GREENChainSAW4Life

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"GREEN energy and smart forest supply CHAIN as driverS for A mountain action plan toWards climate change"

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Final performance analysis of GreenPlasma

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ABSTRACT

The Final Performance Analysis of GreenPlasma presents a comprehensive evaluation of the GreenPlasma system, focusing on its application in the thermoconversion of biomass via pyrolysis. GreenPlasma utilizes high-temperature pyrolysis to convert biomass, specifically woodchips, into a syngas rich in hydrogen and possessing a high calorific value. This deliverable aims to provide an in-depth analysis of the utilization of GreenPlasma for the treatment of forest residue waste from forestry activities.

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1. INTRODUCTION

Green Plasma technology heralds a new era in biomass treatment, specifically designed to tackle the complexities of converting residual forest biomass into energy. This innovative approach harnesses plasma gasification, a process where biomass material encounters high-temperature plasma, resulting in efficient breakdown into valuable syngas. The significance of Green Plasma lies in its versatility and environmental sustainability, offering a promising solution to challenges in biomass treatment and waste management. Within this context, this deliverable explores the performance and potential applications of Green Plasma, with a focus on its integration into the GREENChainSAW4Life project. By examining various aspects including efficiency, environmental impact, and economic viability, stakeholders can gain insights into the transformative potential of Green Plasma technology for sustainable energy production and forest management.

1.1. OVERVIEW OF GREENPLASMA:

Green Plasma technology represents a pioneering approach in the field of biomass treatment, specifically tailored to address the challenges associated with the conversion of residual forest biomass into energy. This innovative technology utilizes plasma gasification, a process where biomass material is exposed to high-temperature plasma, a state of matter consisting of ionized gases capable of initiating various chemical reactions. The core advantage of Green Plasma technology lies in its ability to efficiently break down complex organic materials into simpler, energy-rich gases, primarily syngas (synthesis gas), which is a mixture of hydrogen, carbon monoxide, and minimal quantities of carbon dioxide.

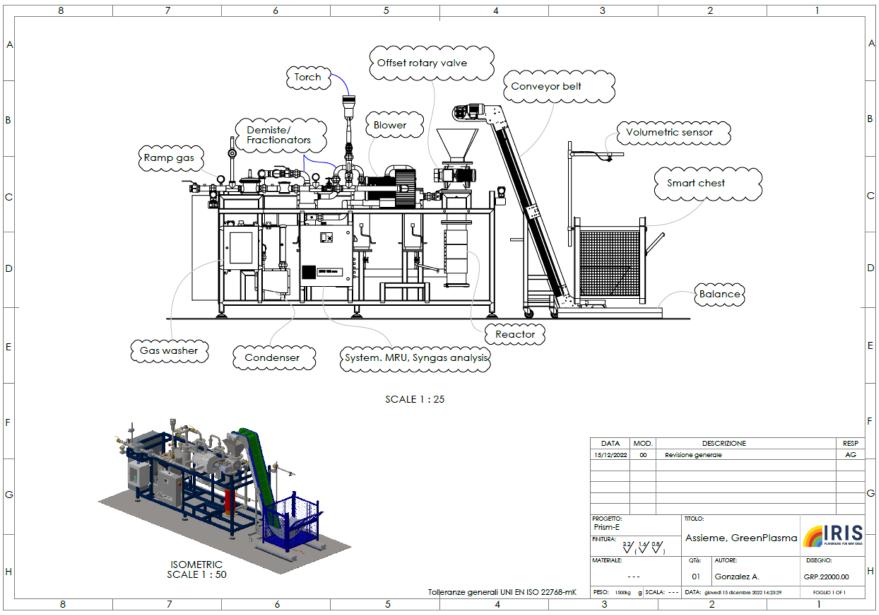

Figure 1.1

1.2. IMPORTANCE OF GREENPLASMA TECHNOLOGY IN BIOMASS TREATMENT:

The relevance of Green Plasma technology to biomass treatment stems from its versatility and environmental sustainability. Unlike conventional combustion processes, plasma gasification operates at significantly higher temperatures, ensuring a more complete breakdown of organic materials, including lignocellulosic biomass found in forest residues. This leads to a reduction in the production of unwanted by-products such as tar and ash, which are common challenges in traditional biomass gasification processes. Furthermore, Green Plasma technology has the capability to process a wide range of biomass feedstocks, including those with high moisture content or irregular sizes, which are often deemed unsuitable for conventional treatment methods.

1.3. ENVIRONMENTAL FOOTPRINT AND PROJECT INTEGRATION:

Another pivotal aspect of Green Plasma technology is its environmental footprint. The process is designed to minimize emissions of greenhouse gases and pollutants, aligning with global efforts towards cleaner energy production. By converting forest residues, which would otherwise contribute to carbon emissions through decomposition or incineration, into a clean and renewable energy source, Green Plasma technology plays a crucial role in the circular economy and sustainable forest management.

In the context of the GREENChainSAW4Life project, Green Plasma technology is instrumental in demonstrating a viable pathway for the utilization of residual forest biomass. By integrating this technology into the biomass-to-energy conversion process, the project aims to showcase an efficient, scalable, and environmentally friendly solution for energy production. This not only addresses the immediate needs of energy generation but also contributes to broader objectives such as reducing reliance on fossil fuels, mitigating climate change, and promoting sustainable practices within the forestry sector.

2. BACKGROUND

Biomass pyrolysis is a process crucial to the sustainable utilization of organic materials such as woodchips. Traditional methods often yield incomplete conversion and undesirable by-products. However, Green Plasma technology, employing plasma gasification, revolutionizes this process.

High-temperature plasma efficiently breaks down complex biomass into valuable syngas, minimizing tar and char production. Forest residue waste, a significant environmental challenge, finds a solution in Green Plasma. This technology offers a versatile and environmentally sustainable approach to convert forest residues into clean energy. Within the GREENChainSAW4Life project, Green Plasma showcases its potential to address waste management challenges, reduce carbon emissions, and promote sustainable energy practices.

2.1. BIOMASS PYROLYSIS AND SYNGAS PRODUCTION.

Biomass pyrolysis is a thermochemical conversion process wherein organic materials, such as woodchips, are decomposed into syngas, biochar, and bio-oil in the absence of oxygen. Traditional pyrolysis processes operate at relatively lower temperatures, leading to incomplete conversion and the production of undesired by-products such as tar and char. However, Green Plasma technology utilizes plasma gasification, a more advanced form of pyrolysis, where biomass material is exposed to high-temperature plasma, consisting of ionized gases, to initiate various chemical reactions. This results in a more efficient breakdown of complex organic materials into simpler, energy-rich gases, primarily syngas, which is composed of hydrogen, carbon monoxide, and minimal quantities of carbon dioxide. The use of plasma gasification enhances the overall efficiency and quality of syngas production, making it a promising technology for biomass treatment and energy generation.

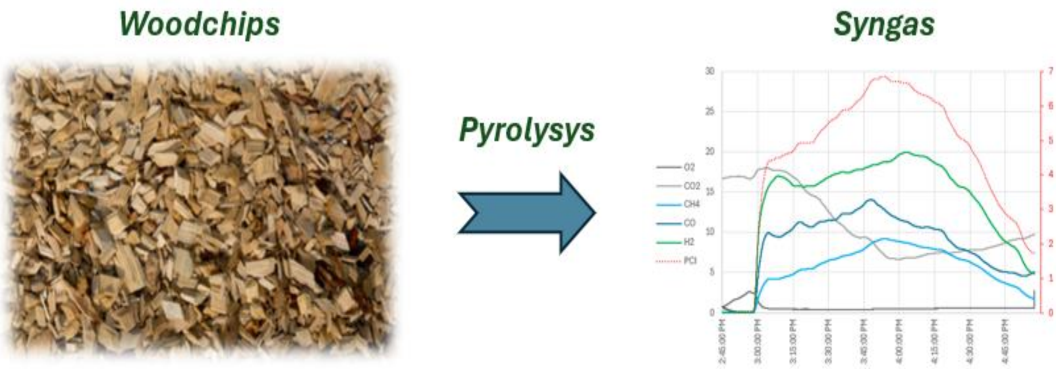

Figure 2.1

2.2. CHALLENGES IN FOREST RESIDUE WASTE MANAGEMENT:

Forest residue waste, including logging residues, sawdust, and wood chips, poses significant challenges for waste management and environmental sustainability. Conventional disposal methods such as landfilling and open burning can lead to air and water pollution, soil degradation, and greenhouse gas emissions. Furthermore, the inefficient utilization of forest residues represents a missed opportunity for resource recovery and renewable energy generation. Sustainable management of forest residue waste requires innovative solutions that not only minimize environmental impact but also maximize the value extracted from biomass resources. Green Plasma technology offers a promising solution by efficiently converting forest residue waste into valuable syngas, thereby reducing reliance on conventional disposal methods, and contributing to renewable energy production.

2.3. INTRODUCTION TO GREENPLASMA TECHNOLOGY

Green Plasma technology represents a pioneering approach in biomass treatment, specifically tailored to address the challenges associated with the conversion of residual forest biomass into energy. By leveraging plasma gasification, Green Plasma technology can efficiently process a wide range of biomass feedstocks, including those with high moisture content or irregular sizes, which are often unsuitable for conventional treatment methods. The versatility and environmental sustainability of Green Plasma technology make it an attractive solution for biomass treatment and energy production, aligning with global efforts towards cleaner energy production and sustainable resource management. As part of the GREENChainSAW4Life project, Green Plasma technology plays a crucial role in demonstrating a viable pathway for the utilization of residual forest biomass, contributing to the project's objectives of reducing carbon emissions, promoting sustainable practices, and enhancing energy security.

Figure 2.2.

3. METHODOLOGY

3.1. DATA COLLECTION AND ANALYSIS METHODS:

The methodology employed for data collection and analysis involves the utilization of a high-tech measurement station equipped with advanced sensors to monitor the composition of syngas generated by the Green Plasma system. This station incorporates sensors for hydrogen (H2), oxygen (O2), methane (CH4), carbon monoxide (CO), and carbon dioxide (CO2), enabling simultaneous measurement of the percentage composition of syngas components. Throughout the operational period, the measurement station continuously collects data on the concentration levels of these gases.

3.2. DATA LOGGING AND CORRELATION:

The collected data, including gas composition percentages and operational parameters of the Green Plasma system, are logged, and recorded for subsequent analysis. These data logs provide a comprehensive dataset for evaluating the performance of the system and identifying correlations between various variables. By analyzing the collected data, correlations between operational parameters and syngas composition can be established, facilitating insights into the efficiency and effectiveness of the Green Plasma technology.

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Figure 3. (Datalogger screenshot shows the of variables saved in file csv).

3.3. PROCESS OPTIMIZATION:

The primary objective of the analysis is to optimize the Green Plasma process for enhanced efficiency and performance. By correlating variables such as temperature, feedstock characteristics, and system parameters with syngas composition, opportunities for process optimization can be identified. Insights gained from the analysis can inform adjustments to operational parameters, equipment settings, and feedstock handling procedures to maximize syngas yield and quality while minimizing energy consumption and environmental impact. Through iterative analysis and optimization, the Green Plasma system can be fine-tuned to achieve optimal performance and contribute to sustainable biomass treatment and energy production.

4. PERFORMANCE ANALYSIS:

4.1. EFFICIENCY OF BIOMASS CONVERSION:

The efficiency of biomass conversion is a critical aspect of evaluating the performance of the Green Plasma system. This analysis focuses on quantifying the efficiency with which biomass, such as woodchips, is converted into syngas. By comparing the mass of biomass input to the system with the mass of syngas produced, the conversion efficiency can be calculated. Additionally, energy efficiency metrics, such as the energy content of the syngas relative to the energy input required for the plasma gasification process, provide insights into the overall efficiency of biomass conversion. The performance analysis aims to assess the effectiveness of the Green Plasma technology in converting biomass feedstock into valuable syngas for energy production.

Efficiency is a key indicator that will be closely monitored, calculated based on the residual material after thermoconversion with pyrolysis, and then subtracting the oxidation factor present in the gas. This gives us, based on the amount of material initially inserted, how much gas we obtain. The formula is:

$$Ec = \frac{(\mathrm{Mi} - \mathrm{R})}{\mathrm{Mi}} * 100$$

Equation 4.1.

$$Mc = (Mi - R) * (1 - \% \frac{CO2}{100})$$

Equation 4.2.

$$XCO2 = \%CO2/100$$

Equation 4.3.

$$Esyngas = \frac{(\mathrm{Mi} - \mathrm{R})}{\mathrm{Mi}} * (1 - XCO2) * 100$$

Equation 4.4.

Where:

Ec: Efficiency conversion of biomass.

Esyngas: Efficiency Syngas

Mi: Initial biomass input.

R: Residual biomass after pyrolysis.

Mc: Syngas

4.2. SYNGAS COMPOSITION AND QUALITY:

The composition and quality of the syngas produced by the Green Plasma system are essential factors in determining its suitability for various applications, including power generation and biofuel synthesis. This analysis involves examining the percentage composition of key gases, such as hydrogen, carbon monoxide, methane, and carbon dioxide, in the syngas. Additionally, parameters such as heating value, calorific value, and impurity levels (e.g., tar content) are evaluated to assess the quality of the syngas. By comparing the syngas composition and quality against desired specifications and industry standards, the performance analysis aims to determine the suitability of the syngas for different end uses and identify opportunities for optimization.

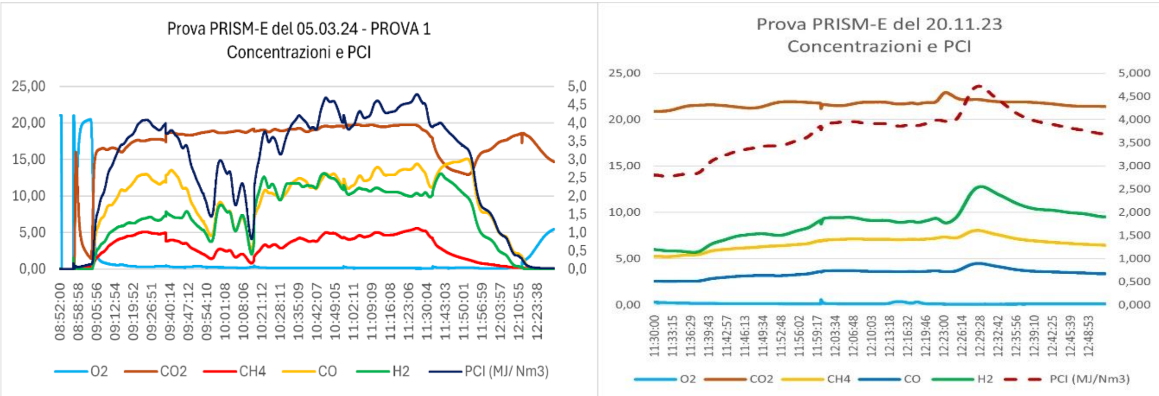


Figure. 4.5. (E.s. Composition %Syngas)

4.3. ENVIRONMENTAL IMPACT ASSESSMENT:

Assessing the environmental impact of the Green Plasma system is crucial for evaluating its sustainability and compliance with regulatory requirements. This analysis considers factors such as emissions of greenhouse gases (e.g., CO2), criteria pollutants (e.g., NOx), and hazardous air pollutants (e.g., particulate matter) associated with the operation of the system. Additionally, life cycle assessment (LCA) methodologies may be employed to evaluate the overall environmental footprint of the Green Plasma technology, including upstream impacts such as feedstock sourcing and downstream impacts such as waste disposal. By quantifying and analyzing the environmental impacts of the Green Plasma system, the performance analysis aims to identify areas for improvement and inform decision-making processes related to sustainability and regulatory compliance.

The environmental impact assessment of the Green Plasma system encompasses various aspects of its operation and emissions. The system's design and operational parameters are carefully considered to minimize environmental impacts while maximizing efficiency and sustainability. Key factors evaluated in the assessment include air emissions, waste generation, energy consumption, and overall ecological footprint.

One significant aspect of the Green Plasma system's environmental impact is its emissions profile. The system produces syngas with nearly negligible levels of NOx, primarily due to the stoichiometric oxidation process, which aims to balance the system during startup phase. This minimal NOx emission contributes to improved air quality and reduced atmospheric pollution.

Additionally, the Green Plasma system incorporates measures to capture CO2 and fractional amounts of HSO4 from the syngas. This is achieved through the utilization of filters containing CaO, porous alumina, and ZnO. These filters effectively capture and sequester CO2 and HSO4, further reducing the system's environmental footprint and mitigating potential greenhouse gas emissions.

Furthermore, the environmental impact assessment considers the system's overall energy efficiency and resource utilization. By converting residual forest biomass into syngas, the Green Plasma system helps mitigate the need for fossil fuel-based energy sources, thereby reducing greenhouse gas emissions and promoting renewable energy adoption.

Overall, the Green Plasma system demonstrates a commitment to environmental stewardship by minimizing emissions, capturing pollutants, and promoting sustainable energy production. Through ongoing monitoring and optimization, the system continues to evolve as a leading solution for environmentally responsible biomass treatment and energy generation.

5. CASE STUDY: GREENCHAINSAW4LIFE PROJECT

5.1. PROJECT OBJECTIVES AND SCOPE:

The GREENChainSAW4Life project aims to address key challenges in forest residue waste management while promoting sustainable energy practices. The project's primary objective is to demonstrate the viability of utilizing Green Plasma technology for the conversion of residual forest biomass into clean energy, specifically syngas. By integrating Green Plasma technology into the biomass-to-energy conversion process, the project seeks to showcase an efficient, scalable, and environmentally friendly solution for energy production. The scope of the project includes conducting pilot-scale trials to assess the performance and feasibility of Green Plasma technology in real-world settings. Additionally, the project aims to evaluate the economic viability and environmental sustainability of implementing Green Plasma technology within the forestry sector.

5.2. INTEGRATION OF GREEN PLASMA TECHNOLOGY:

The integration of Green Plasma technology into the GREENChainSAW4Life project involves several key steps. Initially, a pilot-scale Green Plasma system is installed and commissioned at a selected site to initiate biomass-to-energy conversion trials.

The location of the trials is our company facilities, IRIS S.R.L. The system is a small-scale solution situated within a 20-feet container.

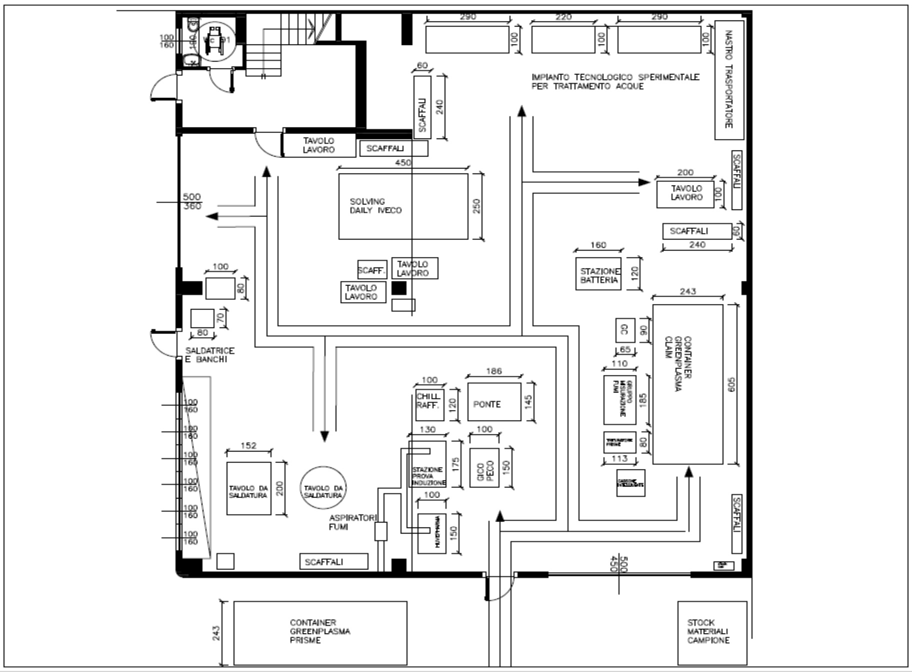


Figure 5.1.

The system is configured to process various types of forest residue waste, including logging residues, sawdust, and wood chips, to evaluate its performance across different feedstock compositions. Throughout the trial period, data on syngas production, energy efficiency, and environmental impact are collected and analyzed to assess the effectiveness of Green Plasma technology in meeting project objectives. Furthermore, collaboration with stakeholders from the forestry industry, and research institutions, is essential to ensure the successful implementation and dissemination of project outcomes.

5.3. RESULTS AND OBSERVATIONS:

The results and observations from the GREENChainSAW4Life project provide valuable insights into the performance and potential applications of Green Plasma technology for biomass treatment and energy production. Analysis of trial data reveals key performance indicators such as biomass conversion efficiency, syngas composition, and environmental impact metrics. These findings contribute to a better understanding of the capabilities and limitations of Green Plasma technology in real-world operating conditions. Furthermore, observations from the project highlight operational challenges, technological innovations, and best practices for optimizing the performance of Green Plasma systems. The outcomes of the project serve as a foundation for future research, development, and deployment efforts aimed at advancing sustainable biomass utilization and forest management practices.

6. ECONOMIC VIABILITY:

6.1. COST ANALYSIS AND RETURN ON INVESTMENT (ROI):

The economic viability of implementing Green Plasma technology is assessed through a comprehensive cost analysis and calculation of the return on investment (ROI). This involves evaluating both the initial capital investment required for acquiring and installing the Green Plasma system, as well as the ongoing operational and maintenance costs. The cost analysis includes factors such as equipment procurement, installation expenses, labor costs, energy consumption, and maintenance expenditures. Additionally, the potential revenue streams generated from the sale of syngas or other by-products, as well as any applicable incentives or subsidies, are considered. By comparing the total costs against the expected financial returns over the system's lifespan, the ROI is calculated to determine the economic feasibility and profitability of deploying Green Plasma technology for biomass treatment and energy production.

6.2. MARKET POTENTIAL AND FUTURE OUTLOOK:

An analysis of the market potential and future outlook for Green Plasma technology is conducted to assess its long-term economic viability and growth prospects. This involves evaluating market trends, demand dynamics, regulatory frameworks, and competitive landscape within the biomass-to-energy sector. Factors such as the availability of biomass feedstocks, energy market prices, government policies, and technological advancements are considered in forecasting the market demand for Green Plasma systems. Additionally, potential opportunities for expanding into new markets or applications, such as decentralized energy production or biofuel synthesis, are explored to capitalize on emerging trends and market opportunities. The market analysis provides valuable insights into the scalability and sustainability of Green Plasma technology as a commercially viable solution for biomass utilization and energy production.

6.3. ECONOMIC BENEFITS OF GREEN PLASMA TECHNOLOGY IMPLEMENTATION:

The economic benefits of implementing Green Plasma technology extend beyond direct financial returns to include various indirect and intangible advantages. These benefits may include cost savings from reduced waste disposal expenses, avoidance of landfilling or incineration costs, and potential revenue generation from the sale of renewable energy credits or carbon offsets. Furthermore, the adoption of Green Plasma technology can enhance operational efficiencies, improve resource utilization, and create new employment opportunities in the biomass-to-energy sector. Additionally, the environmental and social co-benefits associated with reduced greenhouse gas emissions, improved air quality, and sustainable forest management contribute to the overall economic value proposition of Green Plasma technology implementation. By quantifying and monetizing these economic benefits, stakeholders can make informed decisions regarding investment in Green Plasma technology and leverage its potential to drive economic growth, job creation, and environmental sustainability.

7. CONCLUSION:

The comprehensive analysis conducted in this deliverable provides valuable insights into the performance, economic viability, and potential applications of Green Plasma technology for biomass treatment and energy production. Through a systematic evaluation of key aspects including biomass conversion efficiency, syngas composition, environmental impact, and economic feasibility, several conclusions can be drawn:

7.1. EFFECTIVENESS OF GREEN PLASMA TECHNOLOGY:

The analysis demonstrates that Green Plasma technology offers an efficient and environmentally sustainable solution for converting residual forest biomass into valuable syngas. High conversion efficiencies, coupled with low emissions and minimal waste generation, highlight the effectiveness of Green Plasma technology in addressing challenges associated with biomass waste management.

7.2. ECONOMIC VIABILITY:

The cost analysis and ROI calculations indicate that Green Plasma technology can be economically viable, particularly when considering the potential revenue streams from syngas sales and the economic benefits associated with reduced waste disposal costs and environmental impacts. Market potential assessments suggest favorable growth prospects for Green Plasma technology, driven by increasing demand for renewable energy and sustainable waste management solutions.

7.3. ENVIRONMENTAL AND SOCIAL IMPACTS:

The environmental impact assessment reveals that Green Plasma technology offers significant environmental benefits, including reduced greenhouse gas emissions, improved air quality, and sustainable forest management practices. Additionally, the adoption of Green Plasma technology can contribute to social benefits such as job creation, local economic development, and community resilience.

7.4. FUTURE OUTLOOK AND RECOMMENDATIONS:

Looking ahead, the successful integration of Green Plasma technology into the GREENChainSAW4Life project underscores its potential to serve as a model for sustainable biomass utilization and energy production. Recommendations for future research and development efforts include scaling up Green Plasma systems for commercial deployment, exploring new market opportunities, and advancing technological innovations to further enhance performance and cost-effectiveness.

In conclusion, the findings from this deliverable reaffirm the promise of Green Plasma technology as a transformative solution for biomass treatment and energy production. By leveraging its efficiency, economic viability, and environmental benefits, Green Plasma technology can play a pivotal role in advancing sustainable development goals and fostering a transition towards a low-carbon, circular economy.

8. APPENDICES

8.1. DATA TABLES AND CHARTS:

This appendix contains detailed data tables and charts compiled during the performance analysis of Green Plasma technology. Included are tables presenting raw data on biomass conversion efficiency, syngas composition, operational parameters, and environmental impact metrics. Additionally, graphical representations such as line graphs, bar charts, and scatter plots are provided to visually depict trends, correlations, and comparative analyses derived from the collected data.

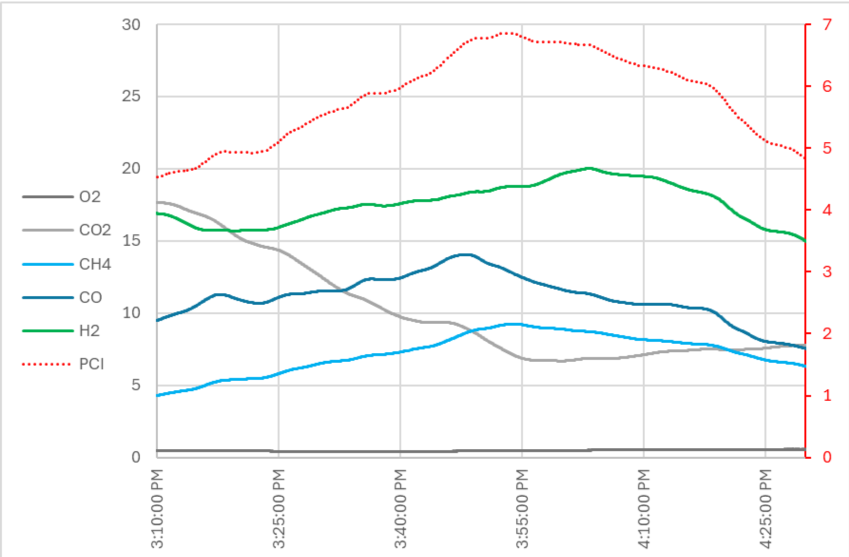
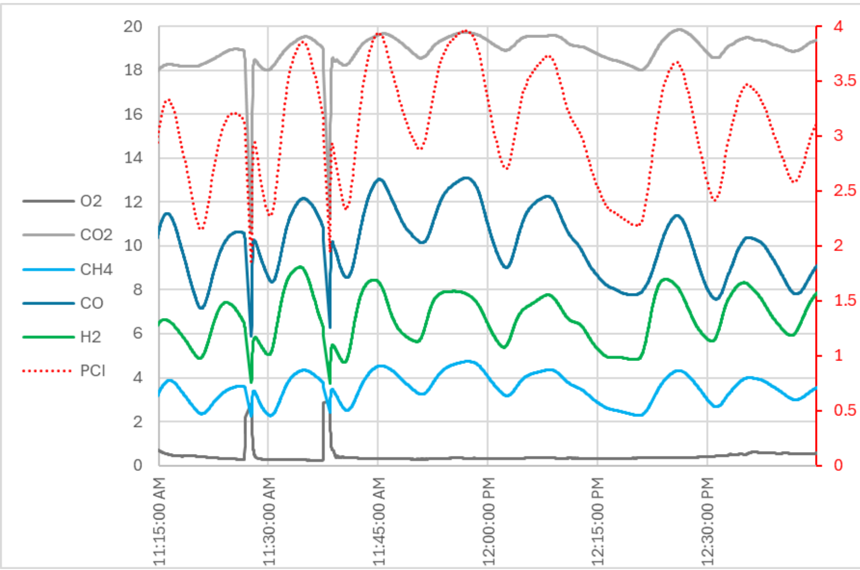


Figure 8.1 (Trial 1)



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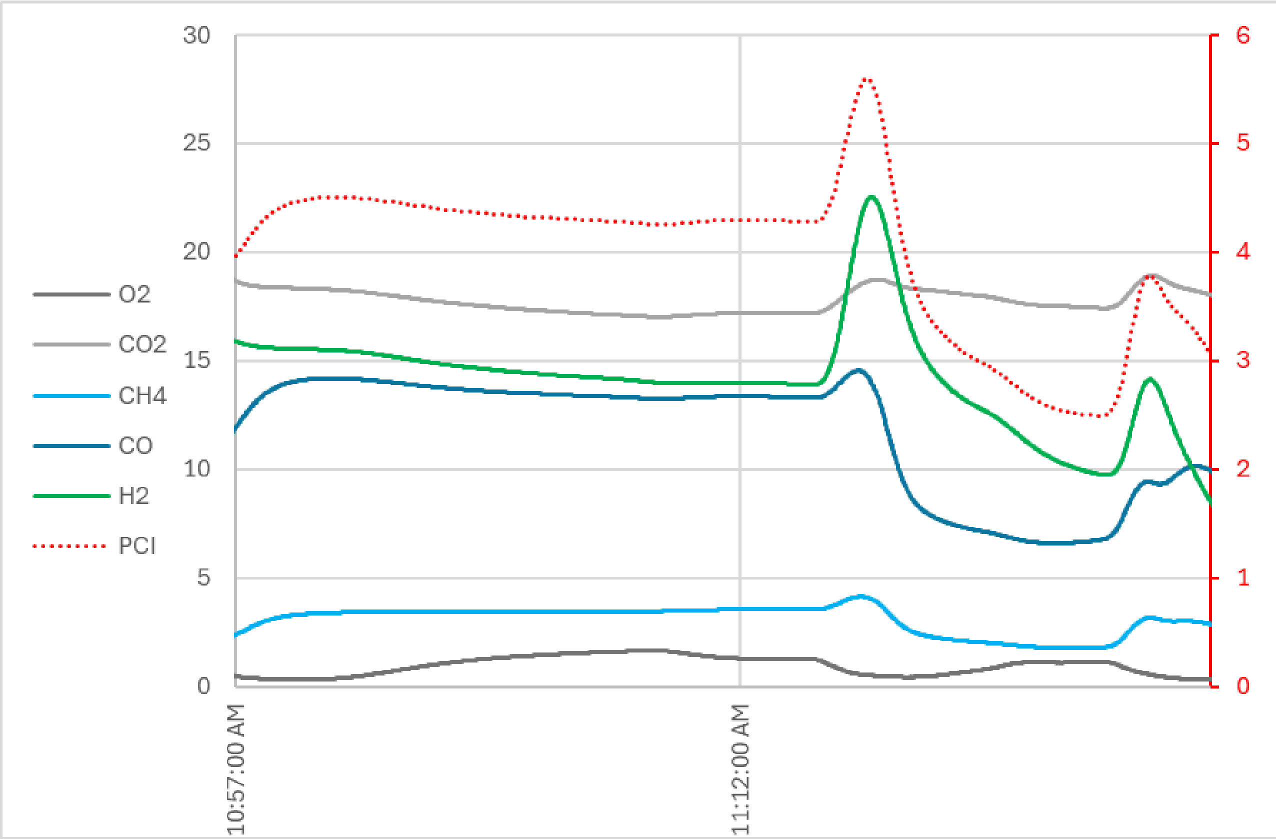

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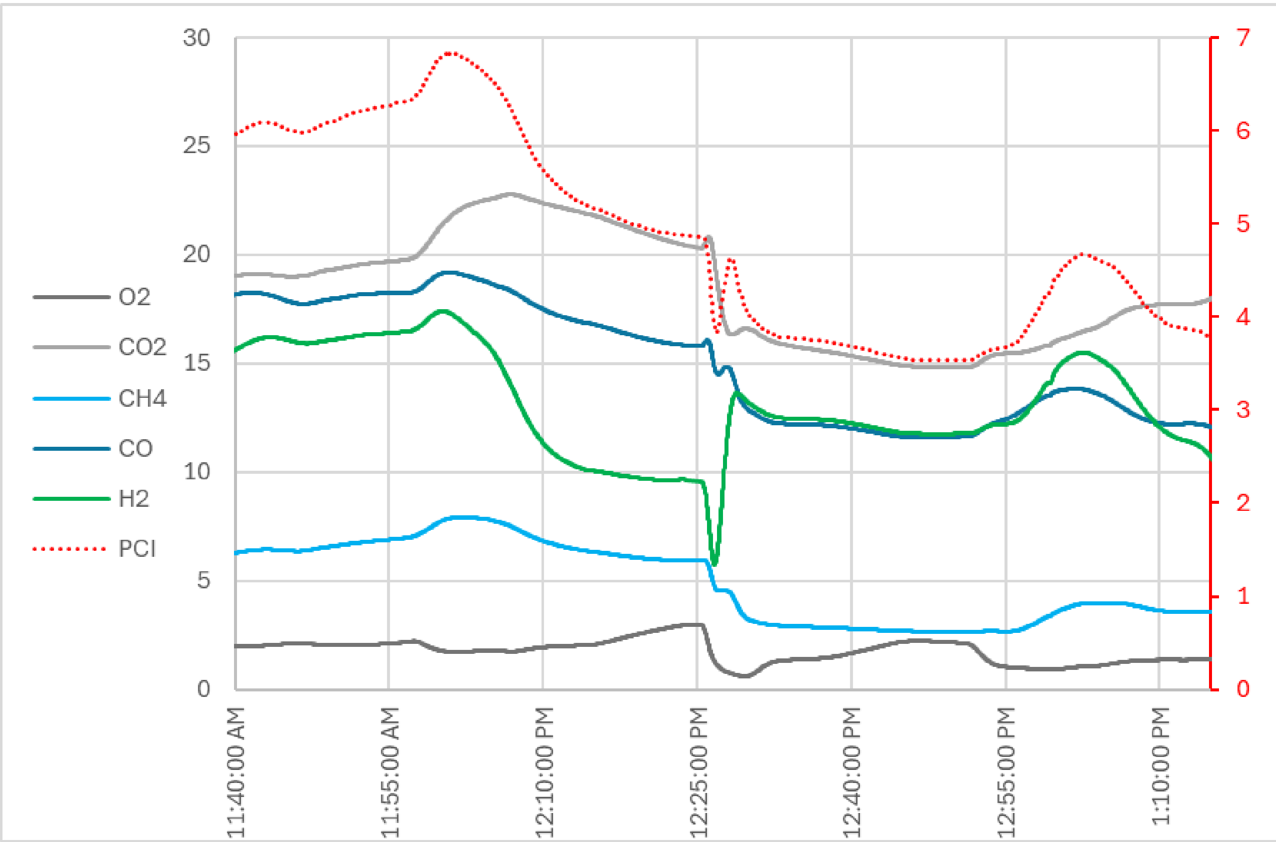

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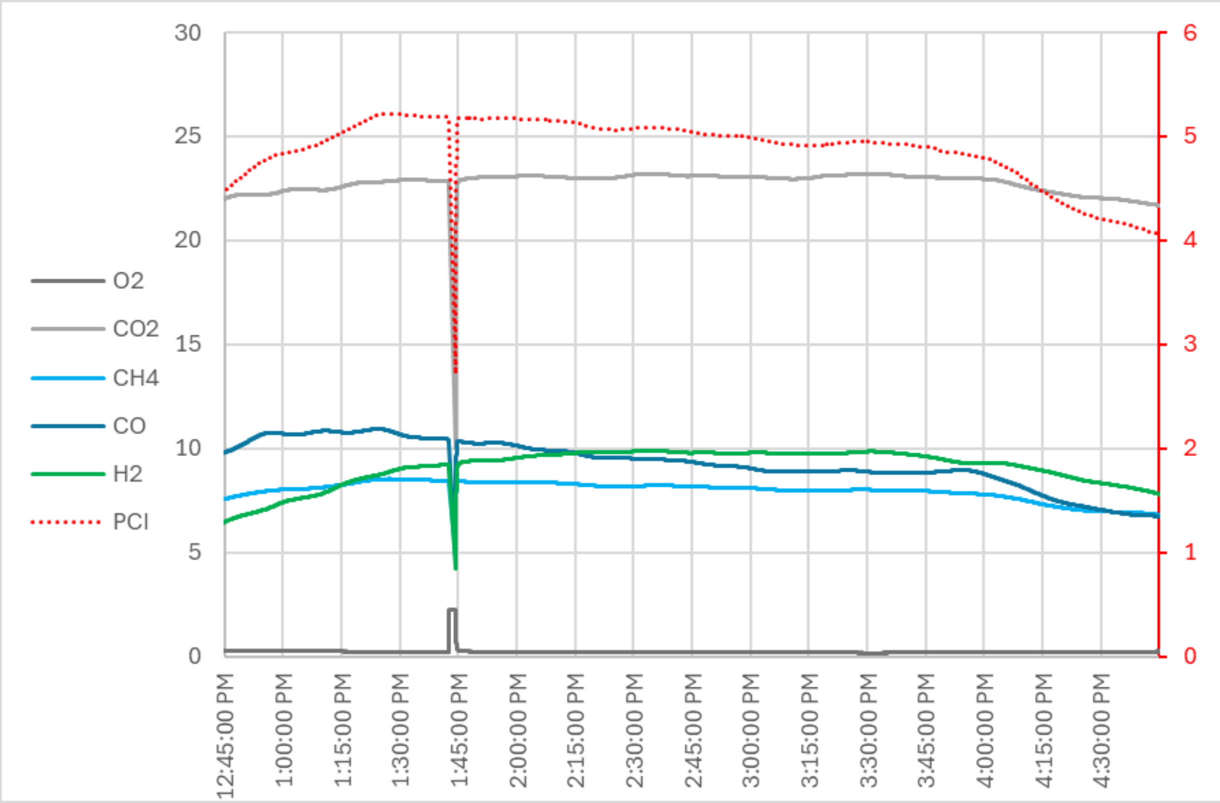

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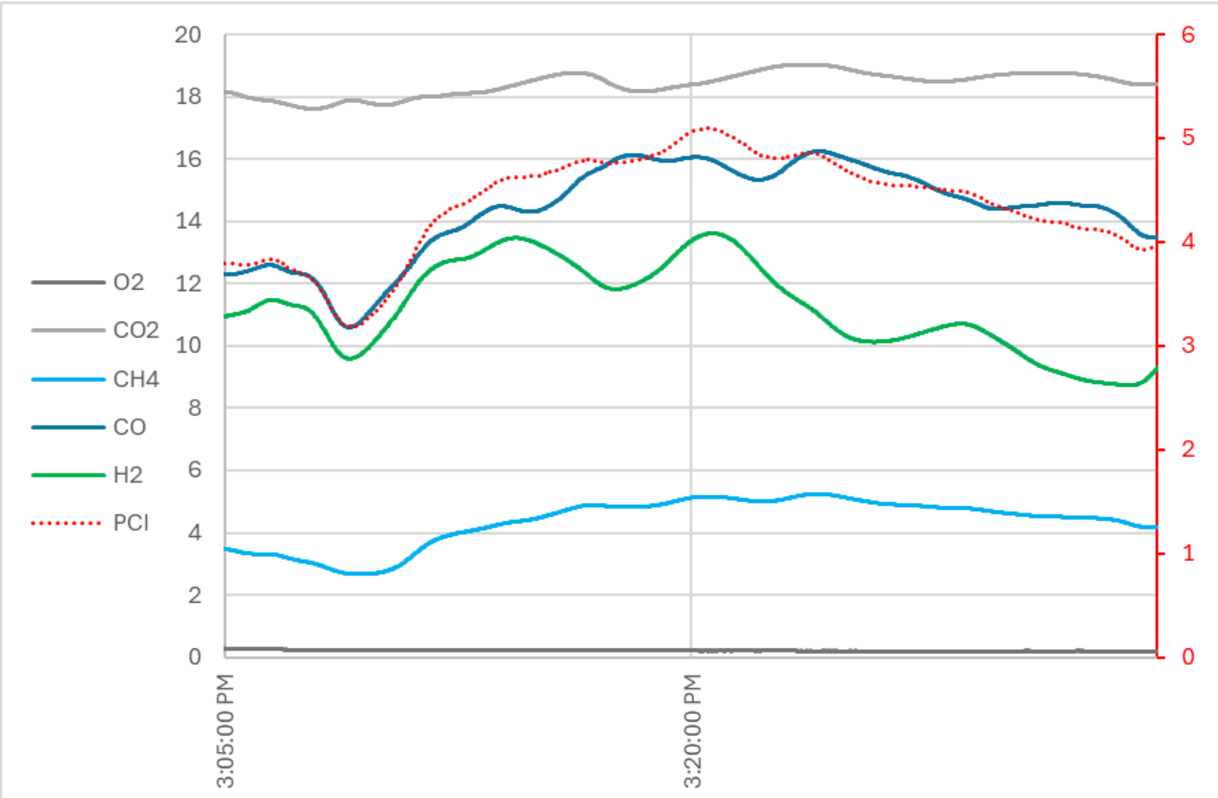

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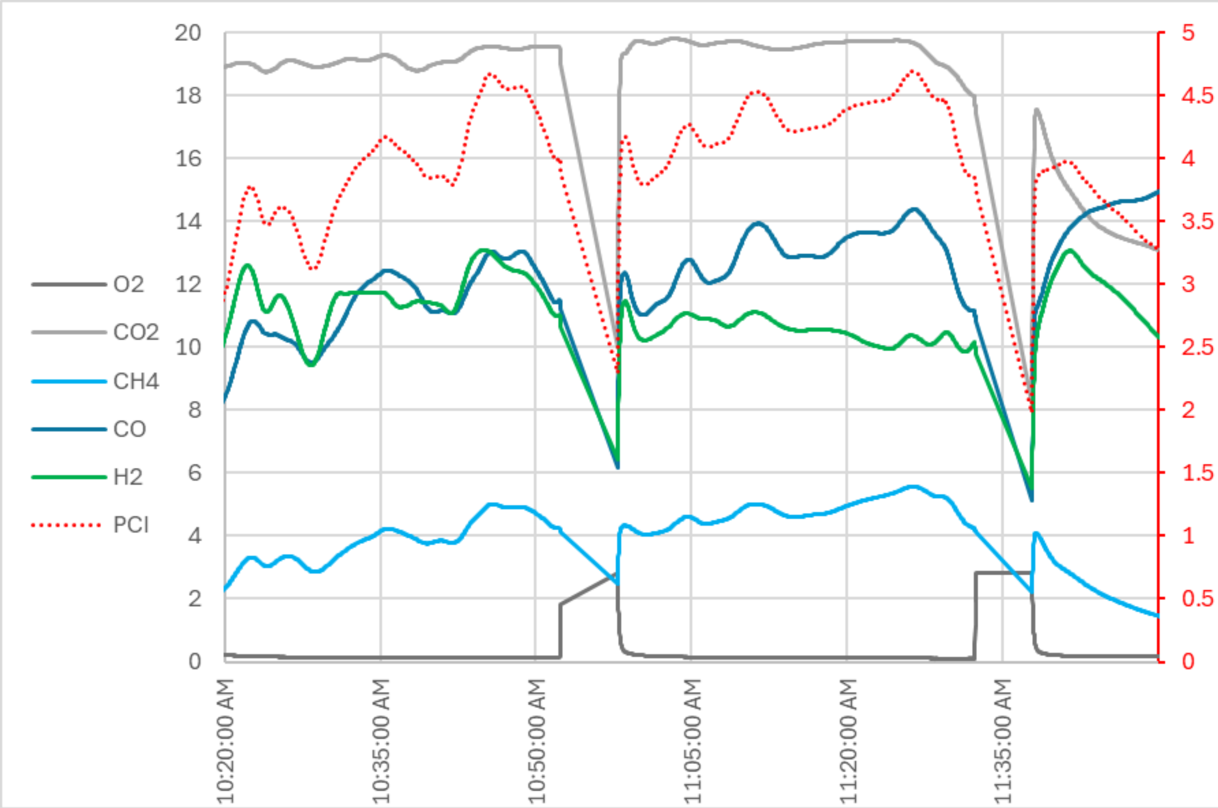
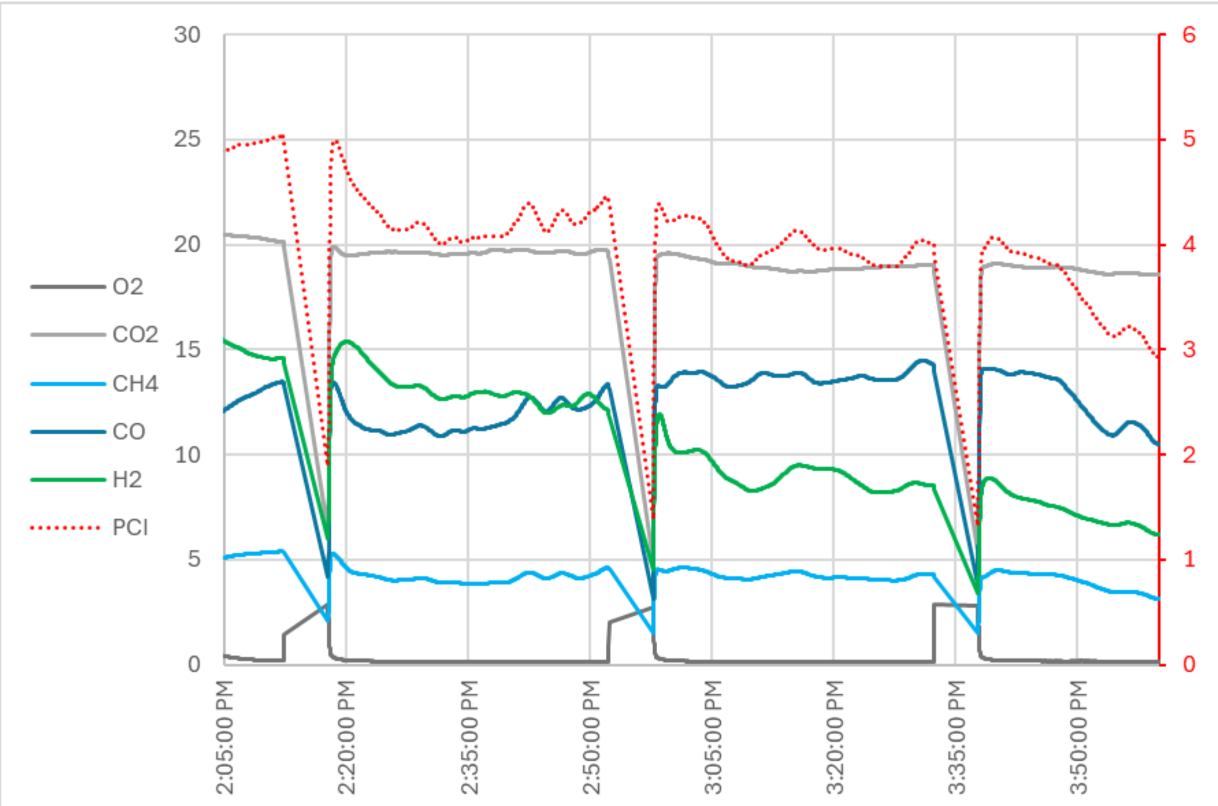


Figure 8.7 (Trial 7)



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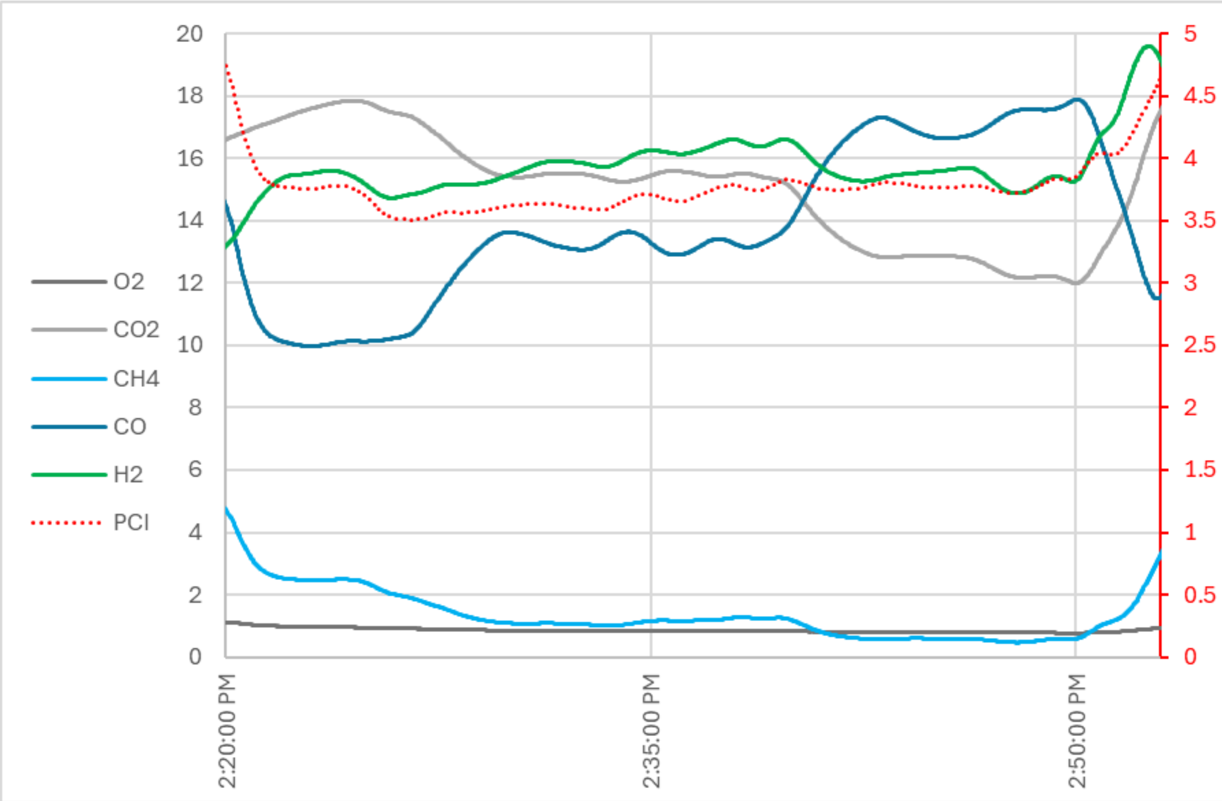

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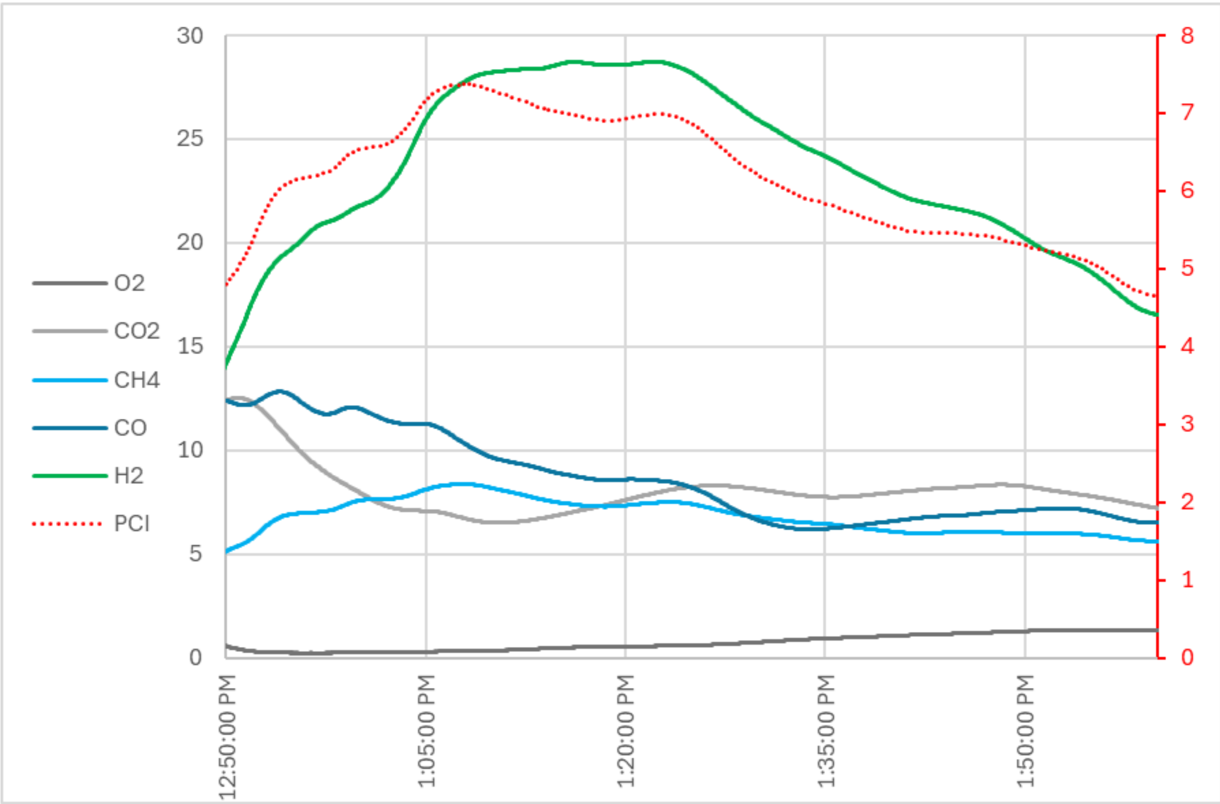

Figure 8.10 (Trial 10)

Trial #	Input mat. (Mi)	Residual after pyrolysis (R)	PCi (MJ/Nm3)	%H2	%CH4	%CO	%CO2	Efficiency (Esyngas)
1	4	0.745	5.84	17.6	7.25	11.2	10	73.2375
2	3.5	0.556	3.09	6.72	3.53	10.1	18.97	68.15780571
3	5.4	1.6	3.98	14.2	3.08	11.7	17.76	57.87259259
4	3.4	0.675	4.85	13.2	4.9	15	18.33	65.45610294
5	3.4	0.15	4.88	9.1	7.97	9.3	22.78	73.81323529
6	6	0.245	4.36	11.2	4.35	14.4	18.4	78.268
7	6	0.155	4.03	11.1	4.03	12.4	18.57	79.32639167
8	6	0.132	4.06	10.5	4.22	12.7	19.22	79.00284
9	12.5	0.32	3.77	15.7	1.34	13.9	15.02	82.804512
10	4	0.315	6.14	23.6	6.83	8.62	8.05	84.7089375

Table 8 (Table of efficiency of the syngas)

8.2. TECHNICAL SPECIFICATIONS OF GREEN PLASMA SYSTEM:

In this appendix, technical specifications of the Green Plasma system deployed for the GREENChainSAW4Life project are outlined. Detailed information on system components, including plasma gasification reactor, sensor array, control systems, and auxiliary equipment, is provided. Specifications regarding system capacity, operating parameters, energy consumption, and maintenance requirements are documented to facilitate a comprehensive understanding of the system's design and capabilities.

8.3. SUPPORTING DOCUMENTATION ON FOREST RESIDUE WASTE MANAGEMENT:

This appendix includes supporting documentation related to forest residue waste management practices and regulatory requirements. Documents such as forestry industry reports, waste management guidelines, environmental impact assessments, and relevant legislation are compiled to provide context and background information for the GREENChainSAW4Life project. Additionally, case studies, research articles, and best practices guides are included to offer insights into effective strategies for sustainable forest management and biomass utilization.