Best Practices on flexible bioenergy

Flexibility through biomass gasification:

Task 33 database and Nong Bua DFB gasifier example

Introduction to gasification database of IEA Bioenergy Task 33

IEA Bioenergy Task 44
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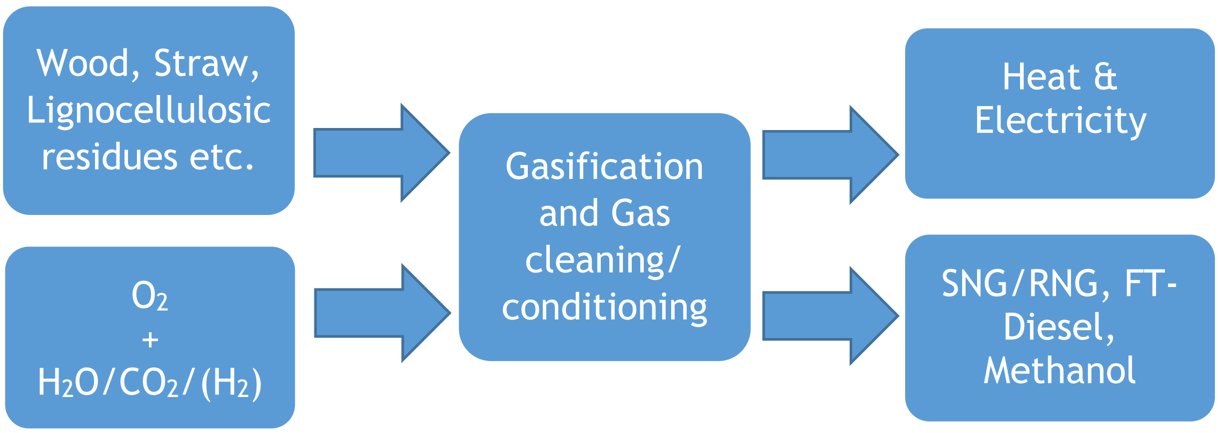
This factsheet first gives an overview on biomass gasification technologies by explaining the basic principles and highlighting advantages especially from flexibility point of view. The latter part presents an example of a Best Practice case from the field, introducing its technical and commercial details. For this purpose, we refer to the work of the **IEA Bioenergy Task 33: Gasification of Biomass and Waste**, which has built up an extensive database over many years of work. The presented Best Practice example has been chosen from their database.

Introduction

Biomass gasification converts solid biomass such as wood from forestry and landscape management, straw, lignocellulosic residues etc. in one or more conversion steps into a burnable gas, referred to as syngas, synthesis gas, product gas or producer gas. Gasification processes themselves are quite flexible regarding the use of feedstock.

Technology advantages

While solid biomass usually can only be burned to produce heat and subsequently electricity by steam turbines and organic Rankine cycles (ORC), the burnable gas from gasification can be used for more efficient and flexible electricity (and heat) production in gas motors, gas turbines and high-temperature solid-oxide fuel cells (SOFC).
Further, different chemicals and chemical energy carriers can be produced from the gas, such as methane (referred to as bio-SNG or RNG, synthetic/renewable natural gas), hydrogen, FT-diesel and methanol. This facilitates the transport, storage, and use of bioenergy in different sectors such as transport and chemical industry.
Finally, inherently biogenic CO_2 is produced and it can be used, even in a flexible way, for sequestration (i.e. negative emissions) or together with renewable hydrogen in PtX processes, i.e. allowing for (even seasonal) energy storage.



Gasification database of IEA Bioenergy Task 33

The IEA Bioenergy Task 33 focuses on the gasification of biomass and waste, maintaining a comprehensive database of gasification projects. This database includes status reports, case studies, and detailed information on plants across Europe, North America, and some parts of Asia and New Zealand. Gasification plants vary from pilot to fully commercial scales, using feedstocks like wood, straw, and other lignocellulosic residues to produce products such as electricity, heat, bio-SNG, FT-Diesel, methanol, H_2, and biochar. These plants offer flexibility by combining multiple product outputs, and enabling negative CO_2 emissions. Investment costs vary depending on size and technology. For further details, contact Jitka Hrbek (jitka.hrbek@boku.ac.at).

Base information	
Database on gasification projects	https://task33.ieabioenergy.com/database/
Status reports and case studies	https://task33.ieabioenergy.com/projects/
Contact person	Task 33: Jitka Hrbek, jitka.hrbek@boku.ac.at
Locations	Mostly Europe, North America, few in Asia and NZ
Owner/Operator	Companies, Utilities, Electricity suppliers
Technology supplier	Several
Status of gasification plants	From pilot plants to fully commercial plants
Feedstock	Wood/straw/lignocellulosic chips/residues/pellets
Products	Electricity, heat, bio-SNG, FT-Diesel, methanol, H_2, biogenic CO_2, biochar
Size	From few 100 kW to several 100 MW
Type of flexibility provided	Combining production of multiple products: electricity, heat, and biochar (enables negative CO_2 emissions)
Investment cost of the plant (€)	Depending on size and technology

Technology description

To convert biomass to syngas, the biomass has to undergo four process steps: drying to remove water at > 100°C, pyrolysis producing volatile organic compounds and carbonaceous rest at > 450°C, gasification of this char at > 650°C, and combustion of char and/or organic compounds. The combustion of part of the feedstock is needed to provide the heat for the three other, endothermic process steps. Therefore, an (under-stoichiometric) amount of oxygen has to be added. While drying and pyrolysis can occur without further gas addition, the gasification of the char needs the presence of a reactant (gasification agent) such as steam, CO_2 and/or H_2, which might stem from the combustion and the drying process, or it can be added.

The choice of gasification agent, temperature level and the arrangement of the four process steps can differ from technology to technology and have a significant influence on the composition of the syngas and on the necessary gas cleaning/conditioning before the use in the downstream, e.g. CHP or synthesis reactor. The main gas species are hydrogen, carbon monoxide, steam and carbon dioxide; further (depending on gasifier type and feedstock) methane, olefins, aromatics, sulphur species (H_2S, thiophenes), nitrogen compounds (e.g. NH_3), nitrogen, ash particles, or alkaline aerosols.

PROJECT NONG BUA DFB GASIFIER

(IEA Bioenergy Task 33: Gasification of Biomass and Waste)

Figure 1. Nong Bua DFB gasifier power plant.

Technical and commercial details

Nong Bua plant in Nakhon Sawan, Thailand uses Dual Fluidized Bed (DFB) gasification technology, which was developed by the Vienna University of Technology. The first plant of such kind was successfully installed in 8 MW_{th} commercial scale power plant in Güssing, Austria in 2001. The technology was also constructed and operated in various other plants in different sizes (up to 32 MW of fuel input). New engineering design and improvements from the Güssing plant were implemented on certain equipment in the Nong Bua plant.

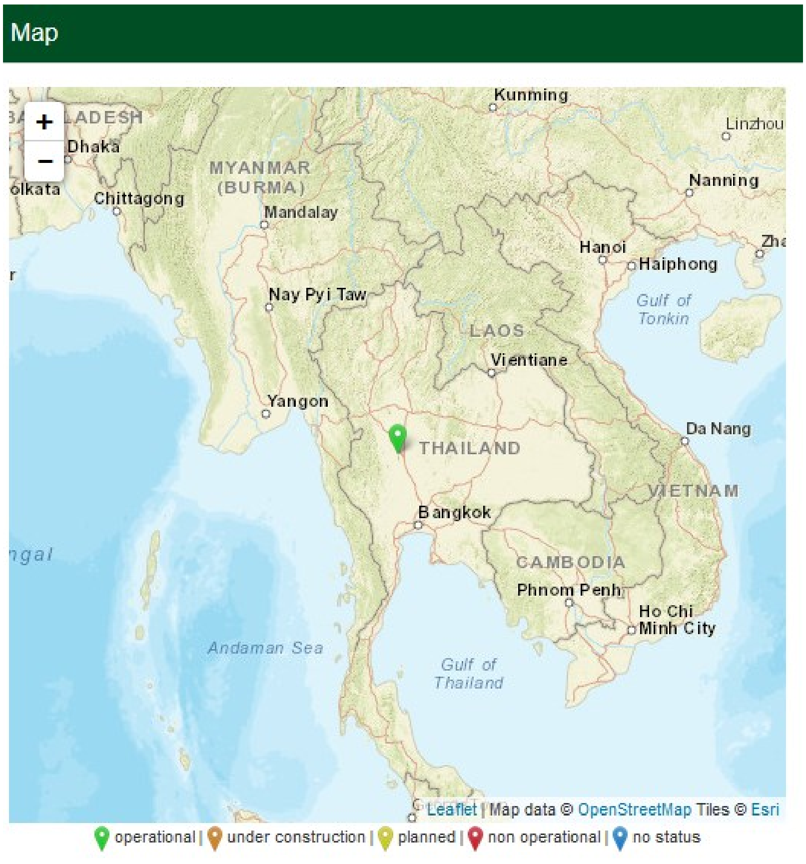


Figure 2. Nong Bua plant in Nakhon Sawan, Thailand. Screenshot from Task 33 website.

The developments included improved fuel feeding system, biomass dryer, gasifier design, tar scrubber design, and heat exchanger system. With these improvements, the 3.8 MW_{th} prototype DFB gasifier has been the first of its kind plant that can be operated with several different biomass resources such as wood chips, sugarcane leaf, corncob, and other renewable biomass resources.

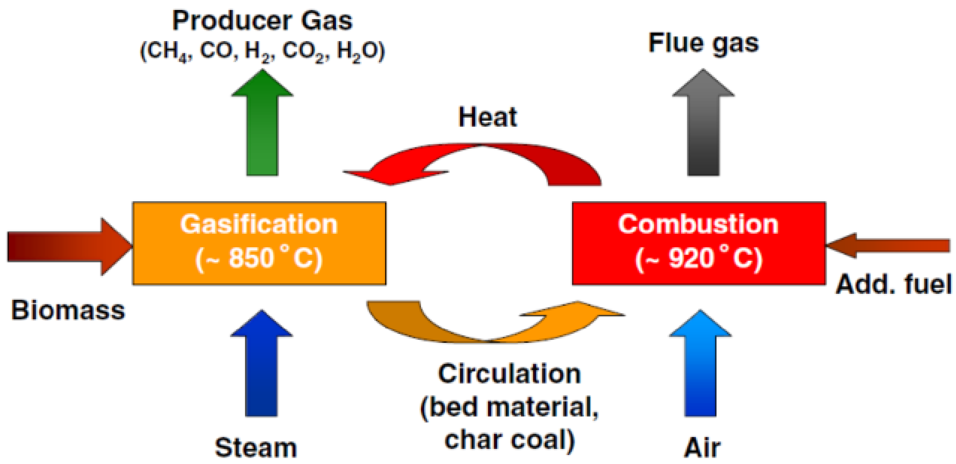


Figure 3. Working principle of DFB gasifier. (Hongrapipat, 2022).

Base information	
Database on gasification projects	https://task33.ieabioenergy.com/database/
Link for more information	https://www.gussingrenewable.com/technology.html Hongrapipat, 2022, Energies, vol. 15, no. 19: 7363[1]
Location	Nakhon Sawan, Thailand
Owner/Operator	GRETHA
Technology supplier	Güssing Renewable Energy
Start of the project	2018
Status	Commercial plant, operational
Feedstock	Lignocellulosics; wood chips (3.8 MW_{th}) and various biomass tested
Products	Power, heat, and gas
Capacity	1 MW_{el} electricity and 1.25 MW_{th} heat, gas
Type of flexibility provided	Feedstock flexibility, and combining the production of multiple products: electricity, heat, gas, and many products that can be produced by further processing
Investment cost of the plant (€)	160 MTHB (about 4.2 M€ in 2024)

Conclusions

- Biomass gasification allows flexibility in feedstock as various options and their combinations can be used.
- Flexibility is provided also by combining the production of multiple products: electricity, heat, and numerous alternatives that can be further produced from the product gas, e.g., fuels and chemicals.

[1] Hongrapipat, 2022. Co-Gasification of Refuse Derived Fuel and Wood Chips in the Nong Bua Dual Fluidised Bed Gasification Power Plant in Thailand. Energies, vol. 15, no. 19: 7363. https://doi.org/10.3390/en15197363