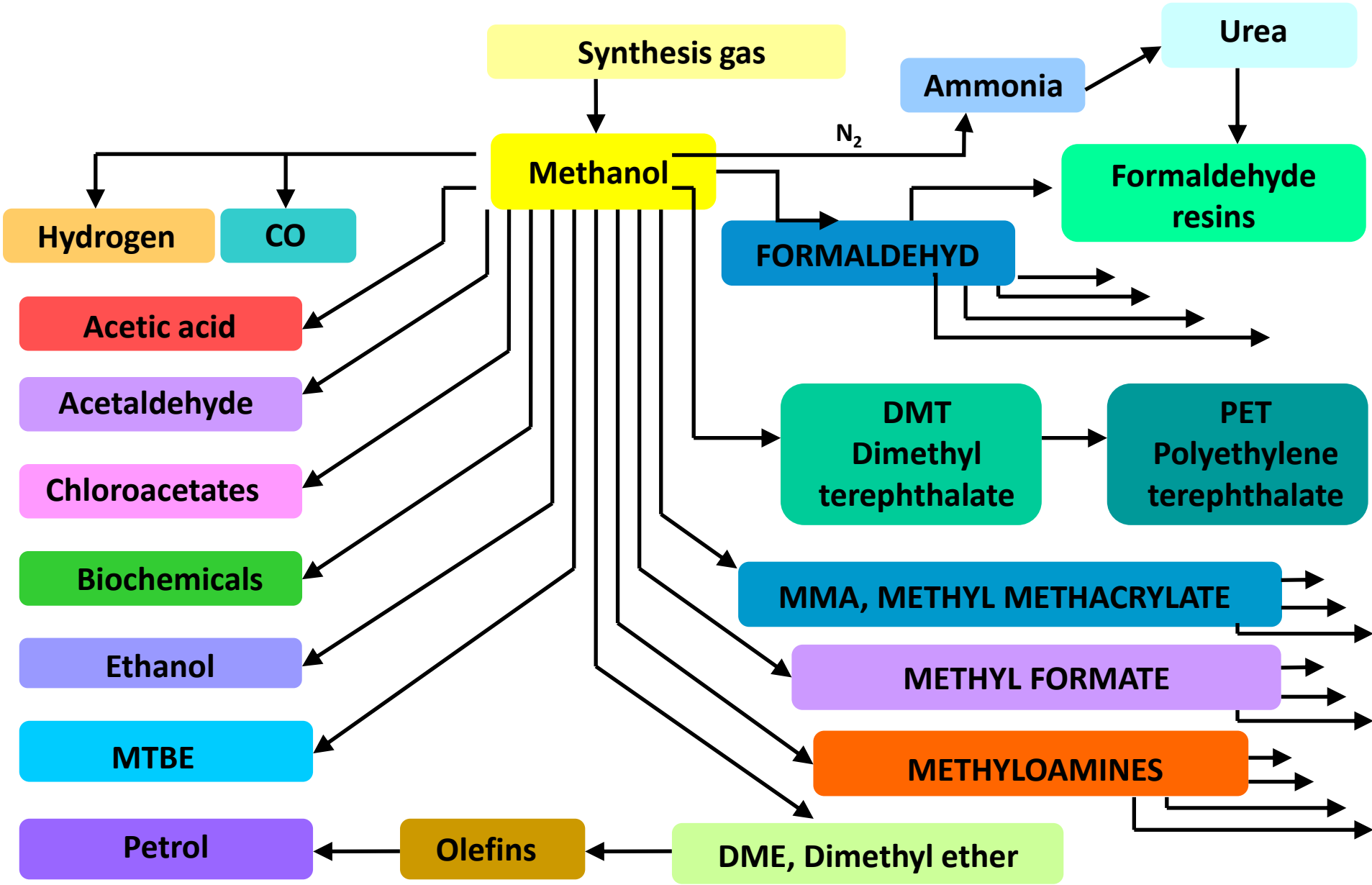
Gasunie, October 2020


Synthesis gas
Urea
Ammonia
N_2
Methanol
Formaldehyde resins
Hydrogen
CO
FORMALDEHYD
Acetic acid
Acetaldehyde
DMT Dimethyl terephthalate
PET Polyethylene terephthalate
Chloroacetates
Biochemicals
MMA, METHYL METHACRYLATE
Ethanol
METHYL FORMATE
MTBE
METHYLOAMINES
Petrol
Olefins
DME, Dimethyl ether

Current project portfolio Torrgas. Biomethanol is next step.

1. SNG:
   a. 30 MW Synthetic Natural Gas(SNG) Delfzijl plant in JV with Gasunie.
   b. Financial closing summer 2021. Front End Engineering finalized. Basic Engineering ongoing.
   c. 15 MW green gas, 6.000 biochar and 40.000 mt of green CO_2.
   d. Target Gasunie/Torrgas is 0.72 BCM green gas by 2030; i.e. 1.400 MW of installed Torrgas capacity.

2. Hydrogen:
   a. 50 MW green hydrogen plant at Chemelot in JV with Brightlands Chemelot: BrigH2
   b. JV is progressing on permit, Front End Engineering, financing etc.
   c. 6.500 mt green hydrogen, 10.000mt char and 110.000 mt of green CO_2.

3. **Biomethanol:**
   a. **100 MW(thermal input) Torrgas is preferred as minimal plant size.**
   b. **100 MW produces 60.000 mt of green methanol from syngas and potentially another 75.000 mt from green CO2(with additional hydrogen supply): 135.000 mt.**
   c. **Torrgas is as licensor aswell as project developer, but not owner/operator.**
   d. **Indicative methanol costprice: €300-350 per mt**.