Plastic Recycling Technologies for Circular Economy Transition: A Comparative Review

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Abstract

The growing issue of plastic pollution calls for changing the traditional system of resource management through linear consumption into a circular economy. In this study, we synthesized and comparatively analyzed plastic recycling technologies to identify their roles, limitations, and implications for the transition toward a circular economy. Through a systematic qualitative review of academic literature and policy documents published during 2020-2025, this study examined mechanical, chemical, and biological technologies based on certain evaluation criteria, including efficiency, product quality, and economic aspects. The findings revealed that mechanical recycling was cost-effective yet lowered the quality of polymers, while chemical recycling provided quality plastics but required significant amounts of energy and investments and biological recycling looked promising yet had low speed of reactions.

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1 Introduction

Low cost, high durability, light weight, and superior flexibility have made synthetic polymers indispensable materials in modern manufacturing. However, with global plastic production approaching 400 million tonnes per year and only a small percentage being effectively recovered and recycled, plastic waste management has become an urgent challenge [1]. Much of the untreated polymer waste is often incinerated, landfilled, or leaks directly into terrestrial and aquatic ecosystems. The environmental persistence of plastics has raised concerns about the accumulation of microplastics in aquatic food chains as well as in human tissues, although long-term physiological effects are still being studied.

To address these challenges, the circular economy model has emerged as a viable alternative to the traditional linear economic model “take-make-dispose”. This model emphasizes maintaining material value in the production and consumption cycle through closed-loop recycling, energy recovery, and sustainable ecological design [2-4]. While

countries like Japan and the European Union have built relatively complete policy and regulatory frameworks to promote this transition, many developing economies, including Viet Nam, still face limitations in infrastructure, inconsistent policy systems, and underdeveloped secondary recycled materials markets [4, 5].

In Viet Nam, legal frameworks have been established to foster a circular economy, notably through the Law on Environmental Protection 2020. The law incorporates Extended Producer Responsibility (EPR) requirements, requiring producers and importers to take responsibility for the collection and recycling of plastic packaging. There are still many challenges concerning the waste segregation and the market demand. Practically speaking, despite the waste collection process being extended in some big cities, the quality of waste sorting from the source is low.

Although recycling technology has made significant progress, these achievements have not yet translated into widespread industrial practice. Chemical recycling technologies can handle mixed or contaminated plastic waste, but large-scale application is still limited by high energy demands, high initial investment costs, and strict process control requirements [6, 7]. Meanwhile, enzyme and microbial-based biorecycling methods are considered to have great potential in plastic degradation, but are currently mostly limited to laboratory or pilot scale [8, 9]. Commercially, while mechanical recycling remains the most widely applied technology, repeated heating and processing cycles degrade the molecular weight and mechanical properties of polymers, leading to reduced quality of recycled materials and limiting their usability in applications requiring high mechanical or safety-related requirements [10].

Beside technological limitations, the development of circular economy also faces many economic and social barriers, such as weak market dynamics, inconsistent waste collection and sorting systems, inconsistent technical standards, and limited community participation [11]. Many technologies have achieved promising results in the laboratory but cannot be widely applied in practice due to unstable input material quality, high operating costs, and fluctuating demand for recycled plastics. In addition, most current studies only focus on individual recycling technologies or policies, while there is a lack of comprehensive comparative studies between methods under different development conditions.

Based on this reality, this study synthesized and analyzed current plastic recycling technologies along with solutions to promote the transition to a circular economy. Three recycling methods, including mechanical, chemical, and biological, were compared based on criteria such as processing efficiency, economic efficiency, quality of recycled products, scalability, and environmental impact. At the same time, the study also considered factors affecting the practical application of recycled plastics, including market acceptance and the completeness of the policy and legal system [11, 12]. Accordingly, this review examines under what technological and implementation conditions mechanical, chemical, and biological recycling routes are most suitable for supporting the transition toward a circular economy.

2 Literature review

2.1 Circular economy in the plastics industry

The circular economy (CE) model differs from the traditional linear model “extraction-use-disposal” in terms of efficient resource management for plastics. Such solutions as reuse, mechanical recycling, chemical recycling, energy recovery, and environmentally friendly product design at the early stages of the life cycle will help reduce waste and increase the efficiency of plastic materials use [2, 4]. The model addresses two significant problems of traditional plastic materials – the dependence on non-renewable fossil fuels and the persistence of the plastic waste in the environment.

For a successful development of the circular economy system in the plastics industry, a comprehensive approach involving various solutions is required. Among the critical factors are designing products for recycling, investing in advanced waste collection and

sorting systems and creating a closed-loop system of recovery and recycling which will ensure high quality of plastic materials through several recycling loops [6, 12]. Beside technologies, the policy is one of the decisive elements of the CE model. There are many policy tools, such as Extended Producer Responsibility (EPR), minimum regulations of recycled material content in products, and financial support policies which proved their effectiveness in recycling promotion in many developed countries [3, 5].

Recent studies have shown that technology, no matter how advanced, cannot create a transition to a circular economy on its own without support from other factors. The transition process can only be effective when there is a stable policy system, appropriate financial resources, and close coordination among stakeholders, including state management agencies, plastic manufacturing enterprises, recycling units, and consumers [1, 3]. This shows that developing a circular economy is not only a matter of technology but also a process of synchronized innovation in management, markets, and the behavior of entities across the entire plastic value chain.

2.2 Plastic recycling technologies

Presently, technologies of plastic recycling are categorized into three categories: mechanical recycling, chemical recycling, and biological recycling, each one having its distinctive features in terms of input material, process, and implementation degree.

Mechanical Recycling: it is a prevalent technology now. It consists of sorting, cleaning, crushing and melting in order to produce recycled plastic pellets [10]. It is appropriate for clean and uniform materials such as PET and HDPE. But heating repeatedly makes changes in the molecular structure which deteriorate material performance making it unusable in case of products with high performance requirements [2, 10].

Chemical Recycling: It is a decomposition of plastic in the form of monomers or chemical substances via depolymerization, pyrolysis, or solvent dissolution [6, 7, 13]. The benefit of the technology lies in processing mixed and contaminated materials which cannot be easily recycled by mechanical means. Recent studies concentrate on developing catalysts and equipment in order to minimize energy consumption and raise efficiency of recycling process [7, 13].

Biological recycling refers to a novel process that employs enzymes or microorganisms to break down certain types of polymers, mainly PET, PLA, and PHA [8, 9, 14]. Despite having great prospects, biological recycling is currently being used on a limited scale due to slow degradation rate, expensive production of enzymes, and problems associated with its industrial use. In recent works, the potential of genetically modified enzymes, including PETase and leaf-branch compost cutinase (LCC), have been emphasized for increasing the efficiency of PET depolymerization under moderate process conditions [8, 9].

In general, each technology has its own advantages and limitations. Therefore, many studies have suggested that no single technology can comprehensively solve the problem of plastic recycling; instead, a combination of multiple methods in an integrated recycling system is needed to improve efficiency and move toward a circular economy.

2.3 Virgin versus recycled plastics

The main differences between virgin and recycled plastics are cost, material properties, safety level, and environmental effects. Virgin plastic materials have stable quality, are easier to process, and meet all technical specifications. On the other hand, the quality of recycled plastics may vary due to dissimilar raw material used and the deterioration of polymers during repeated processing [2, 10].

The chemical recycling of plastics can allow getting materials of comparable quality with virgin materials. Nevertheless, high investments and a lack of practice hinder the practical implementation of this approach [6, 7, 13]. Moreover, residues from the additives, unintended compounds, and other impurities limit the application of recycled plastic materials in highly regulated industries, such as food packaging and medical equipment production [6, 8].

In terms of environmental sustainability, many LCA studies demonstrate that the application of recycled plastics reduces greenhouse gas emissions and the consumption of fossil resources compared to the production of virgin materials [1, 9, 11, 14]. Still, the efficiency of this recycling strategy depends on the energy source, transportation distances, and technology used. Thus, the further increase in the use of recycled plastics requires the continuous improvement of technologies for impurity removal and quality standardization.

3 Research Methodology

3.1 Research approach

In order to evaluate the role of recycling technologies in the move to a circular economy business model in the plastics industry, this literature review adopted a qualitative approach.

The analysis relied exclusively on secondary sources. The review drew on peer-reviewed scientific literature published between 2020 and 2025, supplemented by relevant policy documents and documented industry case studies. More than 20 potentially relevant sources were screened, from which 15 peer-reviewed studies were retained for qualitative content analysis based on their relevance to plastic recycling technologies, circular-economy applications, polymer sustainability, and implementation barriers. The studies were compared across recycling process, product quality, technology readiness, environmental impact, scalability, and practical implementation. Policy documents and industry cases were used only to contextualize regulatory and implementation issues and were not included in the 15-study analytical corpus.

3.2 Comparative review of selected studies

Following the screening process, 15 peer-reviewed studies were selected for comparative qualitative analysis. This literature was used as the basis for the comparison of three major plastic recycling technologies: mechanical recycling, chemical recycling, and biorecycling.

Evaluation of each recycling method was performed based on the following parameters: recycling process, quality of recycled products, technology readiness level (TRL), environmental impact, scale, and practicality [6-10].

The reported findings were qualitatively compared and synthesized to identify common patterns, differences, and knowledge gaps across the recycling technologies.

3.3 Illustrative case-based review

Apart from the literature review, this paper provided a number of case studies to demonstrate the use of circular economy in the plastics industry by organizations and authorities. The case studies were drawn from the initiatives and policies described in the literature on sustainable development.

Selected circular economy projects such as the use of recycled materials, circular products and packaging designs, policies, and better collecting and sorting processes are provided in Table 1 below.

It is important to note that the selected cases did not aim at the comparison of the models in question or their evaluation, but they showed possible directions of practical implementation and the importance of coordination between technology, organizations and policies for the promotion of circular economy.

Table 1 Illustrative examples of circular economy initiatives relevant to the plastics sector

Illustrative initiative/example	Sector	Circular strategy	Illustrative outcome
Dell green packaging	Consumer electronics	Recycled-content packaging	Use of recyclable packaging plastics, including ocean-bound and recycled HDPE, to increase recycled-material content [12].
Adidas – Parley A.I.R. strategy	Apparel	Recycled-material use	Incorporation of PET fibre and nylon recovered from plastic bottles and fishing nets into footwear products [12].

Illustrative initiative/example	Sector	Circular strategy	Illustrative outcome
EU circular-economy and plastics policies	Public policy	Circular product and packaging design	Measures promoting sustainable packaging design, reuse, recycling, and improved quality of recycled plastics [12].
South Korea design-for-recycling policy	Public policy	Design for recycling	Measures encouraging replacement of coloured multi-material disposable plastics with more recyclable transparent mono-material products [11].
Singapore TR 109 Sustainable Packaging Framework	Public/industry standard	Sustainable packaging and 3Rs	Guidance for businesses on reducing, reusing, and recycling packaging from design to end-of-life management [11].
Digital Watermarks Initiative HolyGrail 2.0	Industry collaboration	Digital sorting	Digital watermarking tested at scale to improve identification and sorting of plastic packaging [11].

3.4 Data sources and analytical approach

The body of research for analysis consisted of 15 peer-reviewed articles from among a larger selection of sources identified through the literature review process. The articles discussed recycling technologies for plastics, the circular economy, sustainable polymers, and obstacles to implementation. Content analysis was carried out on the basis of several criteria including the efficiency of recycling, quality of recycled products, level of technology development, environmental effect, scalability, and technological, economic, social, and political barriers. Additional policy-related information and case studies from industries were provided as supplementary materials. Table 2 below showed the research design.

Table 2 Research design matrix

Research Objective	Methodological Approach	Data Sources	Analytical Strategy
1. To explore the role of recycling technologies in advancing the circular economy	Literature-based review	Broader screened literature, supplemented by relevant policy documents and industry case studies	Thematic synthesis
2. To compare recycling technologies (mechanical, chemical, and biological)	Comparative qualitative synthesis	15 core peer-reviewed studies retained for qualitative content analysis	Comparative interpretation of reported findings
3. To discuss practical implementation and scalability	Illustrative example-based discussion	Illustrative industrial and policy examples synthesized from the selected literature	Qualitative policy and implementation analysis

3.5 Ethical considerations

This review is conducted purely from publicly accessible secondary sources only. There are no participants, personal information, or any confidentiality issues at all. All sources have been adequately cited in order to provide credibility and accountability in the research process. This study adhered to ethical research principles.

4 Results and discussion

4.1 Comparative effectiveness of recycling technologies

Three methods of recycling plastics (e.g. mechanical recycling, chemical recycling, and biorecycling) cannot be viewed as interchangeable technologies. They have their unique features concerning the quality of the products obtained, the capacity for handling various input materials, the cost, and the feasibility of implementation [1, 6, 9, 11].

At present, the technology of mechanical recycling is the most commonly used one because of its completeness, low cost of investment, and feasibility. However, repeated melting leads to degradation of the polymer structure, which decreases its quality and makes this method applicable to the production of the goods of low technical requirements only [2, 10].

The technology of chemical recycling can handle mixed or contaminated plastics and obtain the material of a comparable quality with virgin one. Nevertheless, high energy consumption and large investment cost make this method hard to implement at an industrial level [6, 7, 13].

Biological recycling involves the use of enzymes or microorganisms to decompose certain types of plastics, such as PET, PLA, and PHA [8, 9, 15]. Although promising, biological recycling has not yet been widely commercialized because of slow reaction rates and scale-up challenges.

Overall, mechanical recycling is most suitable for clean and well-sorted thermoplastic streams where low cost and scalability are priorities [2, 10]. Chemical recycling is more appropriate for heterogeneous or contaminated feedstocks when higher output quality can justify greater energy and capital requirements [6, 7, 13]. Biological recycling remains more suitable for selected polymers and emerging applications because of its lower technological maturity and scale-up limitations [8, 9, 15]. Table 3 summarizes these comparative characteristics.

Table 3 Comparative overview of recycling technologies

Criteria	Mechanical recycling	Chemical recycling	Biological recycling
Technology readiness levels (TRL)	High	Medium	Low
Material quality retention	Low to moderate	High	Moderate (polymer-specific)
Feedstock flexibility	Limited	High	Limited
Scalability	High	Medium	Low
Cost	Low	High	High
Energy demand	Low to moderate	High	Moderate
Industrial readiness	Established	Developing	Experimental

4.2 Environmental and economic implications

Various studies indicate that the use of recycled plastics contributes to reducing the amount of greenhouse gases emitted and reduces the exploitation of fossil resources compared to the production of virgin plastics [1, 11, 15]. Nonetheless, the extent of environmental benefits varies depending on the type of energy used, transportation distances, and the method of recycling. Mechanical recycling offers the largest emission reductions because of low energy consumption for its operation [10]. The advantages of chemical recycling include the ability to process multiple types of challenging waste plastic materials. However, the environmental benefits can be obtained effectively only if clean energy sources are employed for recycling at high temperatures [6, 7, 13]. Biorecycling is regarded as a promising solution for particular kinds of plastic but the environmental benefits of this type of recycling have not been proved yet because of lack of implementation [8, 9, 15]. For the economic feasibility of recycling types, the most

attractive one is mechanical recycling because of its low prices and implementation. On the contrary, chemical and biological ones have many drawbacks because of their high investment and operational costs [7, 10, 13].

To promote the development of these technologies, supportive policies are needed, such as taxing virgin plastics, regulating the minimum percentage of recycled plastics used in products, and appropriate incentive mechanisms [3, 5, 11].

4.3 Key challenges to large-scale implementation

Despite the considerable technological achievements in plastic recycling, the actual practice is associated with a variety of technical, economical, policy-related, and social barriers [1, 6, 11].

From the technical point of view, mechanical recycling deteriorates the quality of polymer during repeated cycles of processing [10]. Chemical recycling implies complicated processes and high energy consumption [7, 13]. Biorecycling can be applied to a particular type of plastics and is limited by the speed of decomposition and scaling possibilities [8, 9].

In terms of economics, the recycled plastic has to compete with cheap virgin materials. In addition, high investment expenses and volatile prices on raw materials increase the riskiness of recycling projects [3, 5, 10].

As for the policy-related and social factors, non-uniformity in technical requirements, waste classification and certification systems undermines market trust [3, 5]. Also, poor implementation of waste sorting at source and quality issues, particularly, the safety of food contact plastic products are obstacles to recycling [1, 6].

On the whole, in order to implement plastic recycling on a large scale, an integrated approach is necessary.

4.4 Policy and industry implications

The transition to a circular economy model cannot rely solely on technological innovation but requires support from appropriate policies and effective market mechanisms [4, 9, 15].

From the perspective of policy, the use of instruments like EPR, tax for virgin plastic, and requirements for minimum recycled plastic content is an essential step in boosting the demand for recycling [3, 5]. However, the State should also increase the financial support and investments in research to minimize the risk associated with implementing the large-scale technologies of chemical and biological recycling [7, 9, 13].

In terms of companies, emphasis should be placed on product design that takes into account recyclability, reduction in multi-component materials, and use of non-hazardous additives where possible [4, 12]. Furthermore, digital sorting systems like tracer sorting and digital watermarking could be useful in sorting and identifying different materials [11].

Overall, developing a plastic recycling system on the basis of a circular economy approach involves the close collaboration of the State, businesses, scientists, and people. The State improves the policies, businesses invest in the technology and infrastructure, scientists work on improving the technology, and people engage in waste separation [1, 3, 11].

5 Conclusion

This study critically analyzes the existing techniques of plastic recycling in terms of circular economy framework. By analyzing the differences between mechanical, chemical, and biological recycling, the study reveals the advantages, disadvantages, and aspects of technology implementation that include financial and environmental issues, technological and policy-related barriers, etc.

It is found that none of the technologies are sufficient to fulfill all demands related to plastic recycling. Although mechanical recycling remains the most common technique, the quality of material reduces with each recycling process. Chemical recycling allows recycling more complicated plastics, yet it remains restricted by the high expenses and high amount of energy required. Biological recycling has much potential for certain types of polymers, however, it currently remains on the research stage because of the problems associated with scaling. It was found that the environmental efficiency of recycling technologies depends on the energy source, transportation, and processing methods. Hence, it can

be stated that the development of circular economy in the sphere of plastics production requires the combined use of recycling technologies together with certain policies and market for recycled materials.

These findings may also inform recycling-system development in contexts where collection, sorting, and secondary-material markets remain limited. However, their applicability depends on local infrastructure, policy capacity, and market conditions.

References

1. Alaghemandi, M. (2024). Sustainable Solutions Through Innovative Plastic Waste Recycling Technologies. *Sustainability*, 16(23), 10401. https://doi.org/10.3390/su162310401.

2. Bucknall, D. G. (2020). Plastics as a materials system in a circular economy. *Philosophical Transactions: Mathematical, Physical and Engineering Sciences*, 378(2176), 1-34. https://doi.org/10.1098/rsta.2019.0268.

3. Chenavaz, R. Y., & Dimitrov, S. (2024). From waste to wealth: Policies to promote the circular economy. *Journal of Cleaner Production, 443*, 141086. https://doi.org/10.1016/j.jclepro.2024.141086.

4. Fagnani, D. E., Tami, J. L., Copley, G., Clemons, M. N., Getzler, Y. D., & McNeil, A. J. (2021). 100th anniversary of macromolecular science viewpoint: redefining sustainable polymers. *ACS macro letters*, *10*(1), 41-53. https://doi.org/10.1021/acsmacrolett.0c00789.

5. Milios, L. (2021). Towards a circular economy taxation framework: Expectations and challenges of implementation. *Circular Economy and Sustainability*, *1*(2), 477-498. https://doi.org/10.1007/s43615-020-00002-z.

6. Li, H., Aguirre-Villegas, H. A., Allen, R. D., Bai, X., Benson, C. H., Beckham, G. T., ... & Huber, G. W. (2022). Expanding plastics recycling technologies: chemical aspects, technology status and challenges. *Green Chemistry*, *24*(23), 8899-9002. https://doi.org/10.1039/d2gc02588d.

7. Luo, H., Tyrrell, H., Bai, J., Ibrahim Muazu, R., & Long, X. (2024). Fundamental, technical and environmental overviews of plastic chemical recycling. *Green Chemistry*, *26*(23), 11444-11467. https://doi.org/10.1039/d4gc03127j.

8. Orlando, M., Molla, G., Castellani, P., Pirillo, V., Torretta, V., & Ferronato, N. (2023). Microbial Enzyme Biotechnology to Reach Plastic Waste Circularity: Current Status, Problems and Perspectives. *International Journal of Molecular Sciences*, *24*(4), 3877. https://doi.org/10.3390/ijms24043877.

9. Peti, D., Dobránsky, J., & Michalík, P. (2025). Recent advances in polymer recycling: A review of chemical and biological processes for sustainable solutions. *Polymers, 17*(5), 603. https://doi.org/10.3390/polym17050603.

10.Schyns, Z. O., & Shaver, M. P. (2021). Mechanical recycling of packaging plastics: a review. *Macromolecular rapid communications*, *42*(3), 2000415. https://doi.org/10.1002/marc.202000415.

11.Tan, J., Jia, S., & Ramakrishna, S. (2023). Accelerating plastic circularity: A critical assessment of the pathways and processes to circular plastics. *Processes, 11*(5), 1457. https://doi.org/10.3390/pr11051457.

12.Zhu, Z., Liu, W., Ye, S., & Batista, L. (2022). Packaging design for the circular economy: A systematic review. *Sustainable Production and Consumption, 32*, 817-832. https://doi.org/10.1016/j.spc.2022.06.005.

13.Babaei, M., Jalilian, M., & Shahbaz, K. (2024). Chemical recycling of polyethylene terephthalate: A mini-review. *Journal of Environmental Chemical Engineering, 12*(3), 112507. https://doi.org/10.1016/j.jece.2024.112507.

14.Rosenboom, J.-G., Langer, R., & Traverso, G. (2022). Bioplastics for a circular economy. *Nature Reviews Materials, 7*(2), 117-137. https://doi.org/10.1038/s41578-021-00407-8.

15.Fredi, G., & Dorigato, A. (2021). Recycling of bioplastic waste: A review. *Advanced Industrial and Engineering Polymer Research, 4*(3), 159-177. https://doi.org/10.1016/j.aiepr.2021.06.006.

Công nghệ tái chế nhựa trong chuyển đổi sang nền kinh tế tuần hoàn: Tổng quan so sánh

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Tóm tắt Ô nhiễm nhựa ngày càng gia tăng đặt ra yêu cầu chuyển đổi từ mô hình quản lý tài nguyên dựa trên tiêu dùng tuyến tính sang nền kinh tế tuần hoàn. Trong nghiên cứu này, chúng tôi tổng hợp và phân tích so sánh các công nghệ tái chế nhựa nhằm xác định vai trò, hạn chế và những hàm ý của chúng đối với quá trình chuyển đổi sang nền kinh tế tuần hoàn. Thông qua tổng quan định tính có hệ thống các tài liệu học thuật và văn bản chính sách được công bố trong giai đoạn 2020–2025, nghiên cứu xem xét ba nhóm công nghệ tái chế gồm cơ học, hóa học và sinh học dựa trên các tiêu chí đánh giá như hiệu quả xử lý, chất lượng sản phẩm và các khía cạnh kinh tế. Kết quả cho thấy tái chế cơ học có hiệu quả về chi phí nhưng có thể làm suy giảm chất lượng polyme; tái chế hóa học có khả năng tạo ra vật liệu nhựa có chất lượng cao nhưng đòi hỏi mức tiêu thụ năng lượng và vốn đầu tư đáng kể; trong khi đó, tái chế sinh học cho thấy nhiều tiềm năng nhưng vẫn bị hạn chế bởi tốc độ phản ứng thấp.

Từ khóa Kinh tế tuần hoàn; tái chế nhựa; tái chế cơ học; tái chế hóa học; tái chế sinh học.