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Eco-Efficiency: Development of Waste Management Strategies in Complex Adaptive Energy Systems Via Circular Economy

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Abstract

Eco-efficiency is a concept that aims to promote sustainable development by reducing the environmental impact of economic activities by increasing economic efficiency. Waste management is an important area where eco-efficiency can be applied to promote a sustainable approach to dealing with waste. Developing waste management strategies in complex adaptive energy systems through a circular economy is an important aspect of eco-efficiency. Several waste management strategies that can be implemented to promote eco-efficiency include waste prevention, waste minimization, recycling and reuse, biological processing, incineration, and disposal to final landfills using a circular economy is an important approach to waste management that aims to reduce waste disposal and promote the reuse of materials. By adopting circular economy principles, waste can be transformed into valuable resources, and the environmental impact of economic activities can be reduced.

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Introduction

Indonesia is a waste paradise where Indonesia is the second country after China as the country that produces the most waste in the world. According to data from Jambeck (2020), Indonesia dumped 187.2 million tons of plastic waste into the sea, this does not include the amount of used cooking oil and glass waste. It is estimated that Indonesia produces 64 million tons of waste every year. However, according to data from SWI in 2017, only 7 percent of waste was recycled, while 69 percent was piled up in landfills, and the rest was thrown away indiscriminately, including illegal dumping. The causes of the mountains of waste in Indonesia are due to (i) lack of awareness from the community, (ii) lack of solutions from the government, (iii) land management for landfills in cities is still lacking, which causes people to choose rivers as an alternative place, (iv) the increasing population humans,

their needs are increasing, causing the amount of waste to increase, (v) lack of strictness from the government.

Entering a decade towards the sustainable development goals and greenhouse gas emission reduction targets in the Paris Agreement by 2030, the Indonesian Government is increasingly strengthening its commitment and efforts to address economic, social and environmental problems through low-carbon development and a circular economy. A circular economy is a closed-loop economic system approach in which raw materials, components, and products are maintained as useful and valuable as possible thereby reducing the amount of waste materials that are not reused and thrown into landfills. The Circular Economy drives higher green economic growth than typical business scenarios by designing systems and products that require fewer resources, ensuring that extracted raw materials are used efficiently and maximize their lifespan. The circular economy is one instrument that can support the achievement of sustainable development goals.

Tabel 1. Solid Waste Potential As Resource Material

No.	Composition Type	%	Amount (tonnes)	Usage
1.	Compostable Organic	57	37.480.198,27	Compost, biogas,heat,electricity
2.	Plastic	16	10.520.757,41	Raw Material, heat, electricity
3.	Paper	10	65.757.473,38	Raw Material
4.	Metal	4	26.301.189,35	Raw Material
5.	Rubber	2	1.315.094,68	Refused Derived Fuel (RDF)
6.	Textile	3	1.972.642,01	Raw Material
7.	Glass	2	1.315.094,68	Raw Material
8.	Others	6	3.945.284,03	Others
	TOTAL	100	63.754.733,81	

Source: MoEF (2022)

The circular economy is also one of Indonesia's drivers towards economic transformation, particularly supporting the green economy and low-carbon development strategies. Indonesia has adopted the Circular Economy concept into its development vision and strategy. Indonesia's Vision 2045 has elaborated the concept of Circular Economy as a future policy. As a first step in implementing the circular economy concept, the Indonesian Government in collaboration with the United Nations Development Program (UNDP) with the support of the Danish Government has prepared an analysis study of environmental, economic and social potential for its implementation. circular economy in Indonesia in 5 (five) industrial sectors, namely food and beverages, construction, electronics, textiles and plastics. This circular economy development study will be continued with further development stages, such as preparing a National Action Plan and including the circular economy in the next 2025-2029 National Medium Term Development Plan (RPJMN). The challenges and gaps with current actual conditions will certainly be a big joint work. However, with the development of a comprehensive strategy and collaboration between stakeholders, implementing a circular economy will be a concrete solution to the problems we are currently facing.

The corona pandemic has changed the world. Including how we view

our economy and the way we produce and consume. The pandemic has shown that we can change the way we live. I know that it remains more important than ever to ease our shared environmental burden, and the current rethinking of value chains and the restart of the economy after the pandemic presents a clear green opportunity. The Circular Economy puts a framework around these changes. This is a change that requires huge efforts not only from producers and consumers, but from every entity across the value chain..

RESEARCH METHODS

Descriptive qualitative research method is a research method used to describe a phenomenon or event in detail and in depth. This research aims to understand a phenomenon or event thoroughly and in depth, so that the research results can provide an accurate and complete picture of the phenomenon or event.

The research title 'Eco-Efficiency: Development of Waste Management Strategies in Complex Adaptive Energy Systems Via Circular Economy' refers to the development of waste management strategies in complex and adaptive energy systems through the application of circular economy principles. Eco-efficiency itself is a concept that refers to the efficient use of resources and reducing environmental impacts in a production process or business activity.

In this research, researchers will use a descriptive qualitative approach to describe waste management strategies in complex and adaptive energy systems through the application of circular economy principles. This research will involve collecting data through observations, and document studies to understand in depth the waste management strategies implemented in complex and adaptive energy systems.

RESULT

BEST PRACTICE

1. Circular Economy Concept in Waste Management

   Integrated waste management is managed from the source to the Final Processing Site (TPA) by prioritizing the 3R (reduce-reuse-recycle) concept and a circular economy using the Waste Bank mechanism. Waste Banks are a type of waste facility managed by the community (informal sector) collecting waste can be recycled by educating the public to sort waste from the source and take the waste to the Waste Bank. The community gets economic benefits by sorting waste and waste is handled from the source (the concept of a circular economy and environmental conservation).

2. Study of the circular economy potential at PLTSa Bantargebang

   The Bantargebang pilot project is designed to burn 100,000 kg/day of waste with an electricity output of 700 kW. Apart from eliminating waste quickly, significantly and environmentally friendly, PLTSa plants also have circular economy potential. Observation of operational data for August-November 2020 shows that circular economy potential can be identified from electrical products, materials that can be recycled and sold, paving blocks from fly ash, and carbon trading. PLTU Bantargebang can produce renewable energy from waste with a conversion rate of 6.48 Watt/kg-MSW. Meanwhile,

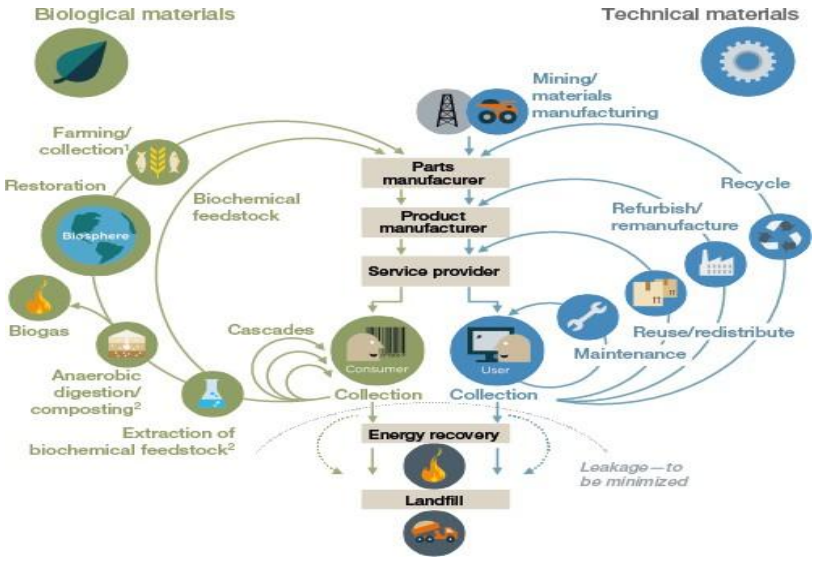
the potential for waste materials to be recycled or resold is 0.7% of the total raw waste. The economic potential of fly ash is paving blocks as a construction material. The paving block production rate is 23.98% of the mass of waste burned. WTE plants can also reduce GHG emissions compared to landfill methods. The GHG emission reduction value from WTE operations is 44.11% lower GWP emissions compared to landfilling.

3. Circular Economy in the Indonesian Construction Industry

Circular Economy (CE) is a concept that aims to economically preserve the value of products, materials and resources for as long as possible while minimizing the waste generated. The CE concept is adapted from the 3R principle (Reduce, Reuse and Recycle). The construction industry is one of the largest waste producing industries. In fact, 30% of the waste in the landfill is construction waste. This research aims to identify and analyze the application of circular economy in the construction industry in Indonesia. There are two main stages in this research. The first stage is to identify construction practitioners' awareness of the circular economy. The second stage is to document the implementation of 3R on various types of construction projects such as building, road and bridge projects. Questionnaires are used to collect data. Around 120 project managers of medium to large scale construction companies in Indonesia were used as respondents. Important Performance Analysis (IPA) is used to represent the awareness of CE construction practitioners. The research results show that the majority of construction practitioners in Indonesia understand the importance of processing construction waste in the context of a circular economy. However, only a few construction companies are serious about processing construction waste. Most construction waste is only disposed of in landfill areas through third parties. Only about 36% of contractor waste is reused and recycled on construction sites.

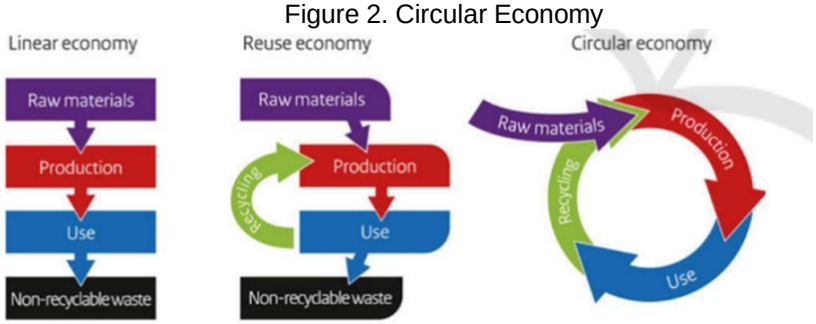
DISCUSSION

Figure 1. Flow Chart



At its core, the circular economy aims to design out waste. Products are designed and optimized for disassembly and reuse cycles. These component and product cycles define the economic cycle and differentiate it from disposal and even recycling, where large amounts of energy are invested and labor is lost. Second, circularity introduces strict differentiation between consumable and durable components of a product. Unlike today, consumables in a circular economy are mostly made from biological materials or 'nutrients' that are at least non-toxic and perhaps even beneficial, and can be safely returned to the biosphere, either directly or in a cascade of successive uses. It is calculated from inception to reuse, and products are subject to rapid technological progress, to upgrade. Third, the energy required to fuel this cycle must be naturally renewable, again to reduce resource dependency and increase system resilience.

Figure 2. Circular Economy



The Circular Economy published by the Ellen MacArthur Foundation provides ample evidence that circularity has begun to make inroads into the linear economy and has moved beyond the concept. A number of businesses have developed on it. Innovative products and contracts designed for a circular economy are already available in many forms—from innovative designs of everyday materials and products (e.g., biodegradable food packaging and easy-to- disassemble office printers) to pay-per-use contracts (for tires for example). Evidently, these examples have in common that their focus is optimizing total system performance rather than that of a single component.

MODEL SUITABILITY

The circular economy aims to utilize and conserve natural resources efficiently and sustainably. The driving forces of a circular economy are global warming, natural resource scarcity, and digitalization. The circular economy can offer solutions to many of the problems we face. The circular economy offers various possibilities for companies to expand and develop profitable growth.

The circular economy is often associated primarily with the efficient use and recycling of materials, but the same principles apply to energy consumption. All activities must follow the waste hierarchy. In practice this means prioritizing the “five stages of waste management”. The first and most important step is the prevention of waste generation and following the reuse and recycling of materials. The best kind of waste is no waste at all. Energy saving measures can be summarized using the same ideology as the waste hierarchy:

1. Minimize unnecessary energy consumption
2. Life cycle assessment
3. Renewable energy production minimizes environmental impact

In addition to reducing emissions, energy savings reduce the need for raw materials used in energy production, lower logistics requirements associated with energy production and extend the life cycle of equipment that utilizes energy. The use of renewable energy also contributes to the circular economy by replacing fossil fuels.

Proper measurement and monitoring is an important factor in reducing energy consumption and waste. Sustainable operations are aware of their environmental impacts and report them transparently. As mentioned above, the most important factor in energy saving is minimizing energy consumption by cutting unnecessary consumption.

CONCLUSION

A circular economy is more than just an opportunity for Indonesia to reduce waste and improve the environment. Like governments around the world, Indonesian policymakers are seeking to support economic recovery from the COVID-19 pandemic. However, the key question remains, whether these recovery policies reinforce the existing 'business as usual' economic structure with its associated negative impacts on the environment, or whether there is an opportunity to 'build back better' where there are efforts to maximize mutual benefits between economy and environment.

This analysis shows that fully adopting circularity opportunities in five key sectors of the economy (food & beverage, textiles, construction, wholesale and retail trade, and electrical and electronic equipment) can be a key component of economic recovery, helping strengthen the economy, creating new jobs, reducing household costs, and preserving the environment. By adopting circular economy opportunities in these sectors, Indonesia's GDP could increase by IDR 593 to 638 trillion (USD 42 to 45 billion) in 2030 (compared to a “business as usual” approach) in 2030; A cumulative 4.4 million net jobs could be created across the economy between 2021 and 2030, of which 75 percent could be for women; CO2e emissions and water use could be reduced by 126 million tons and 6.3 billion m3 respectively by 2030 (equivalent to 9 percent of current emissions and 3 percent of current water use); and the average Indonesian household could save IDR 4.9 million (USD 344) per year, representing almost nine percent of current annual household spending.

By creating new jobs, making supply chains more resilient, and providing business opportunities (especially for Micro, Small and Medium Enterprises), the circular economy can be a key component of Indonesia's economic recovery. However, the analysis also highlights several challenges, including potential job losses and reduced demand for upstream production in the five focus sectors (in some scenarios). A robust multi-stakeholder roadmap is being considered as the next step in this work and will be critical to addressing these issues and overcoming barriers to capturing circular economy opportunities

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