BURMEISTER & WAIN ENERGY

Berkes Group

The Role of Biomass in the Energy Transition

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1. CONTENT

2. SUMMARY

The urgency of decarbonizing the global economy and achieving carbon neutrality by 2050 requires the large-scale deployment of integrated technologies, where biomass and BECCS (Bioenergy with Carbon Capture and Storage) play an irreplaceable role. This document highlights the strategic value of biomass as a dispatchable renewable energy source, capable of supplying both heat and electricity, and serving as a natural vector for carbon capture.

Biomass is an essential tool for deep Decarbonization and the success of Power-to-X (PtX) projects. Its versatility enables it to simultaneously address multiple energy, environmental, and operational challenges. This document outlines the key advantages of incorporating Biomass into PtX systems:

- Enables the production of **renewable electricity, heat, and biogenic CO_2**.
- Supports circular economy models by **valorizing** Agricultural, Industrial, and Forestry **Residues**.
- **Oxy-Combustion** enhances project bankability by **eliminating Amines** process and **reducing CAPEX & OPEX**.
- Makes **negative emissions** achievable through **BECCS**.
- Generates water as a byproduct and turns it into a valuable asset.
- **Stabilizes** Renewable **Energy** systems thanks to its **Dispatchability**.
- It is not just an alternative, it is a strategic necessity.

Integrating **Biomass** into **Power-to-X** projects is essential not only for their technical feasibility but also for their environmental impact. Its Role as a **structural pillar** in the Hydrogen and e-fuels **economy** must not be **underestimated**, it represents one of the few realistic pathways to climate neutrality and possibly the only one to negative emissions.

3. INTRODUCTION

Biomass is a critical tool in energy transition. Unlike other renewable sources such as wind or solar, biomass has the ability to continuously generate both electricity and thermal energy and acts as a carbon sink through the natural process of photosynthesis. This makes it an indispensable technology for achieving global climate goals.

4. A MULTIFUNCTIONAL ENERGY SOURCE

4.1 Generation of Renewable Electricity and Heat

The controlled combustion of biomass enables the simultaneous production of electricity and heat, addressing multiple key energy needs in the energy transition:

- District heating through heat networks.
- Process heat for industry, essential in sectors such as food, chemical, and paper.
- Thermal supply for specific processes in Power-to-X schemes, such as CO_2 capture and methanol synthesis, especially during thermal absorption and distillation stages.
- Dispatchable and controllable renewable electricity generation, ideal as a baseload source in hybrid projects, stabilizing a renewable energy mix dominated by intermittent sources such as solar and wind.

4.2 Source of Biogenic CO_2

Through photosynthesis, crops absorb CO_2 from the atmosphere. As carbon-neutral fuels, their use does not increase net CO_2 concentrations, and if the CO_2 released during combustion is captured and stored, the carbon balance becomes negative effectively removing carbon from the atmosphere.

4.3 Water Generation and Recovery from Biomass

One often overlooked but highly strategic aspect of biomass plants is their ability to generate water. During biomass combustion, the water vapor present in the flue gas comes primarily from the inherent moisture content of the vegetal fuel, as well as from the oxidation of hydrogen contained within the fuel itself. In the flue gas conditioning process prior to CO_2 capture, this vapor is condensed and transformed into liquid water. This water, which would otherwise be lost, can be recovered and reused as an input in various processes within the PtX project.

Since many Power-to-X projects face challenges related to water availability, this capability represents a significant advantage. Biomass enables the transformation of a thermal byproduct into a valuable resource, further reinforcing its role as a key pillar of sustainable project development.

5. STRATEGIC ROLE IN POWER-TO-X-PROJECTS

5.1 Dispatchable Renewable Energy Base

Biomass plants provide continuous baseload energy, helping to stabilize systems that rely on intermittent renewables such as wind and solar. This steady energy supply is essential for the continuous operation of:

- Electrolyzers
- Carbon Capture Systems
- Methanol Synthesis Plant

5.2 Source of Heat for Key Processes

- It supplies the heat required for CO_2 capture processes.
- It provides the thermal energy needed to separate methanol from water during e-methanol synthesis.

5.3 Supply of Biogenic CO_2 for E-Fuels

Biomass is virtually the only sustainable and scalable source of biogenic CO_2. This makes it an essential component to produce synthetic fuels such as e-methanol.

6. ADVANTAGES OVER OTHER RENEWABLE SOURCES

6.1 Comparison with Wind and Solar Energy

Solar and wind: only generate electricity; they do not provide heat or biogenic CO_2.

Biomass: generates electricity, heat, and naturally captured CO_2.

6.2 Complementarity

Biomass serves as a stable backup in response to the variability of other renewables.

It enhances the resilience and operational continuity of hybrid energy systems.

7. NEGATIVE EMISSIONS: BECCS

The BECCS model (Bioenergy with Carbon Capture and Storage) enables the generation of renewable energy while capturing and permanently storing CO_2 emissions, resulting in a negative carbon balance.

- CO_2 is absorbed during the growth of the biomass.
- It is released during combustion.
- It is then captured and stored permanently.

This cycle results in a negative emissions technology, which is crucial for reversing the rise in atmospheric CO_2 concentrations.

8. CIRCULAR USE OF RESIDUES AS BIOMASS

8.1 Types of Residues Used

- **Agricultural**: cereal straw, rice straw, palm leaves, cotton stalks, corn stover.
- **Industrial**: rice husk, olive cake, nut shells, sugarcane bagasse, sunflower husk.
- **Forestry**: wood chips, waste wood, sawmill by-products.

All of these are by-products from other value chains (food, oils, wood) and are often left to decompose in the field or burned in an uncontrolled manner, generating emissions. Using them as Biomass is a clear example of circular economy in action. Some residues classified as Biomass are those shown in Figure 1.

Figure 1 - Examples of Residues Used as Biomass

9. OXY-COMBUSTION

Water electrolysis, used to produce green hydrogen in PtX projects, generates large volumes of oxygen as a byproduct. For every kilogram of hydrogen produced, approximately 8 kilograms of oxygen are generated. In most cases, this oxygen is released into the atmosphere without being utilized. However, using it as the oxidant in Biomass Combustion replacing air enables the implementation of a concept known as oxy-combustion.

Ambient air contains approximately 21% oxygen, 78% nitrogen, and 1% argon. These inert gases do not participate in the combustion reaction and act as diluents, limiting flame temperature. Furthermore, in Conventional Combustion (Figure 2), nitrogen can react with oxygen at high temperatures to form nitrogen oxides (NOx), which require costly emission control systems.

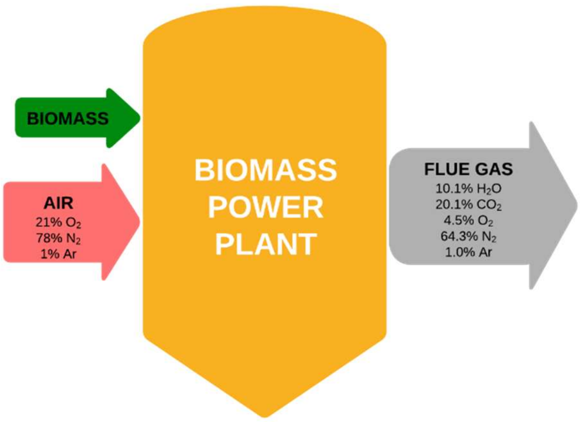

Figure 2 - Example of Biomass Conventional Combustion

By replacing air with oxygen (combined with flue gas recirculation to moderate combustion temperature), nitrogen is removed from the process. This results in a Flue Gas highly concentrated in CO_2 and water vapor (Figure 3), offering the following advantages:

- The CO_2 capture process is simplified. A CO_2-rich flue gas eliminates the need for amine purification, resulting in an estimated 70% reduction in CAPEX for the carbon capture plant, as well as significant OPEX savings by avoiding chemical consumption and thermal energy requirements for the amine process.
- Emission control systems for pollutants are either eliminated or significantly reduced.

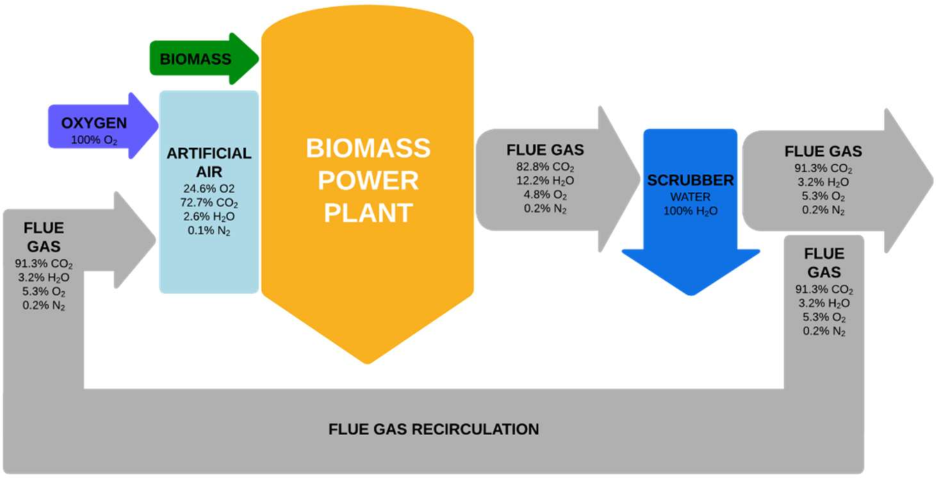

Figure 3 - Example of Biomass Oxy-Combustion

This direct integration of oxygen generated through electrolysis into the biomass combustion system not only increases the overall efficiency and sustainability of the process, but also closes the loop on byproduct utilization within a well-integrated PtX system.

10. CONCLUSIONS

Biomass is not only an optional renewable, it is structural and strategic. Its unique combination of dispatchable heat and power, biogenic CO_2 supply, water generation, and potential for negative emissions makes it indispensable to Power-to-X projects and to the broader decarbonization agenda.

Unlike intermittent sources, Biomass offers stability, circularity, and multifunctionality. It acts not only as a clean energy carrier but also as a critical enabler of CO_2 utilization and storage pathways. Through innovations such as Oxy-Combustion and BECCS, it unlocks substantial reductions in project CAPEX and OPEX while enabling net-negative emissions at industrial scale.

The integration of biomass into PtX schemes is not just a technical optimization, it is a system-defining choice. As energy systems evolve toward climate neutrality, the role of biomass must be understood not as complementary, but as foundational.

11. AUTHORS

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