Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 13, Special Issue 2, 2025
DOI (Journal): 10.37591/JoPC

https://journals.stmjournals.com/jopc

Review JoPC

# Integrated Plasma Gasification Technologies for Enhanced Energy Conversion and Environmental Sustainability: A Short Review

Vedraj Nagar[1,*], Rajneesh Kaushal[2]

***Abstract***

*Plasma Gasification emerged as a constructive tool for waste management and cleaner energy production. The versatility of the process makes it a promising solution of the global energy crises. In this paper, a brief coverup is done of integrated plasma models. Plasma technology is an emerging solution for recycling a wide range of waste making it a highly sustainable, efficient, and environment-friendly process. The integration of Plasma Gasification with complementary technologies further enhances its capabilities, allowing for improved energy conversion efficiency, reduced environmental impact, and expanded application areas. This review paper provides an overview of the effects of integrating PG with a wide range of technologies, including chemical looping, water electrolysis, methanol synthesis, supercritical $CO_2$ cycles, solid oxide fuel cells (SOFCs), sludge pyrolysis, multi-stage flash desalination, direct carbon fuel cells (DCFCs), steam turbine cycles, automobile reforming, $CO_2$ gasification, water shift processes, calcium looping, coal-fired power generation, water-gas shift reactions, acid gas removal, and pressure swing adsorption. The synergistic interactions between PG and these technologies are discussed, along with their implications for energy efficiency, resource utilisation, and environmental sustainability. This review aims to provide insights into the potential of integrated PG systems to address global energy and environmental challenges while advancing the transition towards a more sustainable energy future.*

**Keywords:** Plasma gasification, waste to energy, renewable energy, hybrid plasma models, circular economy

## INTRODUCTION

Plasma gasification uses extremely high temperatures generated by plasma torches to convert waste into syngas, efficiently breaking down even hazardous materials. Traditional gasification operates at lower temperatures and may not fully decompose complex wastes, resulting in different byproducts and potentially higher emissions. Gasification can harm the ecosystem by releasing pollutants, such as heavy metals and particulate matter, into the air and water. This can lead to soil contamination, water pollution, and harm to plant and animal life, disrupting ecosystems and biodiversity. The process also contributes to greenhouse gas emissions.

Plasma gasification utilises high-temperature plasma to convert organic and inorganic materials into syngas, a versatile energy source, while minimising environmental impact. Its efficiency in waste management and energy production makes it a promising solution for addressing global energy crises and advancing towards a more sustainable future [1].

***Author for Correspondence**
Vedraj Nagar

[1]Research Scholar, Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, Haryana, India
[2]Assistant Professor, Department of Mechanical Engineering, National Institute of Technology, Kurukshetra, Haryana, India

Received Date: March 21, 2024
Accepted Date: July 25, 2024
Published Date: February 17, 2025

**Citation:** Vedraj Nagar, Rajneesh Kaushal. Integrated Plasma Gasification Technologies for Enhanced Energy Conversion and Environmental Sustainability: A Short Review. Journal of Polymer & Composites. 2025; 13(Special Issue 2): S67–S75p.

Plasma gasification efficiently reduces waste, producing syngas for energy, and minimizes landfill use. It emits fewer greenhouse gases compared to incineration and generates valuable byproducts like electricity and slag. This technology converts waste into renewable energy, promoting environmental sustainability.

Plasma gasification efficiently reduces waste, producing syngas for energy, and minimizes landfill use. It emits fewer greenhouse gases compared to incineration and generates valuable byproducts like electricity and slag. This technology converts waste into renewable energy, promoting environmental sustainability. Plasma gasification is a versatile technology that can be utilized effectively in various application areas. Majorly the technology focusses on waste management ranges from municipal solid waste, industrial waste hazardous waste and the waste of nuclear establishment. It offers advantage processing of wide variety of waste. Table 1 highlights the various feedstock that can be processed. Additional utilisation of PG process includes energy production, Chemical Synthesis, biomass conversion, water treatment etc. The syngas produced through plasma gasification can be used as a fuel for power generation in gas turbines, steam turbines, or fuel cells. Also, Syngas derived from plasma gasification can serve as a feedstock for chemical synthesis processes, such as the production of hydrogen, ammonia, methanol, and synthetic fuels. The syngas produced through plasma gasification can be used as a fuel for power generation in gas turbines, steam turbines, or fuel cells. This enables the conversion of waste materials into electricity, heat, and other forms of energy, contributing to renewable energy generation and reducing reliance on fossil fuels.

### Need of Hybrid Approach

The transition from conventional plasma gasification to an integrated plasma gasification approach is necessitated by several factors, primarily driven by the need for enhanced efficiency, sustainability, and versatility in waste management and energy production. Firstly, traditional plasma gasification systems, while effective in waste treatment and energy generation, often operate in isolation, limiting their overall efficiency and potential. By integrating plasma gasification with complementary technologies, such as chemical looping, water electrolysis, and solid oxide fuel cells, among others, the overall performance and capabilities of the system can be significantly enhanced. This integration allows for synergistic interactions between different processes, resulting in improved energy conversion efficiency, reduced environmental impact, and expanded application areas.

## ABOUT INTEGRATED PLASMA GASIFICATION CONCEPT (IPGC)

IPGC represents a cutting-edge approach to waste management and energy generation, combining the principles of PG with other complementary technologies [16][17]. One common approach is to combine PG with conventional incineration or pyrolysis processes. In such hybrid systems, the waste material is first subjected to conventional thermal treatment to reduce its volume and remove any contaminants that may interfere with the plasma process. The resulting char or ash is then fed into the plasma gasifier, where it undergoes further conversion into syngas. Another variation of the hybrid model involves coupling PG with advanced gas cleaning and purification technologies [18]. This integration allows for the removal of impurities such as tar, sulphur compounds, and particulate matter from the syngas stream, resulting in a cleaner and more valuable product. By optimising the gas cleanup process, IPGC systems can achieve higher syngas yields and improve overall energy efficiency [13]. Figure 1 provides a glimpse of plasma gasification process. The exhaust gas had to underwent multiple process to make it more valuable and energy efficient.

**Table 1.** Classification of feedstocks processed in PG.

| Category | Feedstock | Reference |
|---|---|---|
| MSW | Household waste, commercial waste, industrial waste | [2]–[5] |
| Biomass | Wood, agricultural residues, energy crops, algae | [6] |
| Plastic waste | Plastic bags, containers, packaging, electronic waste | [7] |
| Medical waste | Infectious and contaminated waste, pharmaceutical waste | [8]–[10] |
| Hazardous waste | Chemical waste, toxic waste, radioactive waste | [11][12][13] |
| Automobile waste | Used tyres and rubber claddings | [14] |
| Sewage sludge | Sludge from waste water treatment plants | [15] |

 

Journal of Polymer & Composites
Volume 13, Special Issue 2
ISSN: 2321-2810 (Online), ISSN: 2321-8525 (Print)

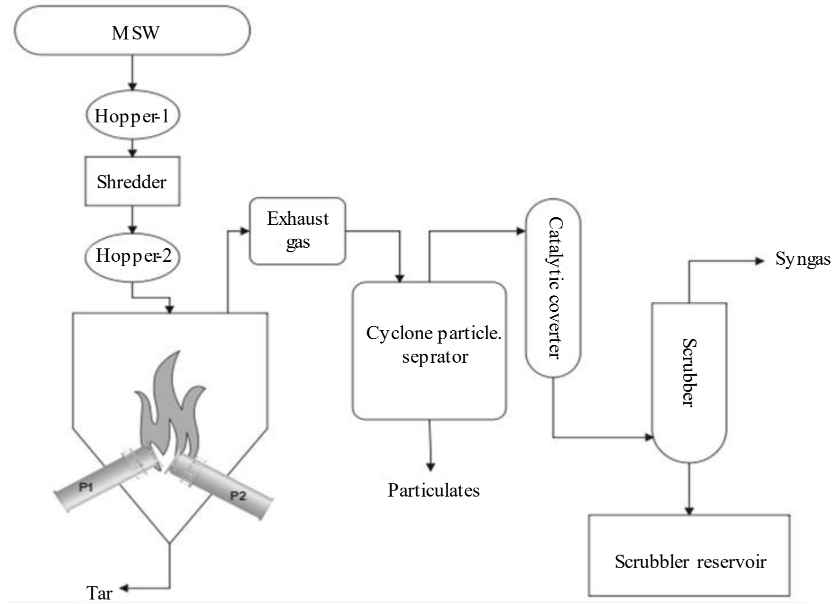

**Figure 1.** Basic plasma gasification model.

Furthermore, Hybrid PG can be integrated with waste-to-energy (WTE) and combined heat and power (CHP) systems to maximise energy recovery and utilisation. In WTE applications, the syngas produced from PG can be used to fuel gas turbines or internal combustion engines, generating electricity and heat [19]. The residual heat from these processes can then be captured and utilised for district heating or other industrial purposes, thereby maximising the overall energy output of the system. Moreover, IPGC holds promise for the sustainable production of biofuels and chemicals from waste biomass [20]. By combining PG with biomass gasification or fermentation processes, it is possible to produce a wide range of valuable products, including bioethanol, biodiesel, and bio-based chemicals. This integrated approach not only helps to mitigate waste disposal challenges but also contributes to the development of a circular bioeconomy, where renewable resources are efficiently utilised and recycled [21].

In addition to its environmental and energy benefits, IPGC offers economic advantages through the generation of valuable by-products and potential revenue streams [10]. The syngas produced can be converted into high-value chemicals or fuels, providing opportunities for revenue generation and diversification. Furthermore, the reduction in waste disposal costs and potential incentives for renewable energy production can contribute to the overall economic viability of IPGC projects [9]. Figure.1 shows various processes clubbed with PG process and their effect on the output.

**Hybridisation Methods in Plasma Gasification Process**

The integration of PG with various technologies can have several positive outcomes, including enhanced efficiency, increased versatility, and improved environmental performance. Integrating plasma gasification with complementary technologies can enhance energy conversion efficiency in several ways. Combination of plasma gasification with other technologies such as gas turbines, steam turbines, or fuel cells effectively optimise the process to extract maximum energy from syngas. Plasma gasification generates high temperatures, typically exceeding 3000°C, which can be harnessed for various purposes such as steam generation or direct electricity generation through a steam turbine. By integrating heat recovery systems, the thermal energy can be efficiently captured and converted into useful work, thereby improving overall energy conversion efficiency. The waste of PG can be harnessed for various purposes such as steam generation or direct electricity generation through a steam turbine. Integrating plasma gasification with complementary technologies in a cogeneration or combined heat and power (CHP) setup allows for the simultaneous generation of electricity and useful heat. This approach maximizes the overall efficiency of energy conversion by utilizing both the electrical and thermal energy outputs of the system. Representation in Figure 2 focusses on individual effect of process on the conversion and overall efficiency of the process. Below are the technologies that are helpful in achieving valuable outcomes:

1. *Integration with chemical looping technology:* The technology enables the conversion of carbonaceous materials into syngas or hydrogen while capturing carbon dioxide through redox reactions involving metal oxide-based oxygen carriers [22]. Integrating PG with chemical looping enhances the overall efficiency of the process and enables carbon capture and utilization, contributing to greenhouse gas mitigation efforts [23].
2. *Integration with alkaline water electrolysis*: Alkaline water electrolysis allows for the production of hydrogen from water using electricity generated by PG [24]. This integration enables the production of clean hydrogen as a renewable energy carrier, supporting decarbonisation efforts and promoting the development of hydrogen-based economies [25].
3. *Integration with methanol synthesis*: Integrating PG with methanol synthesis enables the direct conversion of syngas into methanol, a valuable chemical with diverse industrial applications[9]. This integration streamlines the production process, reduces energy consumption, and expands the range of products that can be derived from waste feedstocks.
4. *Integration with supercritical $CO_2$ cycles*: Supercritical $CO_2$ cycles utilise high-pressure carbon dioxide as a working fluid for power generation, offering higher efficiencies compared to traditional steam cycles [26]. Integrating PG with supercritical $CO_2$ cycles allows for the efficient utilisation of waste heat for power generation, improving overall energy conversion efficiency and reducing greenhouse gas emissions [16].
5. *Integration with solid oxide fuel cells (SOFCs):* Solid oxide fuel cells (SOFCs) enable the direct conversion of syngas into electricity and heat with high efficiency [27]. Integrating PG with SOFCs provides a reliable source of fuel for power generation, enhancing energy conversion efficiency and reducing environmental impact [21].
6. *Integration with sludge pyrolysis:* Integrating PG with sludge pyrolysis processes allows for the treatment of sewage sludge and other organic waste materials to produce syngas or biochar [21]. This integration offers a sustainable solution for waste management while generating valuable products for energy recovery and soil improvement [28][29].
7. *Integration with multi-stage flash desalination*: Multi-stage flash desalination systems utilise waste heat for water desalination, offering an energy-efficient solution for freshwater production [30]. Integrating PG with multi-stage flash desalination allows for the utilisation of waste heat generated during the gasification process, improving overall energy efficiency and water resource management [31].
8. *Integration with direct carbon fuel cell systems (DCFCs):* Direct carbon fuel cell systems enable the direct conversion of carbonaceous materials into electricity with high efficiency [32]. Integrating PG with DCFCs offers a decentralised and sustainable solution for power generation, reducing reliance on fossil fuels and mitigating greenhouse gas emissions [33].
9. *Integration with steam turbine cycles*: Steam turbine cycles utilise steam generated from PG for power generation. Integrating PG with steam turbine cycles enhances energy conversion efficiency and enables the efficient utilisation of waste heat for power generation [10].
10. *Integration with automobile reforming*: Integrating PG with automobile reforming technologies enables the production of hydrogen-rich syngas from liquid hydrocarbon fuels for use in fuel cell vehicles [34]. This integration offers a sustainable alternative to conventional transportation fuels, reducing greenhouse gas emissions and promoting the adoption of hydrogen fuel cell vehicles [10].
11. *Integration with $CO_2$ gasification*: Integrating PG with $CO_2$ gasification processes allows for the utilisation of carbon dioxide as a feedstock for gasification reactions [35]. This integration enhances resource utilisation and reduces greenhouse gas emissions, contributing to carbon capture and utilisation efforts.
12. *Integration with calcium looping:* Calcium looping technology enables the capture of carbon dioxide from syngas streams, reducing greenhouse gas emissions and enhancing environmental performance [36]. Integrating PG with calcium looping allows for carbon capture and utilisation, supporting efforts to mitigate climate change [20].
13. *Integration with coal-fired power generation*: Integrating PG with coal-fired power generation allows for the utilisation of coal as a feedstock for gasification, reducing emissions and improving

 

efficiency compared to conventional combustion processes [37]. This integration facilitates the transition to cleaner and more sustainable energy systems [38].

14. *Integration with water-gas shift reactions*: Water-gas shift reactions convert carbon monoxide and steam into hydrogen and carbon dioxide, improving the quality of syngas produced from PG [39]. This integration enhances the efficiency and versatility of PG systems, enabling the production of high-purity hydrogen for various applications.
15. *Integration with acid gas removal*: Integrating PG with acid gas removal processes allows for the purification of syngas streams by removing acidic components such as hydrogen sulphide and carbon dioxide[40]. This integration improves the quality of syngas produced, making it suitable for a wider range of applications, including chemical synthesis and fuel production[28].
16. *Integration with pressure swing adsorption:* Integrating PG with pressure swing adsorption processes enables the separation and purification of hydrogen from syngas streams[41]. This integration enhances the production of clean hydrogen for fuel cell applications, supporting the transition to low-carbon energy systems.

Results obtained by various researchers using integrated plasma approach are discussed below. The tabular data considers the effect of feedstock processed in the integrated plasma approach. Use of simulation tool is helpful in achieving best possible result. Various simulation tool i.e., Aspen, Ansys, MATLAB, and various others plays critical role in obtaining optimised result. These synergistic approaches optimise energy conversion, reduce environmental impact, and promote sustainable solutions for global energy challenges. The study showed improved conversion efficiency.

Table 2 discussed the author’s work considering integrated waste management techniques.

**Table 2.** Summary of hybrid plasma models.

| **Hybrid system** | | **Feedstock** | **Simulation tool** | **Results** | **Source** |
|---|---|---|---|---|---|
| Primary process | Secondary treatment | | | | |
| PG | CLC | Electrical & electronic waste | ASPEN | $\eta_{net,CKPW} = 72.35\%$<br>$\eta_{net,ESW} = 64.92\%$ | [23] |
| PG | Alkaline water electrolysis Methanol synthesis supercritical $CO_2$ cycle | Medical waste | Aspen plus MATLAB | $\eta_{energy} = 67.42\%$<br>$\eta_{exergy} = 68.60\%$<br>Investment break-even = 3.53 years | [9] |
| PG | SOFC SSG supercritical $CO_2$ cycle multi-stage flash desalination | Medical waste | Aspen Plus EBSILON | $\eta_{npg} = 41.66\%$<br>$\eta_{ue} = 64.95\%$<br>$\eta_{exergy} = 41.25\%$ | [31] |
| PG | DCFC | MSW | Aspen plus MATLAB | $\eta_{overall} = 79.5\%$ | [33] |
| PG | SOFC STC AR | Medical waste | Aspen Plus MATLAB | $\eta_{energy} = 63.20\%$<br>$\eta_{exergy} = 59.25\%$<br>Investment break-even = 3.25 years | [10] |
| PG | Electrolysis process Supercritical $CO_2$ cycle | Biomass | Aspen Plus MATLAB | $\eta_{energy} = 67.98\%$<br>$\eta_{exergy} = 64.82\%$ | [25] |
| PG | SOFC CLC | MSW | Aspen Plus | $\eta_{electrical} = 40.9\%$<br>$\eta_{exergy} = 36.1\%$ | [42] |
| Pyrolysis | $CO_2$ gasification WGS CL | Oil sludge | Aspen Plus | $\eta_{ece} = 36\%$<br>$\eta_{exergy} = 32\%$ | [43] |
| PG | coal-fired power generation | MSW | Aspen Plus =EBSILON | $\eta_{electrical} = 35.16\%$ | [37] |
| PG | WGS AGR PSA | Algae (Enteromorpha Cyanobacteria and Sargassum) | Aspen Plus | (Best results for Enteromorpha)<br>$\eta_{exergy} = 74.46\%$ | [41] |
| PG | WGS | Microalgae | Aspen Plus | $\eta_{energy} = 35.4\%$<br>$\eta_{exergy} = 44.3\%$ | [44] |

 

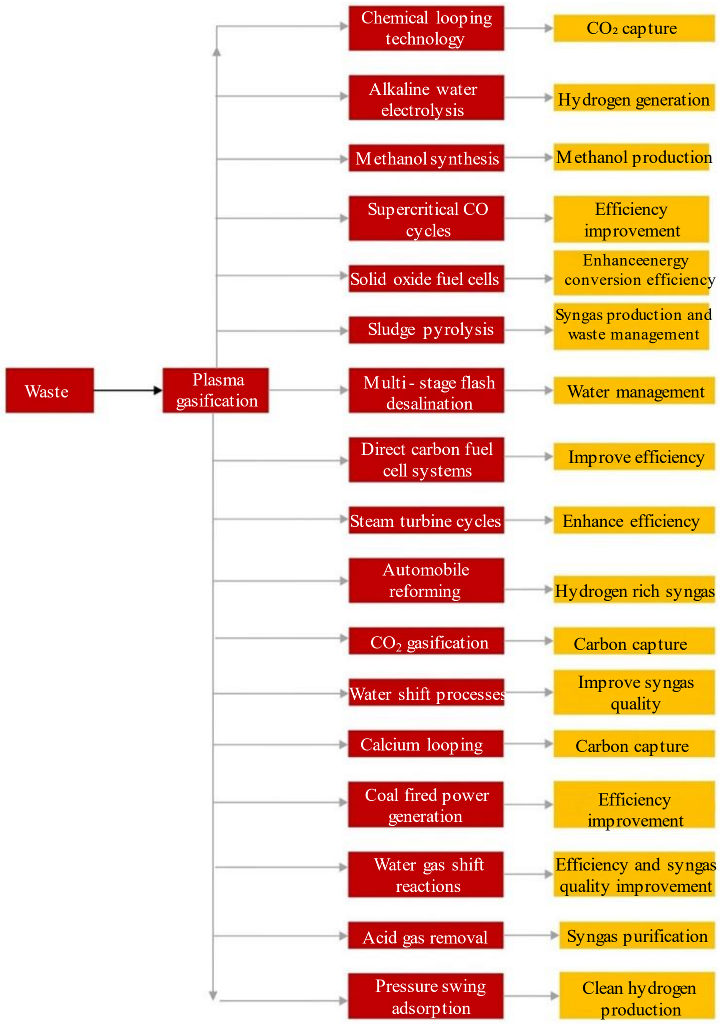


**Figure 2.** List of Integrated models with their benefits.

## NOMENCLATURE AND ABBREVIATIONS

Table 3 shows the abbreviations of integrated models listed below

**Table 3:** Nomenclature and abbreviations of Integrated models

| | |
|---|---|
| PG IPGC | Plasma gasification |
| IPGC | Integrated plasma gasification concept |
| MSW | Municipal solid waste |
| SOFC | Solid oxide fuel cell |
| SSG | Sludge Pyrolysis |
| DCGC | Direct Carbon fuel cell system |
| SOFC | Solid Oxide fuel cell |
| STC | Steam turbine cycle |
| AR | Automobile reforming |
| CLC | Chemical looping technology |
| CL | Calcium looping |
| WGS | Water gas shift process |
| AGR | Acid gas removal |
| PSA | Pressure swing adsorption |

## CONCLUSION

In conclusion, the review underscores the significant potential of integrated plasma gasification (PG) technologies in revolutionising waste management, energy production, and environmental sustainability. By harnessing the power of high-temperature plasma, PG offers a versatile solution for converting diverse feedstocks, ranging from municipal solid waste to biomass and hazardous materials, into valuable syngas. This syngas can be utilised as a clean energy source for power generation, chemical synthesis, and industrial applications, thereby reducing reliance on fossil fuels and mitigating environmental impact.

The integration of PG with complementary technologies, such as chemical looping, water electrolysis, and solid oxide fuel cells, unlocks synergistic benefits, including enhanced energy conversion efficiency, reduced greenhouse gas emissions, and expanded application areas. Hybrid plasma gasification systems, coupled with advanced gas cleaning and purification technologies, present economic advantages through the generation of valuable by-products and potential revenue streams. Moreover, the integration of PG with waste-to-energy and combined heat and power systems maximises energy recovery and utilisation, contributing to a more sustainable energy future.

Simulation studies showcased in the review demonstrate the feasibility and effectiveness of integrated plasma gasification approaches, yielding improved conversion efficiency and economic viability. Utilising simulation tools such as Ansys, Aspen, MATLAB, and others enables researchers to optimise system performance and assess the feasibility of hybrid plasma models.

In essence, integrated plasma gasification technologies represent a promising pathway towards addressing global energy and environmental challenges while advancing the transition to a circular economy. By leveraging the versatility and efficiency of plasma technology in tandem with complementary processes, we can pave the way for a more sustainable and resilient future. Continued research, development, and implementation of integrated plasma gasification systems are imperative for realising the full potential of this innovative approach in waste management, energy production, and environmental stewardship.

## REFERENCES

1. I. J. Cho, H. W. Park, D. W. Park, and S. Choi, “Enhancement of synthesis gas production using gasification-plasma hybrid system,” Int. J. Hydrogen Energy, vol. 40, no. 4, pp. 1709–1716, 2015, doi: 10.1016/j.ijhydene.2014.12.007.
2. L. Mazzoni, M. Almazrouei, C. Ghenai, and I. Janajreh, “A comparison of energy recovery from MSW through plasma gasification and entrained flow gasification,” in Energy Procedia, Elsevier Ltd, 2017, pp. 3480–3485. doi: 10.1016/j.egypro.2017.12.233.
3. M. Sajid, A. Raheem, N. Ullah, M. Asim, M. S. Ur Rehman, and N. Ali, “Gasification of municipal solid waste: Progress, challenges, and prospects,” Renewable and Sustainable Energy Reviews, vol. 168. Elsevier Ltd, Oct. 01, 2022. doi: 10.1016/j.rser.2022.112815.
4. Y. Hu, K. Pang, L. Cai, and Z. Liu, “A multi-stage co-gasification system of biomass and municipal solid waste (MSW) for high quality syngas production,” Energy, vol. 221, Apr. 2021, doi: 10.1016/j.energy.2020.119639.
5. R. Tavares, A. Ramos, and A. Rouboa, “A theoretical study on municipal solid waste plasma gasification,” Waste Manag., vol. 90, pp. 37–45, May 2019, doi: 10.1016/j.wasman.2019.03.051.
6. M. Hlina, M. Hrabovsky, T. Kavka, and M. Konrad, “Production of high quality syngas from argon/water plasma gasification of biomass and waste,” Waste Manag., vol. 34, no. 1, pp. 63–66, Jan. 2014, doi: 10.1016/j.wasman.2013.09.018.
7. R. Mallick and P. Vairakannu, “Experimental investigation of acrylonitrile butadiene styrene plastics plasma gasification,” J. Environ. Manage., vol. 345, p. 118655, Nov. 2023, doi: 10.1016/j.jenvman.2023.118655.
8. A. A. Erdogan and M. Z. Yilmazoglu, “Plasma gasification of the medical waste,” Int. J. Hydrogen Energy, vol. 46, no. 57, pp. 29108–29125, Aug. 2021, doi: 10.1016/j.ijhydene.2020.12.069.

 

9. Y. Wang et al., "A novel methanol-electricity cogeneration system based on the integration of water electrolysis and plasma waste gasification," Energy, vol. 267, Mar. 2023, doi: 10.1016/j.energy.2022.126490.
10. X. Zhao et al., "Thermo-economic analysis of a novel hydrogen production system using medical waste and biogas with zero carbon emission," Energy, vol. 265, no. December 2022, p. 126333, 2023, doi: 10.1016/j.energy.2022.126333.
11. V. E. Messerle and A. B. Ustimenko, "Plasma processing of uranium-containing solid fuels," Fuel, vol. 242, pp. 447–454, Apr. 2019, doi: 10.1016/j.fuel.2019.01.050.
12. M. Danthurebandara, S. Van Passel, I. Vanderreydt, and K. Van Acker, "Environmental and economic performance of plasma gasification in Enhanced Landfill Mining," Waste Manag., vol. 45, pp. 458–467, Apr. 2015, doi: 10.1016/j.wasman.2015.06.022.
13. M. Wang et al., "Highly efficient treatment of textile dyeing sludge by CO2 thermal plasma gasification," Waste Manag., vol. 90, pp. 29–36, 2019, doi: 10.1016/j.wasman.2019.04.025.
14. H. Huang and L. Tang, "Pyrolysis treatment of waste tire powder in a capacitively coupled RF plasma reactor," Energy Convers. Manag., vol. 50, no. 3, pp. 611–617, 2009, doi: 10.1016/j.enconman.2008.10.023.
15. N. Striūgas, V. Valinčius, N. Pedišius, R. Poškas, and K. Zakarauskas, "Investigation of sewage sludge treatment using air plasma assisted gasification," Waste Manag., vol. 64, pp. 149–160, Jun. 2017, doi: 10.1016/j.wasman.2017.03.024.
16. F. Feng et al., "Performance Assessment of a Novel Polygeneration System Based on the Integration of Waste Plasma Gasification, Tire Pyrolysis, Gas Turbine, Supercritical CO2 Cycle and Organic Rankine Cycle," J. Therm. Sci., vol. 32, no. 6, pp. 2196–2214, 2023, doi: 10.1007/s11630-023-1861-4.
17. S. Evangelisti, C. Tagliaferri, R. Clift, P. Lettieri, R. Taylor, and C. Chapman, "Integrated gasification and plasma cleaning for waste treatment: A life cycle perspective," Waste Manag., vol. 43, pp. 485–496, Sep. 2015, doi: 10.1016/j.wasman.2015.05.037.
18. B. Nicolae, "PLASMA GASIFICATION – THE WASTE-to-ENERGY SOLUTION FOR THE FUTURE," Probl. Reg. Energ., vol. 2014–3, no. 3(26), pp. 107–115, 2014.
19. Q. Zhang, L. Dor, L. Zhang, W. Yang, and W. Blasiak, "Performance analysis of municipal solid waste gasification with steam in a Plasma Gasification Melting reactor," Appl. Energy, vol. 98, pp. 219–229, 2012, doi: 10.1016/j.apenergy.2012.03.028.
20. P. C. Kuo, J. R. Chen, W. Wu, and J. S. Chang, "Integration of calcium looping technology in combined cycle power plants using co-gasification of torrefied biomass and coal blends," Energy Convers. Manag., vol. 174, no. June, pp. 489–503, 2018, doi: 10.1016/j.enconman.2018.08.044.
21. A. Perna, M. Minutillo, A. Lubrano Lavadera, and E. Jannelli, "Combining plasma gasification and solid oxide cell technologies in advanced power plants for waste to energy and electric energy storage applications," Waste Manag., vol. 73, pp. 424–438, 2018, doi: 10.1016/j.wasman.2017.09.022.
22. B. Bhui and P. Vairakannu, "Chemical Looping and Plasma Technologies for Gasification of Coal and Biomass," 2018, pp. 499–520. doi: 10.1007/978-981-10-7335-9_20.
23. R. Mallick and V. Prabu, "4-E analyses of plasma gasification integrated chemical looping reforming system for power and hydrogen co-generation using bakelite and acrylonitrile butadiene styrene based plastic waste feedstocks," Energy Convers. Manag., vol. 271, Nov. 2022, doi: 10.1016/j.enconman.2022.116320.
24. X. Cao et al., "Hydrogen Production System Using Alkaline Water Electrolysis Adapting to Fast Fluctuating Photovoltaic Power," Energies, vol. 16, no. 8, pp. 1–13, 2023, doi: 10.3390/en16083308.
25. Q. Zhang et al., "A novel system integrating water electrolysis and supercritical CO2 cycle for biomass to methanol," Appl. Therm. Eng., vol. 225, no. February, 2023, doi: 10.1016/j.applthermaleng.2023.120234.
26. M. Aziz, "Integrated supercritical water gasification and a combined cycle for microalgal utilization," Energy Convers. Manag., vol. 91, pp. 140–148, 2015, doi: 10.1016/j.enconman.2014.12.012.


 

27. M. Singh, D. Zappa, and E. Comini, “Solid oxide fuel cell: Decade of progress, future perspectives and challenges,” Int. J. Hydrogen Energy, vol. 46, no. 54, pp. 27643–27674, 2021, doi: 10.1016/j.ijhydene.2021.06.020.
28. K. Yin et al., “Thermodynamic analysis of a plasma co-gasification process for hydrogen production using sludge and food waste as mixed raw materials,” Renew. Energy, vol. 222, no. June 2023, p. 119893, 2024, doi: 10.1016/j.renene.2023.119893.
29. A. Mountouris, E. Voutsas, and D. Tassios, “Plasma gasification of sewage sludge: Process development and energy optimization,” Energy Convers. Manag., vol. 49, no. 8, pp. 2264–2271, 2008, doi: 10.1016/j.enconman.2008.01.025.
30. A. A. Tareemi and S. W. Sharshir, “A state-of-art overview of multi-stage flash desalination and water treatment: Principles, challenges, and heat recovery in hybrid systems,” Sol. Energy, vol. 266, no. October, p. 112157, 2023, doi: 10.1016/j.solener.2023.112157.
31. J. Lv et al., “Thermodynamic and economic analysis of a conceptual system combining medical waste plasma gasification, SOFC, sludge gasification, supercritical CO2 cycle, and desalination,” Energy, vol. 282, no. August, p. 128866, 2023, doi: 10.1016/j.energy.2023.128866.
32. D. Cao, Y. Sun, and G. Wang, “Direct carbon fuel cell: Fundamentals and recent developments,” J. Power Sources, vol. 167, no. 2, pp. 250–257, 2007, doi: 10.1016/j.jpowsour.2007.02.034.
33. M. Mehrpooya and S. S. Hosseini, “A novel integration of plasma gasification melting process with direct carbon fuel cell,” Int. J. Hydrogen Energy, no. xxxx, pp. 1–14, 2023, doi: 10.1016/j.ijhydene.2023.08.183.
34. G. Chen, X. Tu, G. Homm, and A. Weidenkaff, “Plasma pyrolysis for a sustainable hydrogen economy,” Nat. Rev. Mater., vol. 7, no. 5, pp. 333–334, 2022, doi: 10.1038/s41578-022-00439-8.
35. R. Mallick and P. Vairakannu, “CO2 plasma gasification of bakelite-based electrical switch waste feedstock,” J. Clean. Prod., vol. 423, p. 138813, Oct. 2023, doi: 10.1016/j.jclepro.2023.138813.
36. N. Florin, M. Boot-Handford, and P. Fennell, “Calcium looping technologies for gasification and reforming,” in Calcium and Chemical Looping Technology for Power Generation and Carbon Dioxide (CO2) Capture, Elsevier, 2015, pp. 139–152. doi: 10.1016/B978-0-85709-243-4.00007-0.
37. P. Pan, W. Peng, J. Li, H. Chen, G. Xu, and T. Liu, “Design and evaluation of a conceptual waste-to-energy approach integrating plasma waste gasification with coal-fired power generation,” Energy, vol. 238, Jan. 2022, doi: 10.1016/j.energy.2021.121947.
38. J. Liu et al., “Thermo-Economic Analysis of a Plasma-Gasification-Based Waste-to-Energy System Integrated with a Supercritical CO2 Cycle and a Combined Heat and Power Plant,” Energy Technol., vol. 10, no. 8, pp. 1–19, 2022, doi: 10.1002/ente.202200101.
39. W. H. Chen and C. Y. Chen, “Water gas shift reaction for hydrogen production and carbon dioxide capture: A review,” Appl. Energy, vol. 258, no. October 2019, p. 114078, 2020, doi: 10.1016/j.apenergy.2019.114078.
40. D. Bhattacharyya, R. Turton, and S. E. Zitney, “Acid gas removal from syngas in IGCC plants,” in Integrated Gasification Combined Cycle (IGCC) Technologies, Elsevier, 2017, pp. 385–418. doi: 10.1016/B978-0-08-100167-7.00011-1.
41. H. Qi et al., “Thermodynamic and techno-economic analyses of hydrogen production from different algae biomass by plasma gasification,” Int. J. Hydrogen Energy, 2023, doi: 10.1016/j.ijhydene.2023.06.038.
42. P. Jiang et al., “Novel two-stage fluidized bed-plasma gasification integrated with SOFC and chemical looping combustion for the high efficiency power generation from MSW: A thermodynamic investigation,” Energy Convers. Manag., vol. 236, no. March, p. 114066, 2021, doi: 10.1016/j.enconman.2021.114066.
43. Z. Chu, Y. Li, C. Zhang, and Y. Fang, “Process analysis of H2 production from pyrolysis-CO2 gasification-water gas shift for oil sludge based on calcium looping,” Fuel, vol. 342, no. February, p. 127916, 2023, doi: 10.1016/j.fuel.2023.127916.
44. P. C. Kuo, B. Illathukandy, W. Wu, and J. S. Chang, “Energy, exergy, and environmental analyses of renewable hydrogen production through plasma gasification of microalgal biomass,” Energy, vol. 223, May 2021, doi: 10.1016/j.energy.2021.120025.

 