

Research Horizon

ISSN: 2808-0696 (p), 2807-9531 (e)

Research Horizon

Volume: 04

Issue: 04

Year: 2024

Page: 205-220

Development of Environmentally Friendly Technology for Key Industries in Achieving Golden Indonesia

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Abstract

Indonesia aims for Golden Indonesia 2045, combining economic prosperity, social justice, and environmental sustainability. Facing challenges like deforestation, pollution, and climate change, sustainable development is urgent. Developing eco-friendly technology in areas like renewable energy, waste management, sustainable agriculture, and manufacturing is key for growth while addressing these challenges. This research aims to identify and analyze the development of environmentally friendly technology that can support key industries in achieving the vision of a Golden Indonesia 2045. The research methods used include literature studies, secondary data analysis, and interviews with industry experts and environmental experts. The analysis results show that the development of environmentally friendly technology is a strategic step that supports the vision of Golden Indonesia 2045, which emphasizes sustainable and environmentally sound economic growth. Various technologies such as renewable energy, waste management, energy efficiency and sustainable transportation are the main focus in achieving this goal. The findings of this research provide an important contribution to the understanding of the role of environmentally friendly technology in industrial transformation towards a Golden Indonesia 2045.

Keywords

Environmentally Friendly Technology, Golden Indonesia 2045, Key Industries.

1. Introduction

Indonesia's ambitious vision of Golden Indonesia 2045 represents a comprehensive and holistic approach to national development that transcends mere economic progress. At its core, this vision reflects a profound commitment to fostering social equity and environmental sustainability as pillars of long-term prosperity and well-being for the nation. Unlike a narrow focus solely on economic growth, Golden Indonesia 2045 emphasizes the imperative of achieving balanced development. This means ensuring that progress and opportunities are accessible and beneficial to all segments of society, including marginalized communities and vulnerable populations (Purwanggono, 2020). The vision recognizes that true advancement is measured not just by GDP figures but by the quality of life, equity in access to resources and opportunities, and social cohesion across diverse communities. Equally crucial to this vision is the imperative of safeguarding the natural environment for present and future generations. Indonesia's rich biodiversity, unique ecosystems, and natural resources are invaluable assets that must be preserved and managed sustainably. This entails responsible stewardship of land, water, and air resources, conservation of biodiversity and ecosystems, and mitigating the impacts of climate change through proactive measures (Firdaus et al., 2023).

Golden Indonesia 2045 underscores the interconnectedness of economic, social, and environmental dimensions of development (Elmi & Librianty, 2023). It recognizes that sustainable progress cannot be achieved at the expense of social justice or environmental degradation. Instead, it seeks to harmonize these dimensions, ensuring that economic growth is inclusive, environmentally responsible, and contributes positively to societal well-being. In essence, Golden Indonesia 2045 envisions a future where prosperity is not just measured by material wealth but by the collective well-being of all Indonesians. It aspires to a society where opportunities are accessible to everyone, where environmental stewardship is a shared responsibility, and where progress is sustainable and resilient in the face of global challenges. This vision serves as a guiding beacon for shaping policies, strategies, and actions that steer Indonesia towards a brighter, more equitable, and sustainable future. However, Indonesia is confronted with a multifaceted array of environmental challenges that pose substantial threats to its long-term sustainability. One of the most pressing issues is deforestation, driven primarily by agricultural expansion and logging activities. This rampant deforestation leads to extensive habitat loss, contributes to the depletion of biodiversity, and plays a significant role in exacerbating climate change by releasing carbon stored in forests into the atmosphere. Moreover, Indonesia grapples with pervasive air and water pollution, primarily stemming from industrial emissions, rapid urbanization, and inadequate waste management practices. Industrial activities release pollutants into the air and waterways, leading to serious environmental degradation and posing health risks to both humans and wildlife. The rapid growth of urban areas further intensifies pollution levels, creating challenges in maintaining clean and healthy living environments.

The impacts of climate change add another layer of complexity to Indonesia's environmental challenges (Siregar & Sagena, 2023). Rising sea levels threaten coastal communities and ecosystems, while extreme weather events such as floods, droughts, and storms disrupt livelihoods and infrastructure. Changes in temperature and precipitation patterns also affect agriculture and natural ecosystems, leading to shifts in habitats and biodiversity loss. These environmental challenges are interconnected and require urgent and coordinated action to address effectively. The complex nature of these issues necessitates innovative solutions, robust policies, and collaborative efforts across sectors and stakeholders. Immediate attention is crucial

to safeguarding Indonesia's natural resources, protecting public health, and building resilience to the impacts of climate change for present and future generations.

Addressing the multifaceted and interconnected environmental challenges facing Indonesia demands urgent and proactive action, coupled with the implementation of innovative and sustainable solutions. Central to this endeavor are key industries such as energy, transportation, manufacturing, agriculture, and waste management, which play pivotal roles in both contributing to these challenges and offering opportunities for transformative change. The energy sector, for instance, is a significant contributor to greenhouse gas emissions and air pollution, primarily through the combustion of fossil fuels for electricity generation and transportation. Transitioning towards cleaner and renewable energy sources, such as solar, wind, hydro, and geothermal power, presents a critical opportunity to reduce emissions, improve air quality, and enhance energy security. Similarly, the transportation sector, characterized by growing vehicle fleets and urban congestion, contributes significantly to air pollution and carbon emissions. Promoting sustainable transportation solutions, including public transit systems, electric vehicles, and non-motorized transport options, can reduce pollution levels, alleviate traffic congestion, and promote healthier urban environments.

In the manufacturing sector, industrial activities generate pollutants, waste, and emissions that impact air, water, and soil quality (Gaur et al., 2020). Adopting eco-friendly manufacturing processes, implementing circular economy principles, and investing in clean technologies can minimize environmental impacts, reduce resource consumption, and promote efficient waste management practices. Agriculture, while essential for food security and rural livelihoods, also poses environmental challenges such as deforestation, soil degradation, water pollution, and greenhouse gas emissions. Encouraging sustainable agricultural practices, including agroecology, organic farming, precision agriculture, and responsible land use management, can enhance productivity, conserve natural resources, and mitigate environmental impacts.

Waste management is another critical area that requires attention, as improper disposal and inadequate waste treatment contribute to pollution, habitat destruction, and health hazards. Implementing efficient waste management systems, such as recycling, composting, and waste-to-energy technologies, can reduce waste volumes, minimize pollution, and recover valuable resources (Parashar et al., 2020). While these industries are fundamental to economic development and societal progress, their current practices often exacerbate environmental challenges. Transitioning towards more sustainable practices is not only imperative for mitigating environmental impacts but also for ensuring long-term economic resilience, resource efficiency, and societal well-being. Collaboration between government, industry, academia, and civil society is essential to drive this transition and achieve a harmonious balance between economic growth and environmental sustainability.

Therefore, in the pursuit of Golden Indonesia 2045, the development and widespread adoption of environmentally friendly technology emerge as critical strategies to address the nation's pressing environmental challenges while supporting sustainable economic growth. One key aspect is the transition towards renewable energy sources, such as solar, wind, hydro, and geothermal power. These renewable sources offer clean and sustainable alternatives to fossil fuels, reducing greenhouse gas emissions and mitigating the impacts of climate change. Embracing these technologies not only decreases Indonesia's reliance on finite and polluting energy sources but also promotes energy security and resilience. Efficient waste management practices are also integral to achieving environmental sustainability. Initiatives such as recycling, composting, and waste-to-energy projects help minimize waste generation, divert materials from landfills, and reduce pollution. By implementing these practices on a large scale, Indonesia can significantly reduce its

environmental footprint and contribute to a circular economy where resources are used efficiently and waste is minimized. Promoting sustainable agricultural practices is another crucial component of Golden Indonesia 2045. Practices such as organic farming, precision agriculture, and responsible land use management conserve natural resources, protect biodiversity, and enhance food security. These approaches minimize the use of harmful chemicals, reduce soil erosion, and promote resilient farming systems that can adapt to climate change challenges. In the manufacturing sector, adopting eco-friendly production methods and embracing circular economy principles is essential. Green production methods prioritize resource efficiency, minimize pollution, and reduce environmental impacts throughout the production process. Circular economy principles aim to close the loop of material use, promoting reuse, recycling, and remanufacturing to minimize waste and maximize the value of resources. By integrating these environmentally friendly technologies and practices across key industries, Indonesia can effectively address its environmental challenges while fostering sustainable economic growth. This holistic approach aligns with the goals of Golden Indonesia 2045, ensuring a harmonious balance between economic prosperity, social equity, and environmental stewardship for generations to come.

Investing in environmentally friendly technologies can help Indonesia reduce its environmental impact, enhance resource efficiency, and promote sustainability (Nainggolan et al., 2023). This approach aligns with the goals of Golden Indonesia 2045, addressing environmental challenges while supporting economic growth, social well-being, and resilience. Transitioning to renewable energy and efficient waste management reduces greenhouse gas emissions, combats pollution, and preserves natural resources. Optimizing resource use and promoting circular economy practices benefits industries by lowering costs and improving competitiveness. Promoting sustainable practices fosters environmental responsibility, reduces pollution, and creates opportunities for innovation and job creation. Cleaner environments and access to sustainable products improve social well-being and quality of life. Additionally, adopting eco-friendly technologies builds resilience to climate change, ensuring a more sustainable and inclusive future for Indonesia. The primary objective of this research is to develop a comprehensive understanding of the role of environmentally friendly technology in achieving Golden Indonesia 2045, particularly focusing on key industries.

3. Methods

The research approach is qualitative. The research method used to develop environmentally friendly technology for key industries in achieving Golden Indonesia 2045 includes several main stages. First, in-depth literature research was carried out to identify the latest trends in environmentally friendly technology from various sources such as scientific journals, industry publications, research reports, and other related documents. Second, secondary data analysis was carried out to analyze industrial, environmental, government policy and economic data to understand the context and challenges faced by key industries. Third, interviews with industry experts from various sectors were conducted to gain direct insight into industry needs, obstacles faced, and their views on innovative solutions. Finally, interviews with environmental experts were conducted to understand the environmental impact of key industries, evaluate proposed technological solutions, and obtain input on environmental aspects that need attention. By combining these methods, research can produce a holistic and in-depth understanding to support the development of environmentally friendly technologies that are in line with industry needs and sustainability principles.

4. Results

Current trends in green technology refer to the latest innovations and developments in various fields aimed at reducing negative impacts on the environment and supporting sustainable development. Some of the latest trends in green technology. Renewable Energy. Rapid growth in the use and development of renewable energy technologies such as solar, wind, hydro and biomass power marks an important shift towards cleaner and more sustainable energy sources. Solar panel technology continues to improve with increasing efficiency and decreasing production costs, supported by government incentivization and subsidy programs that stimulate the adoption of solar energy in various sectors, from households to commercial and industrial projects. Meanwhile, wind turbine installations both on land and at sea are becoming more widespread thanks to advances in turbine design and energy production efficiency, offering huge potential to produce clean and stable energy. The construction of hydroelectric power plants also continues, from large scales such as dams to small scales such as micro hydro, with a focus on developing technology to optimize the use of water resources.

Apart from that, the use of biomass as an energy source has also experienced significant development, especially in the use of organic waste and non-food biomass to produce thermal energy, electricity and biofuels (Apriliyanti & Rizki, 2023). Overall, this trend reflects a positive transition towards a more diverse and environmentally friendly energy portfolio, which is expected to reduce dependence on fossil fuels and reduce greenhouse gas emissions to support global environmental protection efforts. Sustainable transport, key in reducing the environmental impact of the transport sector, includes several key aspects: the rise of electric cars with better battery technology and extensive charging infrastructure, the focus of governments and transport companies on environmentally friendly public transport such as buses electricity and high-speed trains, the popularity of shared vehicle concepts such as car-sharing, and the innovation of electric bicycles as an environmentally friendly and cost-effective alternative (Rahmawati & Pratama, 2023). These innovations not only reduce greenhouse gas emissions and air pollution, but also promote sustainable lifestyles in urban communities, having a positive impact on the environment and public health.

Leveraging the Internet of Things (IoT) to optimize energy usage is a very effective strategy in various sectors such as households, industry and commercial buildings. Examples of IoT applications for energy efficiency include the use of smart meters and smart devices in households, connected sensors and automation systems in industry, as well as the use of smart sensors and integration of energy management systems in commercial buildings (Solechan et al., 2022). Through these applications, IoT helps identify energy savings opportunities, reduce waste, and increase awareness about energy consumption patterns. This makes a significant contribution to efforts towards a more sustainable and environmentally friendly energy system. Sustainable agriculture is increasingly adopting advanced technologies to increase efficiency and minimize environmental impacts. Technologies such as vertical farming, hydroponics and the use of drones for crop monitoring are becoming popular as they provide many benefits. Vertical farming optimizes the use of space, while hydroponics reduces water use and the risk of soil and water pollution. The use of drones in monitoring provides accurate and fast information, enabling farmers to take timely action (Fauzi et al., 2023). Thus, these technologies not only increase agricultural productivity but also pay attention to environmental sustainability and natural resources.

Waste Management and Recycling. Waste management and recycling are important aspects of protecting the environment. Efficient recycling technology helps reduce waste and the use of new, environmentally unfriendly materials. Some of the technologies that are developing in this regard include organic waste

management, plastic recycling, electronics recycling (E-waste), and the development of environmentally friendly materials (Rachmat & Susiati, 2024). Through the development of this technology, it is hoped that a more sustainable economic cycle can be created by minimizing waste and maximizing the reuse of existing resources.

Water Conservation. Innovation in technology for water conservation plays an important role in maintaining the sustainability of water resources. Several developing water conservation technologies, such as efficient water delivery systems, the use of recycled water, and real-time water quality monitoring, have made a major contribution to efforts to maintain the availability of clean water for the needs of today and future generations (Nainggolan et al., 2023). With these innovations, it is hoped that more efficient and sustainable water use can be achieved, as well as maintaining water cleanliness and safety for the environment and society as a whole.

Green Buildings. Green buildings are becoming a major focus in efforts to reduce the environmental footprint of the construction sector. Some characteristics of green buildings include the use of environmentally friendly materials, energy efficiency, and intelligent energy management systems. The latest technologies and practices in green buildings include the use of environmentally friendly materials, energy efficiency, and intelligent energy management systems (Nainggolan et al., 2023). By implementing this green building concept, we can not only reduce the environmental impact of buildings, but also provide long-term economic benefits through energy savings and more efficient management.

Use of Sustainable Materials. Use of sustainable materials is key in the journey towards a cleaner and more sustainable environment. Initiatives such as the development of new environmentally friendly materials, material recycling technology, and technology-based waste management are increasingly developing (Nugraha et al., 2024). With the development of sustainable materials and increasingly advanced recycling technology, it is hoped that a more sustainable and environmentally friendly material cycle can be created. This will help reduce negative impacts on the environment and natural resources, and support efforts to create a greener future for future generations. These trends reflect a strong push towards greener and more sustainable technologies in various aspects of life and industry. Then, researchers collected secondary data sourced from the Central Statistics Agency and the Ministry of Environment and Forestry of the Republic of Indonesia regarding industrial, environmental, government policy and economic data in order to understand the context and challenges faced by key industries. Table 1 presents data on industry, environment, government policy, and the economy.

Table 1. Industry, Environment, Government Policy, and Economy Indonesia

No.	Aspect	Data
1	Industry	Number of Industries: 30,788 units
		Industrial GDP Contribution: 18.67%
		Employment in industry: 19.34 million people
2	Environment	Greenhouse gas emissions: 1.24 gigatons of carbon dioxide equivalent (Gt CO ₂ e)
		Air pollution levels: annual concentration of PM 2.5 reached 71.7 ug/m
		Area of deforested forest: 257,000 Hectares
3	Government Policy	Environmental laws: 22 pieces
		Waste management programs: 6 programs
		Incentives for green technologies: 6 programs
4	Economy	GDP Growth: 5.04%
		Inflation: 2.75%
		Unemployment rate: 5.32%

Table 1 shows that data related to industry shows that there are 30,788 industrial units operating, with a contribution of 18.67% to the Gross Domestic Product (GDP) of the country or region of Indonesia. In addition, as many as 19.34 million people work in this industrial sector, showing the importance of this sector in creating significant employment opportunities. Meanwhile, environmental data reveals several serious problems. Greenhouse gas emissions reached 1.24 gigatons of carbon dioxide equivalent (Gt CO₂e), indicating great pressure on the environment due to human activities. The level of air pollution is also a concern with the annual concentration of PM 2.5 particles reaching 71.7 ug/m³, illustrating the health risks that can arise from unhealthy air. In addition, the area of deforested forests reached 257,000 hectares, providing an illustration of environmental damage that needs to be addressed immediately. On the government policy side, there are 22 environmental laws that demonstrate significant regulatory efforts to protect the environment. In addition, there are 6 waste management programs and 6 incentive programs for environmentally friendly technology, showing the government's commitment to addressing environmental problems through various initiatives. The economic data presented also provides a positive picture. GDP growth reached 5.04%, indicating stability and strong economic growth. The maintained inflation rate at 2.75% also indicates price stability which is important for people's welfare. Meanwhile, the relatively low unemployment rate of 5.32% indicates that there are good job opportunities for the population.

Secondary data analysis reveals that several significant environmental challenges are faced by key industries in Indonesia. Greenhouse gas emissions are a major problem, especially from sectors such as energy, transportation and manufacturing. Air and water pollution is also a serious concern, especially in large cities and densely populated industrial areas. Deforestation, caused by agricultural expansion and logging activities, causes habitat loss and significant biodiversity loss. Excessive water use, especially in the agricultural and industrial sectors, threatens the availability of clean water for communities and natural ecosystems. Apart from that, inefficient waste management is also a serious problem, especially in sectors with high waste production such as the chemical and manufacturing industries. Environmental challenges in Indonesia are presented in Table 2.

Table 2. Environmental Challenges in Indonesia

Environmental Challenges
Greenhouse Gas Emissions (from energy, transportation and manufacturing sectors)
Air and Water Pollution (in big cities and industrial areas)
Deforestation (due to agricultural expansion and logging activities)
Excessive Water Use (especially in agricultural and industrial sectors)
Inefficient Waste Management (in sectors with high waste production such as chemical and manufacturing industries)

Table 2 shows that some of the environmental challenges are broad, covering sectors such as energy, transportation, manufacturing, agriculture, and the chemical industry. Greenhouse Gas Emissions, including the energy sector from fossil power plants, motorized vehicles in the transportation sector, and production processes in the manufacturing sector. Greenhouse gas emissions such as CO₂, methane (CH₄), and nitrogen oxides (NO_x) cause significant global warming and climate change. Air and water pollution occurs in big cities and industrial areas as a result of burning fossil fuels, industrial emissions, domestic waste, and the use of toxic chemicals. Air pollution causes public health problems and water pollution threatens the sustainability of water ecosystems. Deforestation can be caused by agricultural expansion for the production of food and other commodities, as well as unsustainable forest logging activities for the timber and non-timber industries. Deforestation causes loss of habitat, biodiversity, and increases CO₂ emissions due to forest

burning. Excessive water use usually occurs in the agricultural sector with inefficient irrigation and in the industrial sector with high water use for production and cooling processes. This causes a decrease in the availability of clean water and increases pressure on water resources. Inefficient Waste Management occurs in sectors with high waste production such as the chemical industry, manufacturing, intensive agriculture and the health sector. Waste that is not managed properly can pollute land, water and air, and endanger human health and the environment.

Literature studies also highlight the serious environmental impacts of industrial activities in Indonesia. Ecosystem damage due to excessive exploitation of natural resources, including forests and wetlands, threatens the survival of local species and reduces ecosystem services that are important for humans (Niman, 2019). Loss of biodiversity is also a serious problem, because Indonesia is a mega biodiversity country with a very high number of plant and animal species (Daulay et al., 2020). Industry's contribution to global climate change cannot be ignored either, with emissions of carbon dioxide and other greenhouse gases contributing to global warming and changes in extreme weather patterns (Mubarok, 2023).

Interviews with industry experts reveal several key factors causing the environmental challenges faced by industry in Indonesia. First, production practices that are not environmentally friendly, such as the use of dangerous chemicals, poorly managed waste disposal, and unsustainable use of natural resources, are one of the main causes. Second, excessive use of fossil fuels in production and transportation processes is also a significant factor in increasing greenhouse gas emissions and air pollution. Third, the lack of awareness of the importance of sustainability among industry causes a lack of motivation to adopt environmentally friendly production practices and reduce environmental impacts. Lastly, the lack of strict regulations and weak law enforcement means that some industries tend not to prioritize environmental sustainability in their operations. In this context, industry experts highlight the importance of adopting more sustainable production practices, such as energy efficiency, use of environmentally friendly raw materials, better waste management and investment in clean technologies.

They also stressed the need for stricter regulations and effective law enforcement to encourage industry to be more responsible for the environmental impacts of their activities. Awareness of the importance of sustainability is also considered crucial in changing the industrial mindset towards more environmentally friendly and sustainable production practices. In interviews with environmental experts, several things highlighted included the need to strengthen environmental regulations to monitor and regulate industrial activities to make them more environmentally friendly. The development of environmentally friendly technology is also a focus, by prioritizing innovation to reduce the industry's negative impact on the environment. Apart from that, increasing public awareness about the importance of protecting the environment is also considered very important, because environmentally conscious people can encourage behavior change and support sustainability measures.

The use of renewable energy is also emphasized as one of the main solutions to reduce greenhouse gas emissions and reduce dependence on fossil fuels which damage the environment. Strengthening environmental regulations is expected to create a clear framework and encourage industry to adopt more environmentally friendly production practices. The development of environmentally friendly technologies, such as the use of renewable energy, more efficient waste processing, and carbon capture technologies, are considered important steps in improving the industry's environmental footprint. Increasing public awareness, through environmental education and advocacy campaigns, is considered to be able to shape public opinion in favor of sustainability and put pressure on industry to act more responsibly towards the environment. Finally, the use of renewable energy, such as solar, wind and hydro power, is a solution that can reduce greenhouse gas emissions

and reduce the industry's negative impact on the environment. By combining efforts to strengthen regulations, develop environmentally friendly technology, increase public awareness, and use renewable energy, it is hoped that a more sustainable industrial environment can be created and have a positive impact on the environment and society as a whole. Eco-friendly technologies relevant to key industries are diverse and continue to evolve along with demands to reduce environmental impact and improve sustainability.

To overcome environmental challenges in the manufacturing industry, strategies such as using clean energy through renewable technologies such as solar power or biomass, implementing clean production processes with zero-waste manufacturing or clean production, as well as using environmentally friendly materials such as recycling and bio-plastic is the key. Implementing this strategy not only reduces environmental impacts and carbon emissions, but also has the potential to reduce long-term energy costs, optimize the use of raw materials, reduce production waste, and produce more environmentally friendly products (Arfarita, 2023). Thus, adopting green technology and production practices will be a strategic step in building a more sustainable manufacturing industry in the future. Agriculture and Agribusiness. To overcome environmental challenges in agriculture and agribusiness, implementing sustainable strategies such as organic farming, smart irrigation and organic waste management is an important step. Vertical farming technology also provides efficient solutions in land and water use, while reducing transportation and energy consumption. The use of sensors and IoT technology for environmental monitoring will help farmers manage resources more efficiently and minimize negative impacts on the environment (Saragih et al., 2020). With these steps, agriculture and agribusiness can play a role in maintaining environmental sustainability while still meeting the need for quality food.

To overcome environmental challenges in the energy and power generation sector, strategies such as investment in renewable energy such as solar, wind, hydroelectric, and biomass power, development of energy storage technologies, and implementation of smart grids with monitoring and control technologies Sophistication is key. These measures not only help reduce greenhouse gas emissions and dependence on fossil fuels, but also enable better energy efficiency and more flexible adjustment to fluctuations in renewable energy supply (Nugraha et al., 2024). In this way, the energy and power generation sector can play an active role in maintaining environmental sustainability while meeting society's sustainable energy needs. To overcome environmental challenges in the transport and mobility sector, strategies such as the use of electric vehicles, investment in sustainable public transport and optimizing green logistics can be effective solutions. By adopting electric vehicles, both for individual and public transportation, we can reduce exhaust emissions and air pollution, as well as reduce dependence on fossil fuels. Investments in sustainable public transportation such as high-speed trains, electric buses, and bicycle infrastructure can reduce private vehicle use, address traffic congestion, and minimize the environmental impact of transportation. In addition, optimizing delivery routes, using environmentally friendly vehicles, and implementing fleet management technology in green logistics can help reduce transportation emissions in the supply chain and support more environmentally efficient deliveries (Butarbutar et al., 2024). With these steps, we can move towards a more sustainable and environmentally friendly transportation system.

Strategies that can be applied in the construction and building sector to overcome environmental challenges include adopting green building concepts, using environmentally friendly materials, and implementing digital technology such as Building Information Modeling (BIM) (Pihawiano et al., 2024). By reducing the carbon footprint, choosing sustainable construction materials, and optimizing resource use through digital technology, this sector can play an active role in

maintaining environmental sustainability and reducing negative impacts on the ecosystem.

The application of sustainable technology refers to the use of technology that considers its impact on the environment, social and economy in a holistic manner. This technology is designed to minimize environmental footprints, reduce waste and pollution, use resources efficiently, support economic sustainability, and improve social welfare. In the context of business and industry, the application of sustainable technology can include the use of renewable energy, environmentally friendly waste management, optimization of production processes for efficiency and effectiveness, and the use of sustainable materials and products (Nainggolan et al., 2023). The application of sustainable technology has the potential to have a significant impact on environmental sustainability and economic growth.

This approach has a significant positive impact in maintaining environmental quality and supporting ecosystem sustainability for future generations. Through the use of renewable energy technologies such as solar panels, wind turbines, and hydropower, as well as the use of environmentally friendly materials such as bamboo, recycled plastic, and green building materials, it can reduce greenhouse gas emissions and carbon footprints, reducing air, land, and pollution. water, as well as promoting more sustainable practices in the use of natural resources. The development of efficient waste management technology and a source-based approach are also important factors in supporting this effort. Support from strong environmental regulations is also needed to control industrial emissions and encourage the use of clean technology (Arifin et al., 2023). All of this, when integrated in a holistic and diverse approach, is expected to have a positive and significant impact in maintaining environmental sustainability for future generations.

Conservation of natural resources is an important foundation in maintaining the sustainability of our environment. Through energy efficiency technology, better waste management and the use of recycled materials, we can contribute significantly to supporting resource conservation for future generations. Energy efficiency technologies such as LED lighting and smart HVAC systems help reduce excessive energy consumption, while advanced waste management technologies enable material recycling and reduced need for new resources. The use of recycled materials and the application of environmentally friendly technologies such as electric cars and solar panels also reduces dependence on non-renewable natural resources (Yasminingrum, 2023). By integrating these technologies and adopting sustainable practices, we can safeguard the availability of valuable natural resources for the future. This not only protects the environment, but also reduces the overall carbon footprint.

The application of digital technology and automation in production processes has a significant impact on various industries. The main benefits include optimizing efficiency and productivity, reducing production waste, minimizing energy consumption, increasing industrial competitiveness, and reducing overall production costs (Raza & Komala, 2020). By optimizing production processes, companies are not only more competitive in the market but also have a positive impact on the environment through reduced waste and more efficient energy consumption. This shows that digital technology and automation have an important role in maintaining the sustainability of our industry and environment. Product and Service Innovation. Product and service innovation driven by the application of sustainable technology does have a significant impact in providing more environmentally friendly solutions. Various examples of these innovations include electric vehicles that reduce exhaust emissions, green buildings that use renewable energy and environmentally friendly materials, recycling products that reduce waste, and digital solutions for environmental management such as air pollution monitoring or efficient waste

management (Nainggolan et al., 2023). All of this creates new opportunities in a market that is increasingly concerned about sustainability, allowing companies to respond to the demands of consumers who are more environmentally conscious and paving the way for sustainable economic growth.

The application of sustainable technology has a significant impact in improving the quality of life of society as a whole. Reducing pollution, increasing the availability of clean energy, access to clean water, and maintaining environmental health are some of the positive outcomes of using this technology. This creates better conditions for the health, hygiene and quality of life of society as a whole (Daulay et al., 2020). Thus, sustainable technology not only protects the environment, but also creates a healthier and more livable environment for future generations. Opening of New Job Opportunities. The opening of new jobs is one of the positive impacts of the development of the sustainable technology industry. Southern sectors such as renewable energy, waste management and digital technology open up diverse and sustainable employment opportunities. This not only encourages inclusive economic growth but also creates a more stable and environmentally friendly economic base for the future (Soniansih & Kusmiati, 2021).

The application of sustainable technology significantly supports companies and governments in complying with increasingly stringent environmental regulations. This not only reduces possible legal risks but also improves the company's reputation in terms of sustainability and social responsibility. With the adoption of this technology, companies strengthen their commitment to environmentally and socially responsible business practices, creating a better environment for all parties involved. Sustainable Infrastructure Development. Investments in sustainable technologies positively encourage the development of environmentally friendly infrastructure. For example, efficient public transportation networks, renewable energy systems, and green buildings all lead to more resilient and sustainable infrastructure. This not only creates an ecologically better environment but also improves people's quality of life and supports sustainable economic growth (Nainggolan et al., 2023).

Effective integration of environmentally friendly technologies in key industries refers to the process of adopting and implementing technologies that support environmental sustainability in industrial sectors that have a major impact on the environment. This includes the application of technologies that minimize emissions, reduce waste, increase the efficiency of resource use, and promote sustainability principles in production and operational processes (Nainggolan et al., 2023). Environmental Audit. Environmental audits are an important process for evaluating the environmental impact of production processes and industrial operations as a whole. This audit aims to identify areas that can be improved in an efficient and environmentally friendly manner, so that the company can implement appropriate corrective actions. Thus, environmental audits help companies manage and minimize their environmental footprint, while supporting sustainable and responsible business practices. Research and Development (R&D). Investment in research and development (R&D) is an important step in developing new environmentally friendly technologies. Companies can carry out internal R&D or collaborate with research institutions and universities to produce sustainable innovations. Through R&D, companies can create more efficient solutions, reduce environmental impact, and improve overall business performance. Collaboration with research institutions also opens up opportunities for the exchange of knowledge and resources, accelerating the development of sustainable technologies.

The use of renewable energy is a strategic step in supporting environmental and business sustainability. Companies can switch to renewable energy sources such as solar, wind, or biomass power to reduce greenhouse gas emissions and dependence on fossil fuels. Additionally, using technology that optimizes energy efficiency in

daily operations also helps reduce excessive energy consumption and minimize environmental impact. The combination of the use of renewable energy and energy efficiency technology can bring long-term benefits to companies in reducing operational costs and creating a more sustainable work environment.

Optimizing the production process through implementing technology that reduces waste and emissions and paying attention to the recycling process can provide many benefits for companies. Technologies that minimize waste and emissions help reduce the environmental impact of production operations, creating cleaner and safer work environments. In addition, paying attention to the recycling process can reduce the use of new raw materials, save production costs, and support sustainable practices. The combination of production process optimization technology and environmentally friendly principles can increase operational efficiency and make a positive contribution to the environment and company sustainability. Environmental Certification. Obtaining environmental certification such as ISO 14001 is an important step in ensuring that environmental quality standards are met in a company's operations. With this certification, companies can demonstrate their commitment to good environmental practices and meet applicable environmental regulatory requirements. In addition, developing and following action plans to comply with applicable environmental regulations is also an integral part of companies' efforts to maintain environmental sustainability and minimize the negative impacts of their operations. By integrating environmental certification and appropriate action plans, companies can improve their reputation for sustainability and social responsibility, and have a positive impact on the surrounding environment.

Providing education and training to employees about environmentally friendly practices is an important step in building environmental awareness throughout the work team. With this training, employees can understand the importance of sustainable practices in company operations and how they can actively contribute to protecting the environment. Apart from that, this training also helps increase employees' knowledge and skills in implementing environmentally friendly actions in their daily work. By building environmental awareness throughout the work team, companies can create a work culture that focuses on sustainability and social responsibility, which will ultimately have a positive impact on the environment and surrounding communities. Partnership with Suppliers and Consumers. Partnerships with suppliers and consumers are an important strategy in building a sustainable business. Collaboration with suppliers helps ensure a sustainable supply chain, from raw materials to finished products. By working together to implement environmentally friendly practices, companies can minimize negative impacts on the environment and encourage innovation in production processes. Meanwhile, communicating openly with consumers about the company's environmental commitment and the benefits of environmentally friendly products is an important step in building strong relationships with consumers who care about the environment. Clear and transparent information about product sustainability can increase consumer awareness and help them make more environmentally responsible choices. Thus, partnerships with suppliers and consumers are the foundation for running a sustainable business and supporting environmental conservation efforts.

The use of digital technology such as the Internet of Things (IoT) has great potential in supporting environmental sustainability. By implementing IoT, companies can optimize resource use and reduce waste in a more efficient way. For example, using IoT sensors to monitor and control energy or water usage in real-time can help identify areas where efficiency can be improved. Additionally, digital technology also enables better data collection and analysis, so companies can make more informed decisions in managing resources and reducing their environmental footprint. By leveraging artificial intelligence and data analysis, companies can

identify consumption patterns that can be optimized, leading to more efficient and sustainable use.

Continuous monitoring and evaluation are at the core of sustainability efforts within the company. With continuous monitoring systems, companies can measure the environmental impact of their industrial activities, from greenhouse gas emissions to water and energy use. Routine evaluation is an important milestone for evaluating the effectiveness of sustainable strategies that have been implemented, with a focus on improvement and development of better strategies. Commitment to environmental quality is reflected in the company's efforts to continuously improve their environmental performance. This not only creates a cleaner and healthier environment, but also increases stakeholder confidence in the company's commitment to sustainable practices. Thus, continuous monitoring and evaluation is not only a technical step, but also a manifestation of the company's commitment to maintaining environmental quality for future generations.

Environmental monitoring and evaluation is an important practice in maintaining the environmental sustainability of industrial activities. Continuous monitoring allows companies to identify environmental impacts in real-time, such as greenhouse gas emissions, water use and waste production. Meanwhile, regular evaluations help identify areas that need to be improved or optimized in an effort to improve the company's environmental performance. By effectively integrating monitoring and evaluation, companies can take more appropriate steps to maintain environmental sustainability and minimize the negative impacts of their industrial operations. Environmental Risk Assessment. Environmental risk assessment is an important step in industrial environmental management. The aim is to identify potential environmental problems that may arise from the company's activities and take appropriate preventive measures. This risk assessment process includes identifying various factors, such as possible leaks of hazardous materials, potential air or water pollution, and impacts on local ecosystems. By conducting comprehensive risk assessments, companies can reduce the likelihood of adverse environmental incidents occurring and improve the sustainability of their operations.

A solid environmental policy is a vital foundation in carrying out company operations in a sustainable and environmentally responsible manner. Several important aspects that must be considered in developing a strong environmental policy include comprehensiveness, compliance with regulations, transparency, accountability, as well as consultation and collaboration with various related parties. By integrating all these aspects, companies can ensure that their environmental policies not only meet the highest standards in sustainable practices, but also support a balance between economic growth and environmental protection. Technological Innovation. Technological innovation is one of the main keys in the journey towards sustainability and environmental responsibility. Investments in research and development of new, environmentally friendly technologies provide a strong foundation for driving innovation in production processes and more efficient and sustainable operations. By continuously driving innovative changes in technology, companies can achieve an optimal balance between economic growth and environmental protection, bringing significant positive impacts to the environment and society as a whole.

Partnerships and collaboration are important strategies in advancing sustainable initiatives. Collaboration with governments, research institutions, and environmental organizations allows companies to get the support and resources needed to strengthen environmentally friendly practices. In addition, building partnerships with suppliers and customers who have similar commitments also helps create a more sustainable business ecosystem, where all parties play an active role in protecting the environment and society. Education and training. Providing

education and training to employees on environmentally friendly practices is an important step in building environmental awareness throughout the organization. By increasing employees' understanding of the importance of sustainable practices, they can play an active role in protecting the environment and implementing policies that support sustainability. In addition, building overall environmental awareness throughout the organization also helps create a work culture that cares about the environment and encourages innovation in achieving sustainable goals.

Utilizing natural resources wisely and sustainably and developing strategies for using renewable energy and energy efficiency in industrial operations are important steps in supporting environmental sustainability. By utilizing renewable resources such as solar, wind and biomass energy, companies can reduce negative impacts on the environment and increase the efficiency of energy use. The development of these strategies also helps in achieving overall sustainability goals and reducing dependence on non-renewable resources. Recycling and Waste Management. Using recycling technology to reduce waste and optimize the use of raw materials as well as managing waste safely and responsibly in accordance with environmental standards is an important strategy in efforts to maintain environmental sustainability. Recycling helps reduce the amount of waste that goes to landfill, reduces pressure on natural resources, and extends the lifespan of recyclable materials. Safe and responsible waste management also reduces the risk of environmental pollution and ensures that the production process runs in accordance with sustainability principles. Transparency and Communication. Maintaining transparency in reporting environmental impacts to the public and communicating openly with stakeholders about the company's commitment to the environment and the efforts made are very important principles in sustainable practices. Transparency in reporting provides clear and accurate information about how company activities impact the environment, while open communication with stakeholders such as communities, governments, and non-profit organizations helps build trust and gain support for sustainable initiatives.

5. Conclusion

Renewable energy technologies, such as solar, wind, and biomass, continue to grow, while sustainable transportation includes electric cars and bicycles. IoT technology is used for energy efficiency in various sectors, while sustainable agriculture utilizes advanced technologies such as vertical farming and drones. Water conservation and green buildings play a role in reducing the environmental footprint. In Indonesia, the industrial sector faces environmental challenges such as greenhouse gas emissions, air pollution, and deforestation. To overcome these challenges, stricter regulations, development of environmentally friendly technologies, increased public awareness, and use of renewable energy are needed. Key strategies include environmental audits, R&D, use of renewable energy, optimization of production processes, environmental certification, employee education, collaboration with suppliers and consumers, and use of digital technology and continuous monitoring. This study has limitations, such as the lack of attention to infrastructure challenges and regulatory barriers in implementing environmentally friendly technologies, as well as the lack of consideration of the level of public awareness. The implications of these findings can be a basis for the government in formulating policies that support the development of environmentally friendly technologies, encourage investment by the private sector, increase public education and awareness, and encourage collaboration between government, industry, academia, and civil society in developing sustainable solutions to environmental challenges. These results can also be the basis for further research on the impact of environmentally friendly technologies on economic growth and the environment.

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