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BARRIERS, SUPPORTING FACTORS AND IMPLEMENTATION OF GREEN MANUFACTURING IN INDONESIA: A LITERATURE REVIEW

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Abstract

Industry considers that the implementation of environmental standards is a cost that makes selling prices more expensive and indirectly reduces the competitiveness of the company. Industries can implement various ways to minimise environmental impacts with their production processes, one of which is by using Green Manufacturing (GM). This paper will discuss the literature review on Green Manufacturing that has been done which will be divided into several topics of study, including the definition of GM, supporting and inhibiting factors for GM implementation, studies on various GM practices or implementations and GM Execution in Indonesia. Research has indicated that if GM is not well managed due to lack of understanding on how to start or due to lack of awareness on the use of GM in Industry. GM policies in various sectors will differ depending on the size of the company/organisation, however, these differences must still follow the legal umbrella that already exists in Indonesia.

Keywords: *Barriers, Supporting Factors, Implementation, Green Manufacturing*

INTRODUCTION

All human beings want a decent place to live therefore the need for regulations to protect the environment is widespread but the acceptance is still uneven. This is due to the belief that environmental regulations often erode the competitiveness of an Industry. The prevailing view is that Ecology and Economics are at odds with each other, on the one hand the benefits of implementing environmental standards will have an impact on the social benefits of society. On the other hand, Industry considers that the implementation of environmental standards is a cost that makes selling prices more expensive and indirectly reduces the competitiveness of the company.

Indonesia's environmental quality improved again in 2022. The Ministry of Environment and Forestry (KLHK) noted that this year's Environmental Quality Index (IKLH) score was 72.42 points. The index score recorded an increase of 1.36% compared to the previous year which was 71.43 points. The figure is also higher than this year's target of 69.22 points (Data Indonesia, 2022)

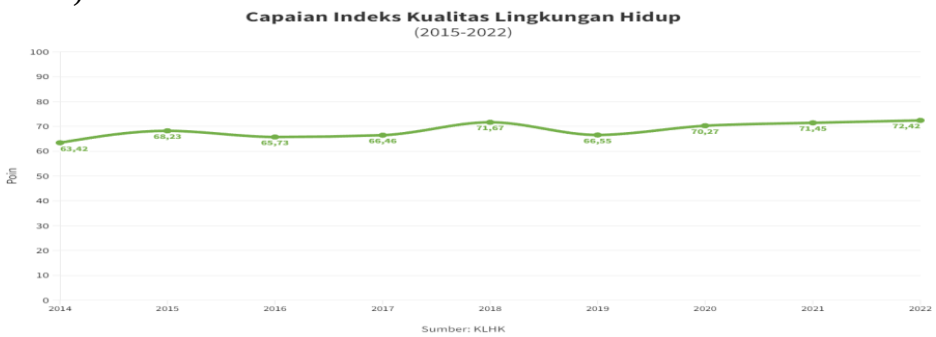

Figure 1. Indonesia's IKLH Achievement (Source KLHK)

Well-designed environmental regulations can trigger innovations that lower the total cost of a product or increase the value of the product itself. Such innovations allow companies to use raw materials, energy and labour more productively. This is expected to offset the costs of

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environmental impacts. Ultimately, this increased resource productivity makes the company more competitive (Florida et al., 2001).

Industries can implement various ways to minimise environmental impacts with their production processes, one of which is by using Green Manufacturing. Green Manufacturing (GM) can reduce raw material costs (e.g. by recycling waste), production efficiency (e.g. by reducing energy consumption and water consumption), increase costs due to work accidents (Safety awareness) and improve the company's image by reducing the environmental impact on society (Porter & Van der Linde, 1995).

This paper will discuss the literature review on Green Manufacturing that has been done which will be divided into several study topics, including the definition of GM, supporting and inhibiting factors for GM implementation, studies of various GM practices or implementations and GM Execution in Indonesia.

LITERATUR REVIEW

Review of Green Manufacturing and the Urgency of Implementation.

Environmental degradation and ever-increasing CO2 emissions have necessitated green manufacturing practices for industries around the world. In this perspective, green manufacturing (GM) practices are conceptualised and practised by large-scale companies in developed countries. However, small and medium-sized enterprises (SMEs) in developing countries are still struggling to adopt GM practices (Karuppiah et al., 2020).

Green Manufacturing is a production process that considers inputs with low environmental impact, is efficient, and minimises waste or pollution by recycling waste (Atlas & Florida, 1998)

Micro, Small and Medium Enterprises (MSMEs) and large manufacturing industries are two important contributors to industrial growth and development in every country's economy, especially in Indonesia. Pressure from national and international agencies creates urgency for these two sectors to shift to GM from conventional manufacturing. GM minimises waste and pollution and generates better financial and image benefits, if implemented correctly. Therefore, it is imperative to understand the drivers of GM and the underlying relationship between them (Seth et al., 2018)

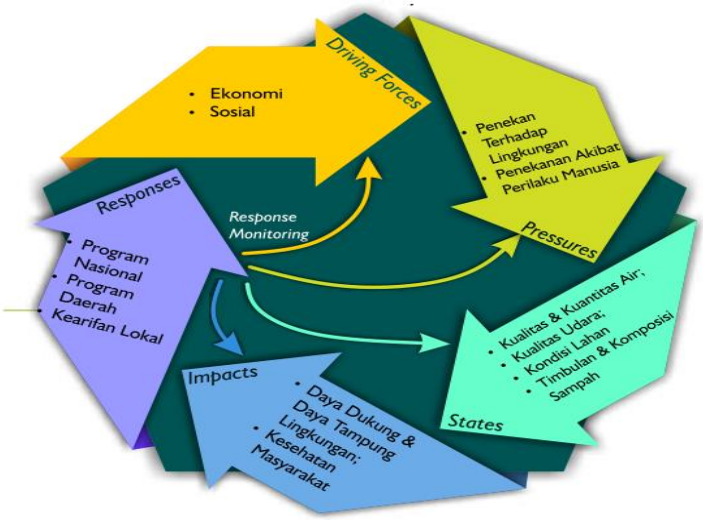

Figure 2. Model DPSIR (Driving Forces, Pressure, State, Impact, and Response) Indonesia

According to a Boston Consultancy Group report published in 2011, environmental concerns can be categorised into three broad categories:

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a. Increased emissions and climate change

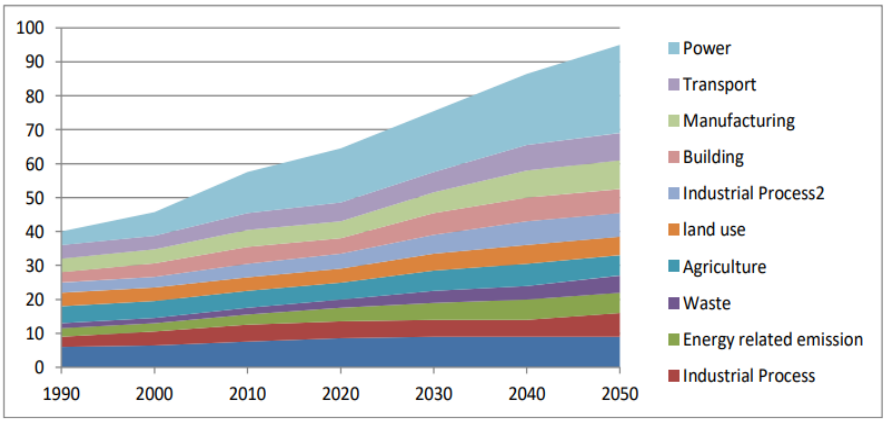

Figure 3. Estimated greenhouse gas emissions in 2050 across different segments

Figure 3 shows the expected increase in Greenhouse Gas (GHG) emissions across different sectors by 2050. This could mean that by the end of the century, corresponding temperatures could increase by up to 4 – 6°C above pre-industrial levels. These unprecedented changes are expected to have major impacts on global ecosystems, hydrological systems, sea levels, crop production and various activities (Saxena & Srivastava, 2022)

8. Rapid depletion of rare natural resources

With increasing population and industrialisation, consumption of natural resources (e.g. timber, coal, oil, food, water, etc.) is increasing rapidly, while their availability is shrinking. This leads to periodic demand-supply mismatches with highly fluctuating prices, impacting both corporate margins and consumer spending. Natural resource depletion, mineral depletion, and energy depletion, and their effects are becoming a major cause hindering economic growth in many countries (Nawaz et al., 2019).

8. Increased waste production and pollution

Increased industrialisation and urbanisation have led to significant growth in waste production and environmental pollution. Industrial effluents with chemical composition can be potentially hazardous to health, and their disposal without treatment can lead to soil pollution and water pollution. The release of industrial waste in rivers and other water bodies damages local habitats.

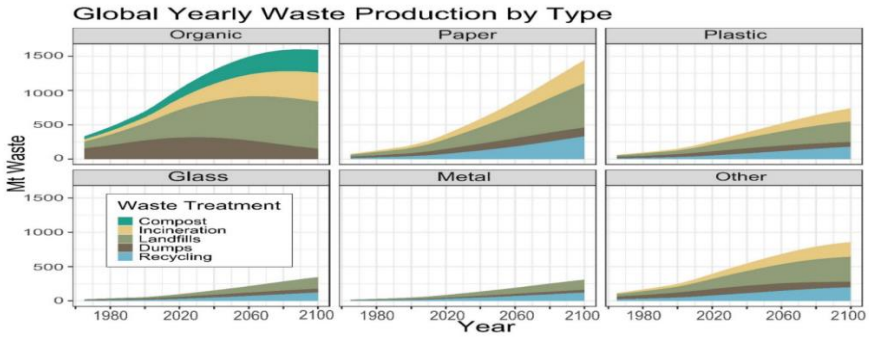

Figure 4. Global projections of future waste production by Type and Treatment

From 2015 to 2050, the share of organic waste decreased from 47% to 39%, while the share of other waste types increased, especially paper. The share of waste treated in landfills

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decreased from 28% to 18%, and sustainable recycling, composting, and energy recovery treatment increased (Chen et al., 2020).

In addition, during the period 2017 – 2019, the Directorate General of PPKL KLHK has carried out marine debris monitoring in 24 locations in 22 provinces throughout Indonesia. The location selection is adjusted to the criteria contained in the Directorate General of PPKL's Marine Debris Monitoring Guidelines. Along with what has been done by LIPI, an inventory of marine litter is carried out to obtain basic data on marine litter on the coast, especially beach litter (Kementrian Lingkungan Hidup & Kehutanan Indonesia, 2020)

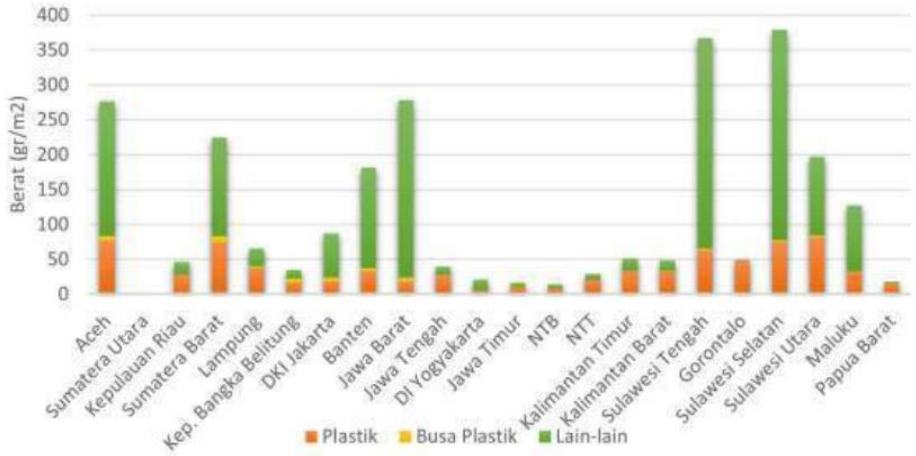

Figure 5. Marine debris weight and plastic composition in Indonesia in 2019

RESEARCH METHOD

To better understand what is meant by Green Manufacturing (GM) and the Urgency of Its Application, GM Obstacles and Supporting Factors as well as GM Implementation in various Industries, a literature review was conducted on various articles from several journals and articles that discuss GM. The various articles are ummarized and selected in accordance with the discussion criteria that are used as topology in the Journal in this discussion, the selected articles will be grouped into three parts, namely discussing Green Manufacturing and the Urgency of Implementation, GM Obstacles and Supporting Factors and GM Implementation in various Indonesian Industries.

RESULTS

The Urgency of Green Manufacturing Implementation

How to solve the contradiction between economic growth and ecological environment protection is a practical problem that must be solved urgently at present. The development of green technology in the manufacturing industry must rely on technological innovation. However, the process of implementing green innovation in the manufacturing industry is full of uncertainties and high risks (Sun et al., 2020) but GM can be applied to all sectors of production allowing waste and pollution, enabling economic progress and conserving resource (Yildirim et al., 2020).

The production process uses inputs with relatively low environmental impact and high efficiency and produces outputs with relatively low environmental impact (Wan et al., 2019).

The benefit of the relationship between GM and operating costs is reinforced by the reduced pollution level in the local city. In addition, there is a synergistic effect of industrial pollution levels and local government pollution information transparency. When companies consider implementing GM, they should try to find ways to make the best use of GM, as GM can increase operating costs. Research in China in 2018 recommended that the government can

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participate in supervising the environmental behaviour of companies and can develop environmental incentive policies (Mao & Wang, 2019).

Manufacturing industries both small and large contribute to GHG emissions and affect the environment. Inefficiencies in energy, supply chain management and manufacturing also lead to increased emissions and waste that affect the environment and financial performance. Therefore, to reduce the adverse impact on the environment, GM should be investigated and implemented in both small- and large-scale industries. Competitive conditions force companies to improve business and enhance green performance, which helps to remain competitive (Seth et al., 2018a).

Strategies used for green manufacturing

One of the things involved in the green manufacturing process to reduce waste in industry is recycling. Leftover production materials can be reused or processed in some way to reduce production costs. In addition, investment in production process improvement, replacing the latest sources for limited ones, are some other things involved in the green manufacturing process. The following are the strategies for Green Manufacturer (Huiling & Dan, 2020):

a. Minimise the amount of energy and resources used
b. Using environmentally friendly energy
c. Minimising the number of emissions and hazardous waste
d. Maximising the reuse of hazardous waste

Companies that are able to create new ways in the production process, distribution, or can create environmentally friendly products will be a company advantage, where green innovation is one of the environmental strategies that can be done (Damas et al., 2021).

The following are green manufacturing strategies in industry that we summarise from various previous studies:

a. *Life Cycle Assessment*
b. *Eco-efficiency*: will serve as a management control to reduce the company's impact on the environment and simultaneously create more value for shareholders (Dewi & Rahmianingsih, 2020)
c. *Green Innovation*: green innovations to minimise adverse environmental impacts that can ultimately increase the value of the company
d. *Carbon Emission Disclosure*: Investors and the public are also likely to be concerned about the impact of carbon emissions, so managers play a role in (Damas et al., 2021)
e. 6R approach (*reuse, reduce, recycle, remanufacturing, recover, redesign*) (Prabowo & Suryanto, 2019)

Government regulations for green manufacturing

Regulations refer to explicit statements addressed to a person or group of people regarding do's and don'ts. This calm environment can create motivation for people to obey and follow all the contents of the regulation. Regulations are made in order to regulate all activities in accordance with the rules in order to achieve goals in an organisation. Operational activities strive not to dispose of waste carelessly which will have an impact on the surrounding environment.

Legal aspects of green manufacturing implementation (Biro Hukum Kementerian Perindustrian., 2020)*:*

- Law Number 3 Year 2014 on Industry (Articles 77 – 83)
- Government Regulation No. 14 of 2015 on the National Industrial Development Master Plan
- Government Regulation No. 29 of 2018 on Industrial Empowerment

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- Minister of Industry Regulation No. 51 of 2015 concerning Guidelines for the Preparation of Green Industry Standards
- Minister of Industry Regulation Number 18 of 2016 concerning Green Industry Awards
- Minister of Industry Regulation Number 41 of 2017 concerning Green Industry Certification Bodies
- Minister of Industry Regulation Number 39 of 2018 concerning Green Industry Certification Procedures

In Indonesia, environmental regulations are governed by laws and regulations of the Ministry of Environment and Forestry. It can be seen from the data in Figure 2 that Indonesia is trying to simplify its environmental regulations to align with the goals of the Indonesian industry and economy (JDIH KMLHK, 2023).

Figure 6. Simplification of ministry regulations on the environment (source: JDIH MNLHK)

Barriers and Supporting Factors for Green Manufacturing

Green Manufacturing is a set of practices that seeks to manage environmental issues, including energy efficiency and reduced wastage of natural resources. According to some authors ((Dubey et al., 2019 & Raut et al., 2019)), GM must incorporate Green Product Design (GPD), Green Technology (GT), and green production. The practices must be implemented through the entire product manufacturing lifecycle (Belhadi et al., 2020).

Higher consumer preference for GDP always brings increased profits. From the perspective of motivating product design, mandated targets and consumer preference for green product design can motivate manufacturers to implement green product design (Li et al., 2021). Consumers are more interested in the appropriate price of Green Products and the company's CSR activities are more implemented to the community (Sana, 2020).

GT acts as a catalyst in translating Green Knowledge (GK) management into improved corporate environmental performance. The results show that resource commitment moderates the interaction of Green Knowledge Management and Green Technology Innovation acquisition, it provides practical knowledge that allows managers to focus on planning, allocating, and budgeting resources for effective green practices that can contribute to improved corporate environmental performance (Sahoo et al., 2023)

GM practices include all initiatives to reduce the adverse impacts of the company's manufacturing operations and protect the Environment (Yildiz Çankaya & Sezen, 2019). These practices positively affect EP by reducing ecological impacts (Inman & Green, 2018).

Previous research has shown several examples of the positive effects of GM practices as well as the implementation of GM in various Industries on EP, for example, reducing air emissions and disposal of solid/liquid waste and hazardous substances; (Green et al., 2019; Yildiz Çankaya & Sezen, 2019) optimise resource consumption and improve energy efficiency (Abu Seman et al., 2019; Namagembe et al., 2019; Piyathanavong et al., 2019)

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However, the integration of GM during all stages of production is a complicated and challenging task as it is important to find a balance between production goals, delay performance, and environmental concerns to satisfy all stakeholders. Therefore, it is necessary to use modern technologies and new decision aids to integrate GM throughout the production life of the production cycle and improve Environtmental Performance (EP). In (Ren et al., 2019) Big Data Analysis (BDA) was used when developing the GM approach. The authors, based on the analysis of several life cycle stages affecting GM and sustainable production, proposed a framework using BDA to improve sustainability, quality, and reduce environmental impacts. The developed framework found support from (Singh & El-Kassar, 2019) which discusses the role of BDA and GM practices in developing sustainable capabilities. Although the study is a theoretical preposition, the authors state that applying BDA capabilities during the entire life cycle in environmental manufacturing leads to operational and EP improvements. Moreover, recent research confirms the positive relationship between BDA and GM (Dubey et al., 2019; Raut et al., 2019; Zhang et al., 2018).
According to Research (Gandhi et al., 2018) summarised in previous research, there are 9 factors that can support GM implementation.

Table 1. 9 Factors that support Green Manufacturing

No	Faktor Penunjang	Signifikansi
1	Top Management Commitment	Owner or manager commitment to GM
2	Technology upgradation	Utilisation of energy- and resource-efficient technologies
3	Cost Savings	Reduction of energy and resource consumption
4	Competitive advantage	Cost savings give the company a competitive advantage
5	Current Legislation	Pollution control, Taxes, Norms – Emission norms
6	Future Legislation	Expected initiation of new legislation, increased level of law enforcement
7	Incentives	Supportive and positive work environment
8	Green brand Image	The respective environmental image in the view of society, CSR
9	Public Pressure	Local communities, politicians, NGOs, media

According to the summary in the discussion (Manik et al., 2019) in terms of the factors that encourage and hinder the implementation of green manufacturing in the company, the most significant ones are:

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- Aim to improve the company's reputation,
- Increase the competitiveness of the company,
- Improve product quality and gain public recognition

Some of the factors that hinder companies from implementing green manufacturing are

- The company did not have a strong organisational structure to support Green Manufacturing and did not have structured environmental management.
- The company owners do not know about green manufacturing practices because they believe that it will only incur a lot of costs without significant benefits to the company.

Implementation of Green Manufacturing in various Indonesian Industries

According to (Seth et al., 2018b) Both MSME and large-scale industries contribute to GHG emissions and environmental impacts. Inefficiencies in energy, supply chain management and manufacturing also lead to increased emissions and waste that affect the environment and the company's financial performance.

Thus, to reduce the adverse environmental impact, GM should be investigated and implemented in MSMEs as well as large-scale industries. Competitive conditions force companies to improve business and enhance Green Performance, which helps to keep companies competitive. Therefore, it is expected that manufacturing companies both SMEs and large-scale industries, should remain vigilant and regularly evaluate performance considering green challenges (Seth et al., 2018b).

During 2022, Indonesia's economy grew by 5.31%, with all sectors experiencing growth. The business sector that experienced the highest growth was transport and storage at 19.87%, followed by food and beverage supply at 11.97% and other services at 9.47%. Meanwhile, the manufacturing sector experienced the largest growth of 4.89%, while the agriculture, forestry and fisheries and wholesale and small trade sectors experienced growth of 4.89% (BPS, 2023).

Figure 7. GDP Growth of Several Business Fields in Indonesia

Below are some industrial sectors that have implemented green manufacturing, namely PT Sekar Lima Pratama is a textile company that has a cotton fabric finishing unit. After the identification, the company still produces waste and has not run an environmentally friendly

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process. Researchers conducted GM identification on the object under study to evaluate the extent to which the company applies GM in the production process.

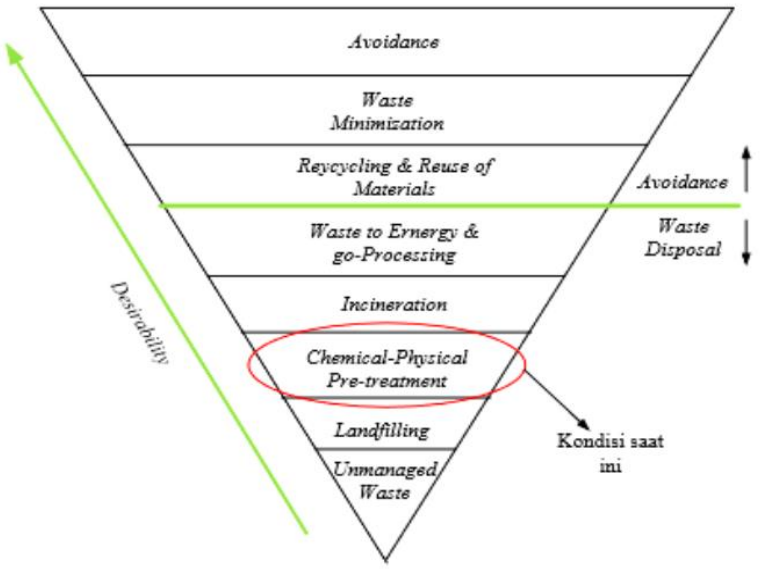

Figure 8. The Green Manufacturing Pyramid Concept

Based on the GM pyramid, the proposal for environmentally friendly processes is to increase the company level from the Chemical-Pretreatment Pre-Treatment level to the Reycycling and Reuse of Materials level. The recommendations made are to use waste condensate as a source of boiler water, reuse sigeing machine cooling water for the starch removal process, bleaching wash water for the scouring process, and make changes to machine parts that can still be used (Prabowo & Suryanto, 2019).

Another study was conducted at a petrol kios in Yogyakarta. Although it is only a kiosk when viewed from the level of risk, this petrol kios has a high risk because it can endanger the lives of others. As a result, to avoid adverse impacts on the environment, petrol kios businesses must conduct environmentally friendly business. The purpose of this study is to determine and analyse how knowledge, public approval, and regulations affect the desire to implement green manufacturing. The sampling method used was purposive sampling. This study collected data from 30 petrol kios businesses through questionnaires given directly to them. The results showed that knowledge and regulations have a positive impact, while public approval does not affect the desire to implement Green Manufacturing (Yusuf, 2019).

Then based on research from (PRADANA, 2021) this study, conducted in laundry businesses in Yogyakarta, aims to determine and analyse the influence of knowledge, government support and public approval on the motivation to implement GM. This study shows that knowledge, government support, and public approval affect the desire to implement GM.

Still within the scope of the industry, namely the handicraft producer IKM Batik Central Java, there are 3 Green Technology used to improve GM, namely Reuse Wax scattered on the floor. Reuse wax that floats in the melorodan process and make a wax catcher tub (Kowen). The results showed that the main motivating factors for GM implementation are supply chain needs, maintaining business image, and public approval (Raharjo & Muhammad Slamet, 2023).

The actual implementation of GM in the utilisation of plastic waste in brick mixtures is also stated in the journal (Dwi & Yustina, 2021) the results of the test show that the quality of bricks with a mixture of plastic bottle waste samples is suitable for use as building construction.

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Research from Probolinggo by (Maryati, 2022) tofu liquid waste treatment which aims to determine the Waste Water Treatment Plant (WWTP) system and the benefits and benefits obtained by the research results show that the WWTP used using the Anaerobic-Biogas system is profitable and contributes to company profits.

As well as the most recent research by (Brilian, 2023) In the ADIBIO10 Fertiliser Factory, it shows that the application of green manufacturing at Adibio10 is quite good, seen from the analysis of environmental waste in the Adibio10 Fertiliser production process, starting from water consumption where the use of water in Adibio10 fertiliser is very minimal because it is only needed in the mixing material in the Granulator process, and from the aspect of waste, Adibio10 fertiliser emits air pollution which according to the author is still within reasonable limits and does not disturb the surrounding community, the aspect of energy consumption also does not require large energy, and the aspect of the materials used is safe and does not contain chemicals.

DISCUSSION

The effect of cost on the implementation of green manufacturing in the company

Wang and Lin (2007) proposed a broad triple bottom line framework to track and categorise sustainability information at the firm level through a sustainability index system. The framework incorporates costs, environmental and social values into economic activities to support management decisions. Their methodology provides suggestions to assist decision-making for green manufacturing. Taylor (1992) suggested that companies should initiate green management and green innovation to improve environmental performance, and fulfil consumer demand to improve the company's image among regulators and the general public.

According to Amaranti et al. (2017), a review that has been carried out related to green manufacturing, the majority of barriers to the implementation of green manufacturing are still low regulatory stipulations and also the lack of knowledge related to green manufacturing by small to medium-sized companies. One of the causes is that companies are still not motivated to implement green manufacturing due to the considerable cost of implementing green aspects, so companies still consider costs with the benefits obtained by the company

Some researchers are motivated to find out whether better environmental performance can lead to economic benefits. Li (2014) observed that better environmental performance tends to reduce raw material costs and unnecessary waste disposal, thereby leading to lower production costs and better financial performance. Companies can achieve environmental performance through the implementation of pollution prevention and cleaner technologies that help minimise high costs or fines arising from non-compliance with environmental obligations (Klassen dan McLaughlin, 1996). The reduction in liability costs will improve environmental performance and therefore help the firm to get better corporate economics. Empirical evidence by Centobelli et al. (2019) among Indian manufacturing firms shows that the better the environmental performance, the higher the financial performance. Contrary to the foregoing, Venkatraman and Nayak (2015) argue that the relationship between Environmental and financial performance is non-existent and indirect. In fact, there is an assumption that the implementation of environmentally friendly practices is an externality for companies (Centobelli et al., 2019). This is because companies are under immense pressure from various stakeholders to adopt green practices, and by succumbing to this pressure, they have to incur additional short-term costs. These short-term costs may improve environmental performance but drain the company's finances (Afum et al., 2020).

CONCLUSIONS AND SUGGESTIONS

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Green Manufacturing is becoming an interesting topic to discuss as people's awareness of the importance of being environmentally friendly increases. People around the world are starting to realise that the environment has limited resources and are starting to worry about its availability, such as the diminishing water supply and the depletion of energy sources. Industry is also starting to pay attention to these environmental issues, one of the approaches taken is through the adoption of GM. Basically, GM is a process of innovation from a conventional industry to an environmentally-based industry in the entire manufacturing process.In this journal, an attempt has been made to summarise writings on GM implementation in industry. As of now there are still limited guidelines for GM to be actualised in industry especially Indonesia due to the lack of familiarity with it. Thus, a strong motivation is needed to make the organisation more environmentally friendly for tomorrow. Indifference to GM will bring more losses.

The main objective of the journal is to study the significance of Green Manufacturing as a whole which is related to Top Management Commitment, Supporting Technology, Cost Savings, Competitiveness, Applicable Regulations along with Government Regulation Plans, Company Incentives, Company "Green" Image & Public Encouragement. Research has indicated that if GM is not well managed due to lack of understanding on how to start or due to lack of awareness on the use of GM in the Industry. GM policies in various sectors will differ depending on the size of the company/organisation, however, these differences must still follow the legal umbrella that already exists in Indonesia.

Environmentally friendly practices that have reduced waste and increased industrial output should now be brought to the core of importance. The use of GM especially in Industry in Indonesia needs to be improved by providing thorough environmental studies and creating better awareness at the level of industry, public and government as a whole.

In future research, there are still many opportunities to conduct research topics in the field of GM related to the implementation of GM in small and medium scale industries as well as large scale industries, energy regulations and environmental regulations in the government.

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