Circular Economy In Recycled Paper Company

Irwan Eko Prabowo
Magister Management Technology, Institut Teknologi Sepuluh Nopember, Surabaya, East Java, Indonesia
irwaneko27@gmail.com

Moses L. Singgih
Industrial Engineering, Institut Teknologi Sepuluh Nopember, Surabaya, East Java, Indonesia,
moseslsinggih@ie.its.ac.id

ABSTRACT

The paper industry is an industry that has high economic value. In the past, the use of wood-based virgin pulp was still the principal ingredient in the paper production process, but with increasing global awareness of its negative impact, the paper industry has switched to using paper waste as the main raw material. The increasing adoption of technology and the cheaper recycled paper prices are driving this movement even more. Using recycled paper as its raw material goes through several more processes to be used as raw material for making fresh paper. In the production process, waste material will appear as water, plastic, sludge (mud), ink, and so on. Currently, waste management and reuse of various kinds of remaining production are still not optimal. The Paper Industry (PI) company is a paper company that produces over 40 tons of plastic waste per day from recycled paper. So far, PI has been trying to manage the waste by using an incinerator, which is then reused as a source of steam for the production process. However, the intake from the process is still insufficient and, economically, it is still more profitable to use coal as the main raw material for the boiler. This is only one of many side products that should still be reusable. Therefore, researchers want to apply Circular Economy (CE) as a solution to this problem. Circular Economy (CE) was chosen as a tool to optimize production processes, design processes, and company operations. The CE approach is projected to have an overall positive impact on the PI. With its application, PI will get an economic surplus, improve the welfare of workers and residents, and maintain environmental conditions due to waste reduction.

CCS CONCEPTS

• **General and reference** → Document types; General conference proceedings; Cross-computing tools and techniques; Estimation; Document types; Surveys and overviews.

KEYWORDS

Circular Economy, Recycled Paper, Paper Industry

ACM Reference Format:
Irwan Eko Prabowo and Moses L. Singgih. 2022. Circular Economy In Recycled Paper Company. In *Proceedings of the International Conference on Engineering and Information Technology for Sustainable Industry (ICONETSI), September 21, 22, 2022, Alam Sutera, Tangerang, Indonesia.* ACM, New York, NY, USA, 5 pages. https://doi.org/10.1145/3557738.3557835

ICONETSI, September 21, 22, 2022, Alam Sutera, Tangerang, Indonesia

ACM ISBN 978-1-4503-9718-6/22/09…$15.00
https://doi.org/10.1145/3557738.3557835

1 INTRODUCTION

When the world is dealing with limited natural resources, the industrial sector is building a circular economy to sustain itself, and the paper and pulp industry is one of the pioneers in adopting this approach. This model is very popular in the pulp and paper industry, in contrast to the traditional (take and make) linear economy, the paper industry is currently developed under the (reuse & recycle) model. “Paper is always recycled,” says Jori Ringman, deputy director of the European Federation of Paper Industries, a non-profit organization. The Circular Economy approach continues to contribute to the industry today as paper companies begin to buy back paper from local governments and ensure that recyclable materials are always available. Paper cannot be recycled forever, the natural fibers used in the paper have wear properties after 5 to 7 times of recycling. This is because not all paper is returned to the paper company and the recycling, collection, and sorting processes have been lost. The pulp and paper industry has the advantage of being at the forefront of promoting the Circular Economy concept. For the wider economy, CE offers many opportunities for those willing to invest their time and energy.

Circular Economy has attracted many researchers to conduct research in various industrial fields, one of which is the research conducted by Adi Wicaksono & Ahmad Kadafi [1], who researched CE in the Glass Industry by using cullet derived from the reuse process or reject products. In addition to the glass industry, the CE concept is also developing in the construction industry. This CE practice in the construction industry aims to reduce the amount of waste generated at the end of a building’s life cycle [2]. The transition to CE was also implemented in the textile and clothing industry [3].

The pulp & paper industry in Indonesia is a significant contributor to the national economy. The paper industry in Indonesia is ranked 8th among pulp producers in the world and 6th position for the largest paper producers in the world. From this, it can be seen, that the Indonesian pulp and paper industry can play a major role in increasing national economic growth.

The process of making paper with paper waste as raw material goes through several stages of the process to obtain the expected product results. In general, 9 processes will be passed by the paper waste that will be reproduced as you can see in figure 1. These processes are the collection and sorting of raw materials, pulping process, screening, de-inking, stock preparation, Wet End Process, Dry End Process, coating, and paper output

CE undoubtedly promises the sustainability of the surrounding environment, but also needs to meet business needs to be called a successful business model in the future. Many cases prove that the

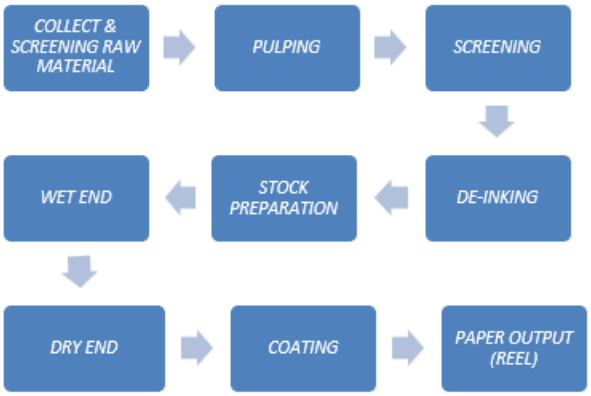

Figure 1: Recycle Paper Production Process

circular economy is good for the environment as well as for profit. Adopting CE can reduce risk and increase system resilience through differentiating business models, separating economic development from resource use and environmental impact, and anticipating increasingly stringent environmental regulations and changing consumer preferences. The research question for this paper is how the circular economy can give a financial impact on paper recycling companies.

2 LITERATURE REVIEW

2.1 Circular Economy Theory

A Circular Economy is a production and consumption paradigm in which materials and goods are currently shared, rented, reused, restored, revised, and recycled indefinitely. Therefore, the product life cycle can be extended. When a product reaches the end of its useful life, its ingredients are reused whenever possible. , adding that CE is an updated economic model of its engineering process, and has the aim of keeping products, components, and materials at their disposal.

Reuse refers to the reuse of a product in its entirety or some of its components after the first life cycle of the product has ended. Recycling is the process of changing materials that will be considered waste into raw materials or new products. The redesign includes activities to change the design of a product, which will use components, materials, and resources that have been recovered from the previous process. Reduce focuses on the initial process of the product life cycle, efficient use of resources at the pre-manufacturing stage, the efficiency of energy, materials, and other resources during the production process, as well as reducing emissions and waste when using the product. Remanufacture itself refers to the reprocessing of a used product to its original condition again by using as much of the old part of the product as possible.

2.2 Material Flow Analysis

Material Flow Analysis is an analytical approach for calculating the flow and stock of material or units in a well-defined system. An MFA system is an engineering model of a manufacturing facility,

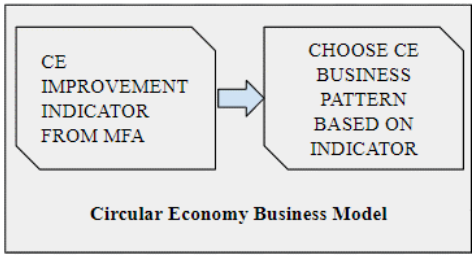

Figure 2: CEBM's Approach For Value Proposition

manufacturing sector, or specific geographic area. The scope of the system model information is adjusted to the research objectives. An MFA system always consists of a boundary system, one or more processes, the flow of material between processes, and a material inventory in the process. The development of the closed-loop system at CE is based on knowledge of how materials move within the system [4].

Therefore, the development and use of MFA are essential for measuring flow through this environment [7]. An MFA can be useful in terms of offering opportunities for legal, regulatory, and efficiency action, identifying environmental issues, and providing technical data for decision making and planning. The graph represents aggregated data that serves as a starting point for a more thorough MFA. Graphs can be used to extract the CE indicator. [5]

2.3 CE strategic management tools

The circular economy challenges companies to rethink supply chains and business models. Several frameworks in the academic and practical literature offer Circular Economy Business Models to rethink how companies create value while adhering to CE principles. Lüdeke-Freund et al. (2019), created a morphology that integrates and unifies the current range of CEBMs [6]. Simultaneously, the CEBM database is analyzed to find possible business model designs or available options for designing business model dimensions such as value propositions or value delivery systems.

3 RESEARCH METHOD

3.1 Data Acquisition

- Raw Material usage: Material used as the main component for recycled paper production, contain OCC (Old Corrugate Card), NCC, water, and chemicals.
- Process Value: Goods that move in the process of paper makings, such as white water, steam, and paper pulp.
- Waste data: In the form of a collection of production waste data components (reject products, sludge, plastics, and others)
- Output Product: The results of the production, finished goods that will be sold to consumers either locally or for export.

3.2 Data Processing

The data that has been collected, can then be used to monitor the use and loss of raw materials, use of chemicals, and process waste flows. However, before all that, it is necessary to understand the

flow and process of the production of paper waste. From this flow, the balanced flow in the paper production system can be obtained. From the diagram, data can be analyzed the opportunities that can be selected for CE Business Model planning that can provide benefits to the company as seen on figure 2. To visualize & evaluate the CEBM planning then we will use the Business model Canvass as a tool to meet those needs

4 RESULT & DISCUSSION

4.1 PI Waste Management Cost

One of the most difficult problems facing PI today is waste management. The use of landfills as a location for storing waste and environmental pollution that arises if not managed properly will cause financial losses and impacts on the company. Every day, PI produces approximately 350 tons of paper. Of this production, 15% of the result is lost waste, material waste in the form of rejected products, process wastewater, and sludge will partly be reused in the process.

PI production waste is divided into 4 types, namely liquid, gas, particulate, and solid waste. Every month, an average of 750 tons of remaining production appears or approximately 5% of total production, costing the company around. The required management fee itself is not small, based on the 2021 financial report from PI, the overhead cost for waste treatment reaches IDR 2.041.522.605,- per month. This number will increase with increasing PI production capacity.

4.2 MFA of a PI production system

In making MFA, it is necessary to have system limits to obtain specific results according to the system being analyzed. Determination of the process is taken based on changes in the type of goods in the production process flow, import value means goods enter from outside the system boundaries into the system, and export value means goods come out of the system to outside the system. PI production process then separated into 5 different processes, that is Stock Preparation Process, Paper Factory Process, Water Treatment Plant, Coal Boiler dan Waste processing

After knowing the limits of the system to be analyzed, the quantity of each item or substance that moves in the system through each process can be given. Value quantity data is obtained from the PI paper production process in 2021, starting from August – December. The units of measurement used are ton and m3.

From the figure 3, we see multiple inputs of process, shown using symbol I (import), and output (goods/substance that going out of the system) shown as E (export). To see the performance of each process we use mass balance calculation. The Mass Balance calculation for each process is then carried out using the formula:

$$\sum input - \sum output = ds\ stock - ds \geq 0$$

Where:
stock=Number of goods keeps within process (T)
ds=Difference number of goods based on input and output of process (T)

From the calculation above, it is known that if an overstock value appears, there will be an additional cost to meet the stock needs of the process. From the diagram, it can also be seen that there are

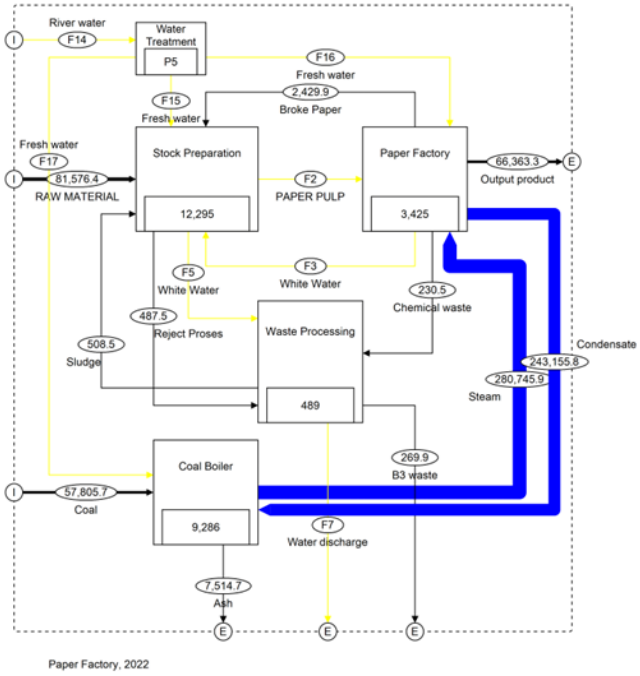

Figure 3: Mass Flow Analysis PI Production System

losses that occur due to the production process, for example, steam loss, and fiber loss which are wasted in the water discharge process.

For P1 (Stock Preparation) the difference between input and output is 121,693.167 tons with stock in inventory data of 102,576 tons and a stock capacity of 250,000 tons, the loss of the production process that appears is 15.7%. For P2 (Paper Factory), the difference between the input and output process is 113,658 tons with stock in inventory data of 103,479 tons and stock capacity of 170,000 tons. Production process loss appears at 8.95%. For P3, (waste processing) it is known that the difference between input and output values is 11,748 tons with stock in inventory data of 10,489 tons and stock capacity of 10,500 tons. Appears loss of 10.7% from the processing. For the process in the coal boiler unit (P4), the difference between input and output is 17,620 tons and the stock in inventory data is 14,286 tons. The stock capacity of the coal boiler can accommodate 25,000 tons of units. It is known that the process loss is 18.9%. Lastly, in P5 (Water Treatment), it is found that the difference between the input and output of the system is 100,171 m3 and the stock in inventory data is 100,872 m3. The capacity of the water pool for this unit is 120,000 m3, it is known that the data difference is 0.67% (recording error)

From the mass balance analysis, we can make some conclusions:

- There is a loss in every production process, for every loss that occurs and is not recorded, most of these components will be iterated in the process (except gas loss (steam), and particulate loss) due to the absence of recording of ditch discharge and internal storage ponds in the PI.

- Overcapacity is found in the waste treatment unit, there is a loss in the process of 10%, this is estimated because the process of using sludge is less than optimal.
- In the waste processing unit, there is process rejects that cannot be processed, mainly rejects in the form of plastic, wire, and secondary sludge.
- The biggest loss is in the coal boiler process unit, there are 3334.8 tons losses in this process. In addition, most of the losses in this unit cannot be iterated because they are in the form of gas loss and particulate loss.

4.3 Circular Economy Business Model

The CE approach in forming a business model is carried out using the 6R, Reuse, Recover, Recycle, Redesign, Reduce, & Remanufacture principles. Based on the MFA, it can be determined the approach taken to increase the company's financial benefits, both from better resource utilization, production waste reduction, and reuse of generated waste. There are 3 improvement plans proposed based on MFA Analysis.

- Reduction of fiber loss in each production process (Recover, Reuse)

In the PI production process, there was a loss of 15.7% in the Stock Prep unit and 8.9% in the Paper Factory unit. This fiber loss can be carried up to the discharge point outside the system and cause the risk of water pollution in the surrounding environment. The potential loss arising from these 2 units is 3,000 tons of fiber or Rp. 15,000,000,000 per year. Steps that can be taken are the addition of screens on the SP and PF processing units, in addition to decreasing the Disc Refiner press parameters on the SP unit.

- Optimization of steam usage (Redesign, Reduce, Reuse)

In the PF process unit at PI, the use of steam uses cascade system technology which has a simple operational and piping process, but the application of energy provided cannot be maximized. It is recommended to change the system from a cascade to a thermos-compressor which is more efficient in energy use and its application can be more controlled to reduce the possibility of rejecting the paper. In addition, the use of a Thermo compressor can maximize condensate return in the system.

- Plastic Pallet unit (Recover, Recycle, Redesign)

Plastic pallet units can solve the problem of plastic waste that is increasingly piling up at PI. Due to insufficient output of waste by using it as boiler raw material, the current condition of plastic waste is increasingly piling up and becomes the company's morning burden. An area of 2000 m2 of potential land by the company cannot be utilized because it is used as a location for storing plastic waste or if it is converted to around IDR 175,000,000 per year. In addition, there are government regulations regarding the prohibition of the disposal of plastic waste out of factories, causing the need for a permanent solution to resolve the buildup of this plastic waste. Based on the calculations, it is estimated that there will be a difference between input and output in the system of 100 tons per month.

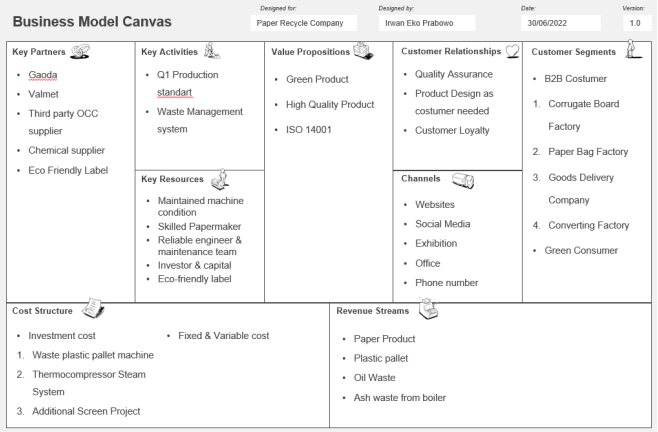

Figure 4: Business Model Canvass based on CEBM

4.4 Business Model Canvass based on CEBMs

The business model canvass is prepared based on the proposed CEBM, there are 3 proposed improvement proposals, namely the manufacture of waste plastic pallet units, changes to the Thermo compressor steam system, and additional screens on the PF PI. These 3 improvement plants will become investment cost as value delivery to help PI Improve its's standard as a paper company while keep increasing profitability as we can see on figure 4

5 CONCLUSION

Based on the discussion regarding the benefits of a Circular Economy on Recycled Paper Companies related to MFA, CEBM, and BMC that has been carried out, the following conclusions are obtained:

- Through MFA it is known that there are losses that appear in every process in the PI production system, this can be corrected by optimizing the production process, and reducing production waste. As a result, a higher level of productivity will be obtained, which will increase company profits
- From the results of the MFA analysis, a CE-based business model approach was taken which resulted in 3 improvement plans, namely :
- Waste Plastic Pellet Machine
- Thermocompressor Steam System
- Additional screen Projects

The author knows that the results of the research carried out are not perfect, therefore several points can be considered further for PT. PI can increase their awareness of environmental conditions and waste management in the company. In the future, this condition will be a burden for the company to grow bigger due to the increasing environmental costs that must be borne by the company. In further research, it is possible to examine further the sub-system process in each process, considering that the results of this research show that the loss value is quite high in each process.

REFERENCES

[1] P. Adi Wicaksono and C. Ahmad Kadafi, "The Improvement of Production Process Impact in Furniture Industry Toward Circular Economy," E3S Web Conf., vol. 202,

2020, doi: 10.1051/e3sconf/202020207052.
[2] G. L. F. Benachio, M. do C. D. Freitas, and S. F. Tavares, "Circular economy in the construction industry: A systematic literature review," J. Clean. Prod., vol. 260, 2020, doi: 10.1016/j.jclepro.2020.121046.
[3] M. Koszewska, "Circular Economy - Challenges for the Textile and Clothing Industry," Autex Res. J., vol. 18, no. 4, pp. 337–347, 2018, doi: 10.1515/aut-2018-0023.
[4] P. H. Brunner and H. Rechberger, "Material Flow Analysis B o o k Reviews Practical Handbook of Material Flow Analysis," Waste Manag., vol. 9, no. 5, pp. 337–338, 2004.
[5] G. Moraga *et al.*, "Circular economy indicators: What do they measure?," Resour. Conserv. Recycl., vol. 146, no. April, pp. 452–461, 2019, doi: 10.1016/j.resconrec.2019.03.045.
[6] F. Lüdeke-Freund, S. Gold, and N. M. P. Bocken, "A Review and Typology of Circular Economy Business Model Patterns," J. Ind. Ecol., vol. 23, no. 1, pp. 36–61, 2019, doi: 10.1111/jiec.12763.
[7] A. Marques, J. Cunha, A. De Meyer, and K. Navare, "Contribution towards a comprehensive methodology for wood-based biomass material flow analysis in a circular economy setting," Forests, vol. 11, no. 1, 2020, doi: 10.3390/f11010106