The Role of Microrecyling Microfactories in Establishing a Global Circular Plastic Economy

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Abstract

The increasing environmental concerns associated with plastic waste and the urgent need for sustainable solutions have prompted researchers and policymakers to pursue a global circular plastic economy. A global circular plastic economy consists of a continuous cycle of reusing materials. The proposal presents a comprehensive analysis of the potential of plastic recycling microfactories as a pivotal component in establishing a global circular plastic economy.

Keywords: Microrecycling, Microfactories, Circular Plastic Economy, Plastic Recycling, Global Policy

1. Proposal

The circular economy aims to minimize waste and promote the continuous use of regeneration of resources. The social costs of the economy of plastic alone were calculated to be around $3.7 trillion USD by the World Wide Fund For Nature (9). Recycling plays a crucial role in achieving these goals by closing the loop in the plastic value chain. Existing plastic recycling methods, such as mechanical recycling and chemical recycling, have limitations in terms of efficiency, scalability, and environmental impact. To address these limitations, the proposal is to implement plastic recycling microfactories.

The microfactories are a small-scale facility that specializes in the recycling and processing of plastic waste into valuable products. A team of researchers from the University of New South Wale Centre for Sustainable Materials Research and Technology developed the microrecyling microfactory so that individual councils can build and customize their factories to suit their needs (1). Microrecyling microfactories is a combination of two concepts. Microrecyling enables the efficient transformation of plastic waste into valuable products, while microfactories are factories characterized by their compact size and use of modular technology. Modular technology is a design in which a system comprises multiple individual components that can be independently created, replaced, or upgraded (14).

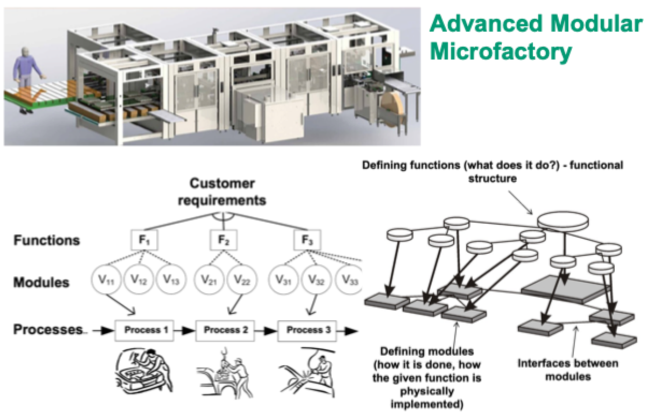

Figure 1: Microfactory diagram, representing the different customer requirements the microfactory can fulfill (16)

1.1 Economic Advantage

The economic advantage of implementing this policy is a reduction in waste and costs in comparison to other methods. A case study on the sustainability of adopting prefabrication (a major part of modular construction) found that it can reduce waste generation by up to 100% (3). This can be explained by the paper "Modularity of Production Systems," which breaks down the reduction in both waste and costs in modular construction to streamline construction and installation, reduce labor costs, optimize the use of materials, and increase quality control (2). Modular construction relies on a well-organized and streamlined supply chain to procure materials and components. This efficiency can reduce costs due to bulk purchasing, reduce transportation costs, and minimize delays. The design also reduces labor costs, as traditional construction requires a significant amount of on-site labor, which can be expensive. Since the modules are manufactured concurrently with on-site preparations, overall construction time is significantly reduced. The manufacturers of the modular components can optimize the use of materials since they have precise control over the construction process. This can result in minimal material wastage and cost savings (4,15). The excess materials can also be recycled or reused within the factory environment to reduce waste further. The factory-based production allows for rigorous quality control processes. Each module can be inspected and tested before it leaves the factory, reducing the likelihood of errors and the need for costly rework on-site. Even the "Evaluation of critical risk factors in the implementation of modular construction" found that "considering the … well-documented benefits, specifically project completion time, cost and construction waste reduction, other less developed countries can also use it as a sustainable alternative over conventional construction" (4). Although the cost per microrecyling microfactory is not available due to the novelty of the concept, referring microfactories in a different industry gives a better understanding of the extent of cost and time reductions. In the automobile industry, traditional factories cost over $1 billion USD and take two years to build, while microfactories cost $50 million USD or less and only a few months to build (6).

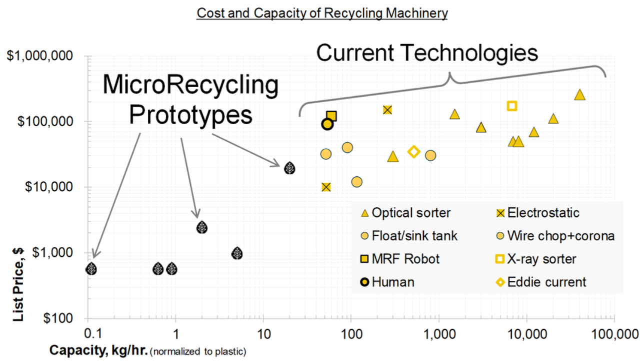

Figure 2: Graph representing the cost and effectiveness of the microrecycling prototypes (17)

The diagram above illustrates the smaller scale and higher efficiency of the microreclying prototypes. Another aspect that should be considered is job creation in local and foreign economies. The microfactories would require workers to operate and maintain the recycling machinery, including machine operators, technicians, quality control specialists, waste collection, sorting, and maintenance personnel. On the other hand, the modular components for the microfactories themselves will require a transportation and construction workforce at various supply chain stages.

1.2 Rapid Implementation & Sustainability

A significant advantage of utilizing microrecycling microfactories is the ability for rapid implementation and long-term sustainability. The plastic recycling microfactories can be rapidly implemented as they are smaller in scale than regular plastic recycling plants (1). Their compact nature allows for quicker setup and less complex logistics. The microfactories have increased production efficiency due to the modular components that can be easily assembled, disassembled, or replaced. Since the assembly technology for the microfactory consists of Industry 4.0, replicating the microfactories at a rapid scale is more efficient than traditional assembly methods (13). The ability for quick production and setup ties in well with the long-term viability of the microrecycling microfactories. They facilitate SDG 11: Sustainable Cities and Communities with increased longevity and decreased environmental consequences compared to other plastic recycling factories. On average, modular buildings have better life cycle performance, determined by factors such as energy efficiency, resilience, lifespan, lifecycle cost analysis, adaptive reuse capabilities, occupant comfort and health, and sustainability (5). Furthermore, reducing the number of machine tools for the production of one component, less handling, shortening the lead times, minimizing the recurrence of workpiece clamping, maximizing the concurrence of operations, as well as the development of machine components and machine concepts for maximum machine multifunctionality result in reduced environmental impacts compared to other factories (2).

1.3 Flexibility

A significant advantage of integrating the microrecyling microfactories is flexibility. The economic objective of modular technology is to ensure efficient production of several different types of products, which may change over time, with the respective changes taking up a shorter time on the same production system while maintaining the requirements for the production's prescribed scope and quality (14). Flexibility is important when considering the creation of the global circular plastic economy. The Lego-brick approach allows councils to build one module at a time, which can then scale up as demand grows (1, 6). Each module can be adapted to suit different regions' needs and local requirements with the high customization involved. The factories themselves can also be disassembled and relocated, allowing for the reuse of modules in different locations or for different purposes, reducing waste and extending the life of building components. Since the microfactories can be produced as small as 100 square meters, the scalability can be adjusted to fit different quantities of recycled plastic and the number of products produced.

1.4 Rapid Implementation & Sustainability

The main advantage of this proposal is creating value from the action of recycling plastic. In addition to their superior efficiency and effectiveness, the microfactories can operate under low material cost and high material supply as long as the plastic waste problem plagues our society while creating positive economic value through recycled plastic products. The resulting recycled plastic products could be used for either economic or social benefits. The microfactories could produce consumer goods from recycled plastic, such as but not limited to packaging, footwear, recreational gear, and stationery goods, to have a return on investment and eventually earn more than the initial costs of the factory (7). Alternatively, the microfactories can produce important goods to help developing nations, such as sanitation and hygiene products, school supplies, water storage containers, medical supplies, water filtration system components, and energy-efficient appliances' components.

2. Considerations

However, it is important to note that the numerous benefits of implementing the microrecycling microfactories come with certain caveats. As noted by the Evaluation of Critical Risk Factors in the Implementation of Modular Construction, adopting modular technology on a large scale comes with multiple risks, especially for developing nations (5). The lack of an experienced and skilled workforce is a potential risk due to the novelty of modular construction in developing nations. Modular construction is an innovative construction method that comes with its own complex processes. The supply chain of modular construction consists of multiple upstream and downstream segments and an increased number of supply chain segments, as well as the complexity of material and information flow, which require effective coordination amongst the involved project participants (5). In developing nations with a less skilled or experienced workforce, these complexities can result in disruptions such as project delays (11). The construction of the microfactories also requires specialized equipment not readily available in less developed nations. Now, it is important to note that specialized equipment and labor are prevalent in many developed nations as modular construction has been predominant amongst global corporations as a cheaper alternative to traditional construction and is, therefore, still economically feasible.

Another major consideration is the risks associated with utilizing this new technology. The microrecyling microfactory is a new technology developed and tested by a team of researchers from the University of New South Wales Centre for Sustainable Materials Research and Technology. New technologies often face technical hurdles, such as reliability, scalability, and efficiency. Microrecycling microfactories need to prove their effectiveness in processing various types of waste materials consistently on a larger scale. There would also be the obstacle of developing the necessary infrastructure and logistics for collecting and transporting waste materials to microfactories, which can be complex and costly. Another concern is the long-term sustainability and maintenance of these microfactories. Although microfactories generally have longer lifecycles, there isn't a proven track record to guarantee long-term sustainability since micorecying microfactories is a new technology. Implementing microrecycling factories in order to create a global circular plastic economy requires different plans of action in order to tackle incentivization for more economically developed nations and support less developed nations.

3. Implementation

There are three potential methods of implementation to integrate the microrecyling microfactories to create a global circular plastic ecosystem. Now, for the following solutions, there needs to be an overseeing framework created in the United Nations to ensure the progress and development of the microfactories. The first step is establishing a United Nations-led global initiative that promotes plastic recycling microfactories as a key strategy for achieving sustainable development goals related to waste reduction and resource convention. The initiative will need to continually monitor the progress of microfactories in terms of waste reduction, economic benefits, and environmental impact to ensure effective implementation. To reduce the imbalance of influence and reduce inequity, it is important to have diverse stakeholder representation in the organization. However, it is important to refrain from standardizing policies to account for variations in local jurisdiction and compliance measures. Standardizing a method as a one-size-fits-all approach would be rendered ineffective in the different socioeconomic statuses across the different nations. The flexibility involved in the microfactories allows for adjustments on a case-by-case scenario, making the proposal more effective in real-world applications than standardized solutions. Collaboration with member states, international organizations, and NGOs to form partnerships that support the implementation of microfactories in various countries and regions is necessary.

1.1 Supporting Communities

The first plan based on the new UN framework would target supporting less economically developed countries struggling with plastic pollution. The initiative could be funded by the United Nations Development Programme, where the microrecycling microfactories can be distributed to struggling communities. The proposal focuses on empowering local communities by creating value for the less economically developed local communities while reusing plastic. These communities will be able to fit the microfactories towards their own needs, whether it be creating commercial or essential goods with the customization available.

Crucially, the communities have the ability to determine the direction of the microfactories which allows for the most effective use of resources and addressal of the specific problems each community faces through the use of local expertise and foreign advice. This ability is important because of the historical cases of initiatives aiming to help local communities failing to address the main problems and involve all stakeholders. For example, in 2010, during what would later be known as the Haiti Earthquake Relief, there was an outpouring of international aid and support, including from the UN and various NGOs (12). While the immediate response provided much-needed assistance, the long-term recovery efforts faced criticism for not effectively rebuilding infrastructure and institutions and for a lack of coordination among aid agencies. Some funds were mismanaged, and there were concerns about the lack of local ownership and involvement in the reconstruction process.

1.2. Self-Sustaining System

Another plan is to create a self-sustaining system of microrecycling microfactories, which the United Nations Environment Programme could fund. The UNEP would invest its resources into creating microrecycling microfactories based on creating a profit from recycled plastic products such as packaging, footwear, and recreational gear. The approach creates a positive feedback loop as the economic value from the recycled products can be reinvested into expanding the microfactory network, creating a self-sustaining system where they continue to fund more microfactories, in the process further increasing the scale and recycling more plastic.

Due to the flexibility of the microfactories, they can also be utilized to produce consumer goods to generate revenue to not only pay off the initial capital cost but also to eventually fund other microfactories in a circular system. The global recycled plastic market size was valued at $69.4 billion USD in 2023 and is projected to reach $120 billion USD in 2030 (10). This is evidence of the growing recycled plastic market, ensuring a healthy demand for plastic recycled products.

1.3 Government Intervention

The final method is engaging the private sector in the process, as it has historically been important for global scalability and innovation. A method of increasing demand for recycled plastic products is government intervention to address negative externalities caused by plastic pollution. Government intervention such as creating government incentives (low-interest loans or subsidies) for recycled plastic products, exempting recycled plastic products from plastic-related taxes, and introducing extended producer responsibility legislation (making manufacturers responsible for end-of-life disposal of their products). A difficulty in the potential deployment of microrecycling factories is foreseeably their funding. While the factories themselves, as aforementioned, are cheaper than other fabrication plants, implementing them to create a global impact does not allow for a simple reallocation of budgeting on the part of the less developed nations. Despite the required initial cost, a cursory consideration of the major stakeholders in implementing microfactories shows that all parties, the host government, the international community, and microfactory-running firms, would benefit from the microfactory. Facilitation of the private sector is necessary to prevent an artificial market and create natural competition. In the private sector, a funding scheme pooling finances from all three identified stakeholders is a potential option, with costs returned in installments following the micro factory's deployment.

4. Conclusion

In conclusion, the proposal is a compelling case for implementing plastic recycling microfactories as a pivotal component in establishing a global circular plastic economy. The urgency to address environmental concerns associated with plastic waste and the social costs associated with plastic pollution underscores the importance of finding sustainable solutions. The concept of microrecycling microfactories offers several advantages. They are modular, flexible, significantly reduce waste generation and costs, and value generated from the recycling process. However, there are important considerations and challenges to address. Adopting this new technology requires skilled labor and specialized equipment, which may be lacking in some developing nations. Moreover, the technology must prove its reliability, scalability, and efficiency on a larger scale. Additionally, the funding required for deploying microfactories poses a significant challenge, which can potentially be addressed through collaborative funding schemes involving host governments, the international community, and microfactory-running firms. To move forward with implementing plastic recycling microfactories globally, the paper suggests a comprehensive action plan. This includes the establishment of a United Nations-led initiative, diverse stakeholder representation, collaboration with member states and international organizations, and funding allocation for research, development, and technical assistance programs. The aim is to ensure effective and equitable implementation while addressing the varying needs of different regions and nations. Successful implementation will require careful planning, collaboration, and investment to overcome challenges and realize the vision of a global circular plastic economy.

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