EXECUTIVE SUMMARY FOR POLICYMAKERS

RESOURCE EFFICIENCY DEMONSTRATION PROGRAMME IN THE FERTILIZER INDUSTRY IN INDONESIA:
Policy insights for low-carbon industrial development

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JAKARTA

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About this research:

The policy brief is prepared as part of the report "Identifying Resource Efficiency Opportunities in the Fertilizer Industry in Indonesia: Findings and Recommendations" which was commissioned by the United Nations Industrial Development Organization under the Partnership for Action on Green Economy (PAGE).

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Main Findings

The fertilizer industry in Indonesia has been supporting the agricultural sector for more than 60 years. Throughout the years, the focus of the fertilizer industry has remained consistent to meet the demands of the farmers, provide an equitable distribution throughout Indonesia, improve the efficiency of production, and provide solutions to the farmers. This study found that the application of resource efficiency techniques in the fertilizer industry can trigger competitiveness, reduce environmental footprint, and assist the government in meeting the climate target. This study finds that some companies have advanced in resource efficiency applications, while others are still behind. For example, some companies have started to innovate new technologies, such as **precision farming or nutrition management in fertilizer soil application** for cacao production at Pupuk Kaltim. At the same time, some companies are still struggling to implement the efficient use of water and energy resources.

Forty-two RECP practices were identified from the four pilot units. To continuously improve resource efficiency in the fertilizer industry, it is essential to create an environment conducive to innovation. Nineteen future recommendations were generated, where the key priorities can be summarized as follows:

- **Promote knowledge sharing and benchmarking** to ensure consistent nationwide implementation of resource efficiency, particularly for state-owned companies.
- Identify innovative technologies and **modify production processes** to support net-zero targets in the fertilizer industry, such as the production of green and blue ammonia, as well as the utilization of CO2 by-products.
- Develop an **integrated and comprehensive data collection system** supported by digitalization to monitor and control productivity and company performance, facilitating impactful, science-based decision-making.
- **Provide incentives, subsidies, or sustainable finance** to fund and promote resource efficiency and circular economy implementation.

It is important not only to limit the focus on gate-to-gate operation but also to consider the **life cycle perspective of fertilizer**, from cradle to grave. This will require the adoption of an integrated approach, involving **all stakeholders** in the fertilizer production chain. This **includes farmers, suppliers and distributors, government agencies, operators, and end users**. The industry must ensure that all products are produced responsibly to reduce resource consumption and environmental impacts throughout the entire lifecycle.

Resource efficiency and cleaner production (RECP) integrated with a life cycle perspective towards low carbon development should be the future focus of sustainability for the fertilizer industry in Indonesia.

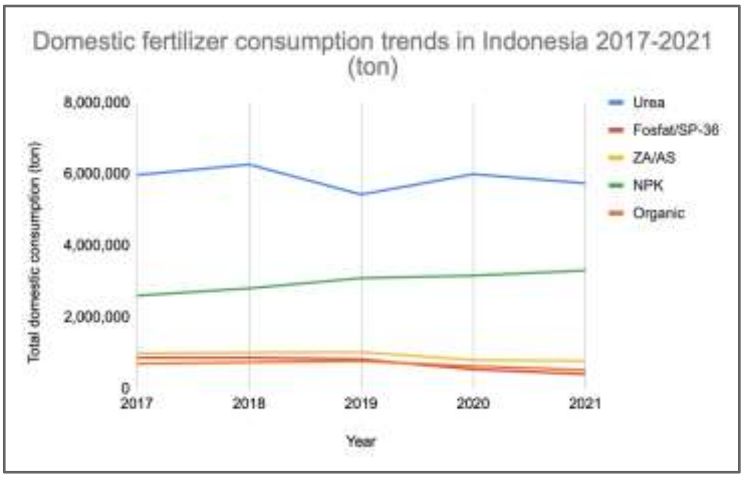
BACKGROUND

In recent years, the issue of global food security has come to the forefront of international discourse. The world's population is growing at an unprecedented rate, and with it, the demand for food has increased. At the same time, climate change and other factors are putting pressure on our ability to produce enough food, including global political stability. This has led to concerns that we may not be able to feed everyone in the future and put the focus on food security.

Several different approaches could help address this problem. One key step is increasing crop yields through better irrigation, fertilizer, and land management techniques. Another is improving access to food by investing in infrastructure and agricultural technology in developing countries. And last and foremost, it is to identify ways to manage resources efficiently throughout the supply chain, from production to consumption.

President Joko Widodo has made increasing agricultural productivity a key priority for his administration. The support from the Indonesia Government is by providing fertilizer subsidies to fertilizer industries with a total amount of 25 trillion IDR per year, as reported in 2021. To achieve this, he has promised to invest in infrastructure and technology and improve access to credit for farmers. The Indonesian government has also implemented various strategies to boost agricultural production, such as building infrastructure: dams, reservoirs, and irrigation networks; using improved varieties of rice, and encouraging farmers to diversify their crops for both domestic consumption and export. This effort is aimed at ensuring that all 267 million Indonesians have access to affordable food.

The fertilizer industry is a vital part of Indonesia's economy intending to boost agricultural production and achieve food production self-sufficiency. Throughout the years, the domestic fertilizer consumption trend has been relatively stable with small fluctuations, as shown in Figure 1. Even though **fertilizer is essential for agriculture, the production and application of fertilizer have significant potential environmental impacts. Thus, Indonesia's fertilizer industry is also considered to have a significant role to play in the country's low-carbon development.**



Graph constructed based on source from Asosiasi Produsen Pupuk Indonesia (Association of Indonesia Fertilizer Producers).

Figure 1 Domestic fertilizer consumption trends in Indonesia from 2017 to 2021

OBJECTIVE

To further understand Indonesia's environmental performance and resource efficiency potential, especially in the fertilizer industry, the United Nations Industrial Development Organization (UNIDO) under the Partnership for Action on Green Economy (PAGE) together with the Indonesian government focal ministry, BAPPENAS (Ministry of National Development Planning) commissioned the Indonesia Cleaner Production Centre (ICPC) to conduct a study to identify resource efficiency opportunities for the fertilizer Industry in Indonesia and provide policy recommendations for government's adoption. The study covers:

- Identification of the **environmental performance** of the fertilizer industry in Indonesia.
- Identification of **resource efficiency opportunities** in the fertilizer industry in Indonesia, especially focusing on the energy efficiency component that maximizes energy performance improvement potential.
- Identification of **technology to assess and improve efficiency performance**.
- **To support the implementation of low-carbon development** and fulfil the requirements of the Ministry of Industry's Green Industry Standard (*Standar Industri Hijau/SIH)*.

METHODOLOGY

The study combined an industrial survey of the fertilizer industry, a desktop study, a literature study, focus group discussions with stakeholders of the fertilizer industry in Indonesia and site visit to the pilot plant. The project was conducted amidst the COVID-19 pandemic (in 2021) and therefore, most of the activities were conducted through online platforms.

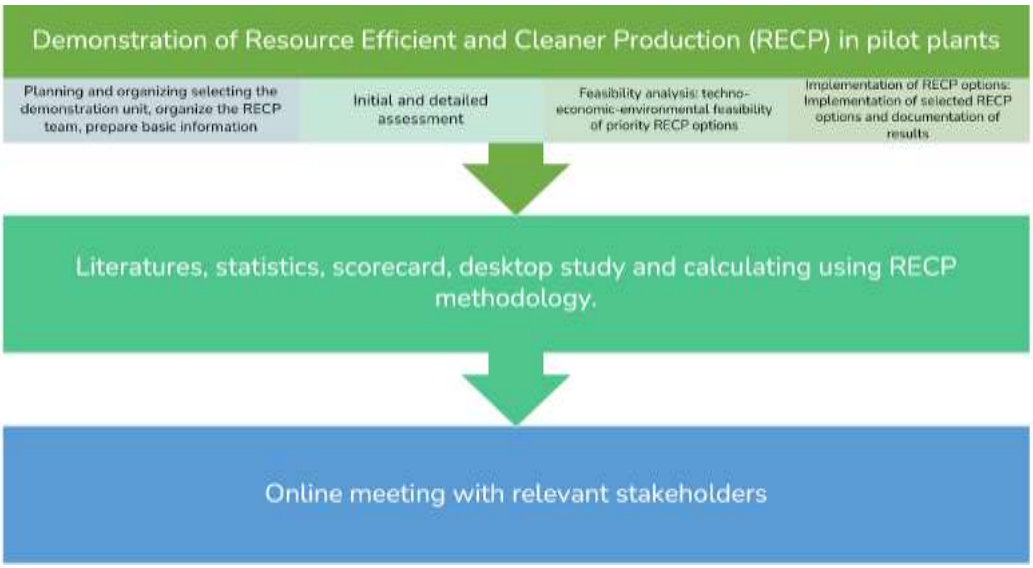


Figure 2 Project Methodology

A survey was distributed to **nine** leading fertilizer companies in Indonesia, consisting of 5 (five) state-owned companies (SOE) or *Badan Usaha Milik Negara (BUMN)* under PT Pupuk

Indonesia (Persero) Group, and 4 (four) private companies. **Six** out of the nine companies responded to the questionnaire and were screened to be selected as the pilot/demonstration units. **Four companies were selected for detailed resource efficiency and cleaner production (RECP) assessment as pilot units**. These companies were PT Pupuk Iskandar Muda (PIM), PT Pupuk Kujang Cikampek (PKC), PT Pupuk Sriwidjaja (PUSRI), and PT Petrokimia Gresik (PKG).

FINDINGS

Resource Efficient and Cleaner Production (RECP) Profile of Pilot Units

The four selected pilot units assessed in this project represent plants established from different eras, from the 1960s, 1970s, 1980s, 1990s, 2000s, and 2010s, and reflected technology representativeness. Figure 3 shows the timeline and summarised profile of the fertilizer companies assessed in this project.

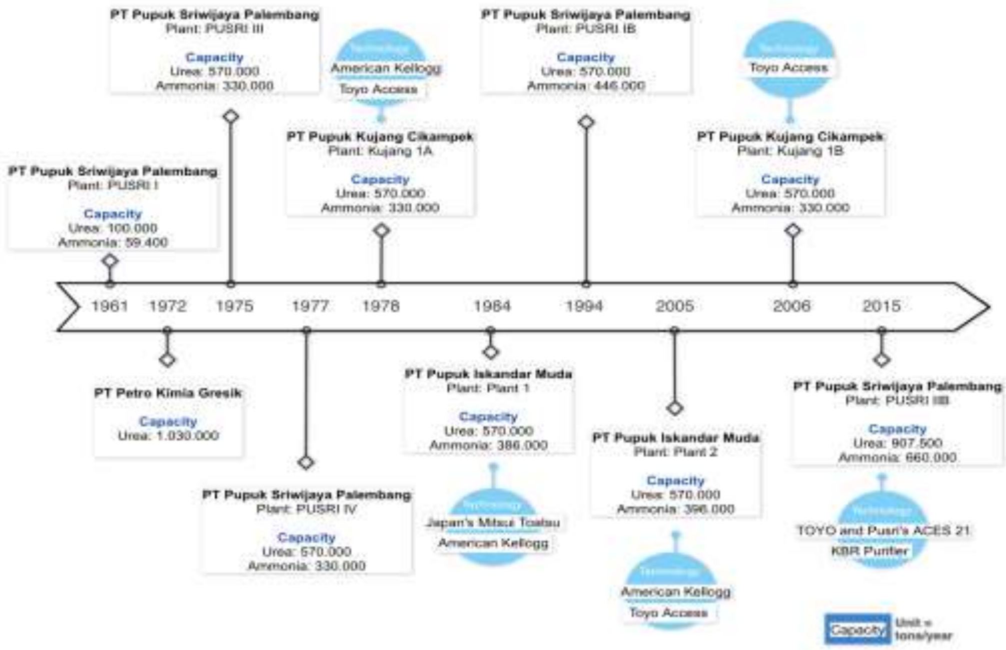


Figure 3 Timeline and profile of fertilizer industries in Indonesia

During the **detailed assessment**, a feasibility analysis consisting of techno-economic environmental aspects was conducted to identify the priority of RECP options. The detailed assessment, including **site visits, data collection, focus group discussions, and a desktop study**, was complemented by the information gathered from the **sustainability reports** of the corresponding organizations.

Resource efficiency assessments at the four companies were conducted for four aspects:

- specific energy consumption (SEC), in MMBTU/ton product
- specific greenhouse gas emission, in kg CO_2 eq./ton product
- specific water consumption, in m^3/ton product
- percentage of wastewater recycled, %.

Table 1. RECP assessment participants (pilot units)

Company	Green Industry Standard (SIH)	PROPER Rating		Market
		2021	2022	
PT Pupuk Iskandar Muda (PIM)	-	BLUE		Aceh, North/West Sumatra, Riau, Kepri, & Jambi
PT Petrokimia Gresik (PKG)	SIH 20122.1:2018	GOLD		Sumatra & Java
PT Pupuk Sriwidjaja (PUSRI)	SIH 20122.1:2018	GREEN	GOLD	Sumatra & West Kalimantan
PT Pupuk Kujang Cikampek (PKC)	SIH 20122:2015	GREEN	GOLD	West Java

Table 2 summarises the RECP profile of the assessed participants in comparison with the Green Industry Standard (SIH) threshold limit and industry benchmark (IBM) for urea production. The specific data or also commonly known as data intensity were calculated based on the annual consumption and annual production. As a benchmark, the upper threshold for the Ministry of Industry's Green Industry Standard (SIH) and global industrial benchmark for urea production are provided.

Table 2 Specific resource consumption for Urea production in the pilot units compared to Green Industry Standard (SIH) and Industrial Benchmark in FY 2021.

Items	PIM	PKG	PUSRI	PKC	SIH	IBM
Specific Energy Consumption (MMBTU/ton)	46.6	37.0	31.0	36.96*	37	
Specific Water Consumption (m^3/ton)	22.11	16.51	12.45	12.75	5.5****	
Specific CO2e emission*** (t-CO2e/ton)	N/A	0.334	0.410	0.237*	1.6	0.43
Percentage of Wastewater recycled (%)	4.38	3.74	2.93	11.70	N/A	90%

*Data based on PKC 2021 Environmental Management Performance Summary (DRKPL). Specific CO2 emission based on 11.86 kg CO2e/50 kg urea)
**Data Financial Year 2021 was not available. Data is calculated based on the average of 2018-2020.
*** Green Industry Standard set the threshold for the specific water consumption only for utility. Data provided by the pilot units are total water consumption which combines water for production and utility.

With the average specific energy combustion of 36.1 MMBTU/ton in 2021, and the threshold of Green Industry Standard (SIH) of 37 MMBTU/ton,

3 out of the 4 RECP pilot units can achieve below the upper limit of SIH.

SIH threshold = 37 MMBTU/ton, Average SEC for pilot units in 2021 = 37.9 MMBTU/ton

Figure 4 Specific energy consumption and Green Industry Standard (SIH) upper threshold.

Energy Efficiency

Most of the companies showed an improved energy efficiency in 2021 in comparison to the 2018 baseline despite the COVID-19 pandemic condition throughout 2020-2021. An improvement of up to 15% was recorded at PKG. It should be noted that PT PIM has a decreased energy efficiency which may be associated with its halt of operation for April 2021. The percentage of improvement in energy efficiency is calculated based on the baseline year 2018 for Urea production. The improvement in energy efficiency is calculated by comparing the projected energy efficiency (based on specific energy consumption in 2018) with the actual energy efficiency (in 2021).

Improvement in energy efficiency =
(Projected energy efficiency - Actual energy efficiency) / Actual energy efficiency

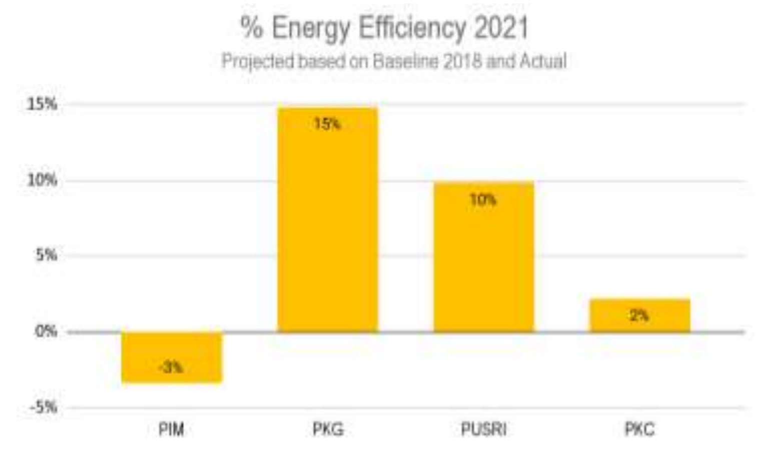


Figure 5 Percentage of improvement in energy efficiency at RECP pilot units in 2021 compared to the baseline year 2018.

The RECP study identified energy efficiency that has been implemented at the units, which reached up to 15% at Petrokimia Gresik (PKG) through efforts such as:

- better process control;
- good housekeeping;
- equipment modification;
- Material and energy efficiency through utilization of useful by-products, and onsite reuse and recycling.

Since the material used in the production is gas, the utilization of by-products and onsite reuse and recycling can also be classified as energy efficiency.

The study revealed that while energy efficiency programs have been put in place at state-owned companies, they have not yet been consistently and fully implemented across all of them or in private companies.

However, those companies that have already achieved the SIH green industry standard and earned a gold rating in the PROPER program can serve as an example for others to follow.

CO_2 Emission

Despite the energy efficiency efforts, the specific greenhouse gas emission did not seem to reduce significantly. The highest CO_2 emission reduction is seen from PUSRI at 3.3% compared to the 2018 baseline. Although the total CO_2 emission is reduced, at the same time, there was a decrease in urea production compared to 2018.

The current method for calculating CO_2e reduction is based on the absolute CO_2 reduction from CO_2 utilization and not based on the projected reduction calculation using baseline. There are a few different approaches that can be used to identify a baseline for calculating CO_2 reduction. Some common methods include:

1. Historical data: This approach uses data from previous years to establish a baseline for current and future CO_2 emissions. This can be useful for identifying trends and patterns over time.
2. Industry averages: This approach compares an organization's emissions to industry averages to establish a benchmark for CO_2 reduction.
3. Best practices: This approach looks at the best practices and emissions levels of leading organizations in the industry to establish a benchmark for CO_2 reduction.

4. Business-as-usual scenario: This approach projects future emissions based on the assumption that an organization will continue with its current practices, without any changes to improve energy efficiency or reduce emissions.
5. Regulatory standards: This approach uses legal standards or regulations as a baseline for calculating CO_2 emissions and reduction.
6. Absolute emissions: This approach establish a benchmark based on the total absolute emissions of a company.

It is important to note that the selection of approach depends on the industry, size, nature of the organization, and the goals of the CO_2 reduction calculation.

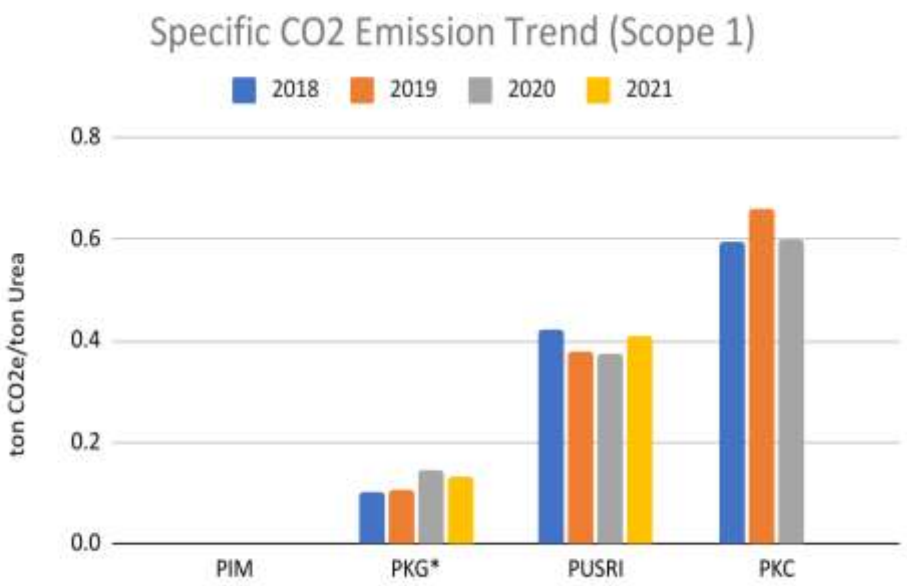


Figure 6 Specific CO_2 emission at RECP pilot units (ton CO_2e/ton urea).

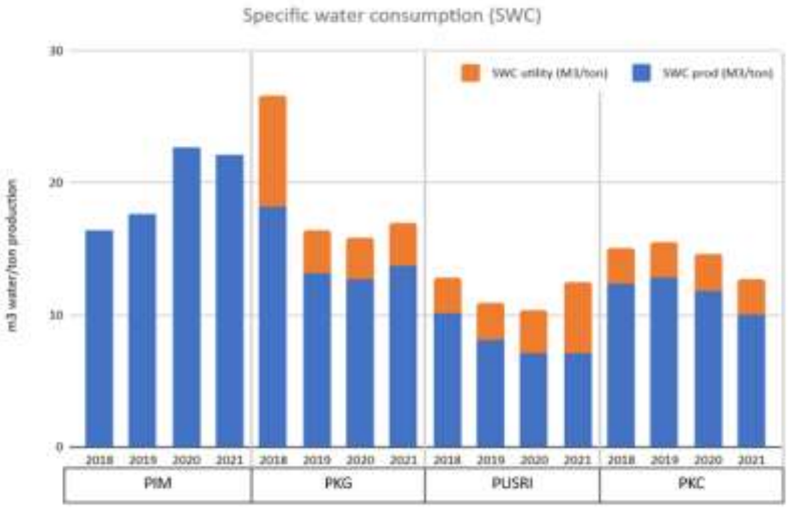
It is recommended to evaluate the SIH limits by considering all factors of CO_2 reduction, including energy efficiency, emissions, and utilization.
Because the approach to CO_2 calculation reduction may differ, it is important to have the same approach to calculation.

Water Consumption

Water is used both in the production process as steam and for utility in the fertilizer industry. Water for steam and chiller requires demineralized water as minerals can cause problems in the boiler and reduce its efficiency. Water is treated through filtration for utility and demineralized for usage in the steam plant.

For the three pilot units that provided utility water consumption data, PKG, PUSRI, and PKC, the **specific water consumption for the utility of the three companies** have met below the green industry standard (SIH) maximum threshold of 5.5 m^3/ton of urea with an **average of 3.6 m^3/ton**. Water usage for production is not an indicator of green industry standards (SIH). Based on the four pilot units, the **specific water consumption for urea production is 13.5 m^3/ton**.

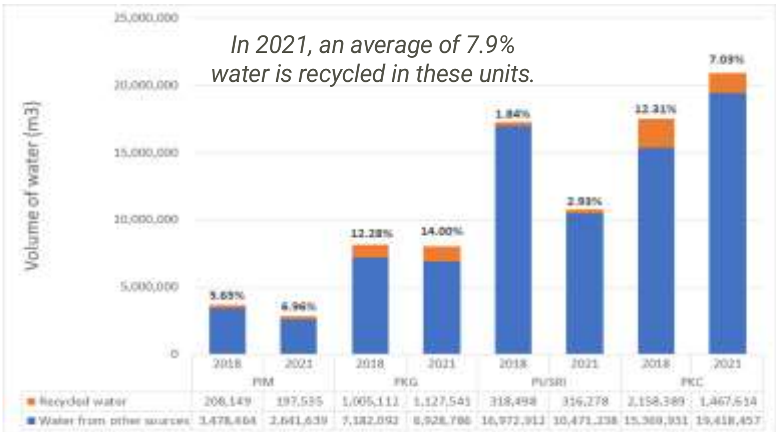
Up until this report is published the Green Industry Standard (SIH) has not included targets on water use for production and water recycling for the fertilizer industry. It is a recommendation to include these in future standard revisions.



- 98% Ammonia separation from wastewater for fuel and water recovery
- Water recovery through hydrolysis and stripping processes (PUSRI effluent treatment).
- The usage of recycled water to reduce water consumption:
    - 16.27% recycled water at PKG
    - 14% recycled water at PKC

through the recovery of condensate, cooling water, backwash and wastewater treatment.

Figure 7 Specific water consumption trend for urea production and utility at pilot units.



	PIM 2018	PIM 2021	PKG 2018	PKG 2021	PUSRI 2018	PUSRI 2021	PKC 2018	PKC 2021
Recycled water	208,149	197,535	1,005,112	1,127,541	318,498	316,278	2,158,389	1,467,614
Water from other sources	3,478,404	2,641,639	7,182,092	6,928,786	16,972,912	10,471,238	15,369,931	19,418,457

Figure 8 Percentage of recycled water and volume of water consumed in the fertilizer pilot units.

Limitations and assumptions:

1. Data provided by PKG is for production of urea, ZA and SP36. Data is shown here is proportion only to urea production.
2. PIM did not provide a differentiation of water consumption for production and utility.
3. Percentage of water recycled is calculated by the amount of water recycled divided by total water from all sources.
4. PKC did not provide 2021 GHG emission data.

Resource Efficiency Best Practices in Fertilizer Sector

There are several resource efficiency practices known globally, as depicted in Figure 9:

Figure 9 Resource efficient and cleaner production (RECP) practices.

There were at least 42 RECP practices identified from the four pilot units, where 63% of the practices are for equipment modification, good housekeeping, and better process control. This reflects that these practices are already common RECP practices implemented in the fertilizer industry.

Recent economic growth in Indonesia has driven improvement in technological and material input change and utilization of waste or by-products as resources in the fertilizer industry. The increased demand for fertilizers has led to investments in technology and R&D, a collaboration between industry, academic researchers, and the financial sector to pursue the adoption of more advanced, cost-effective technologies for boosted productivity and competitiveness in the industry. As shown in Figure 10, 30% of the implemented and in-progress RECP developments are for technological change, input material changes, and utilization of waste/by-products.

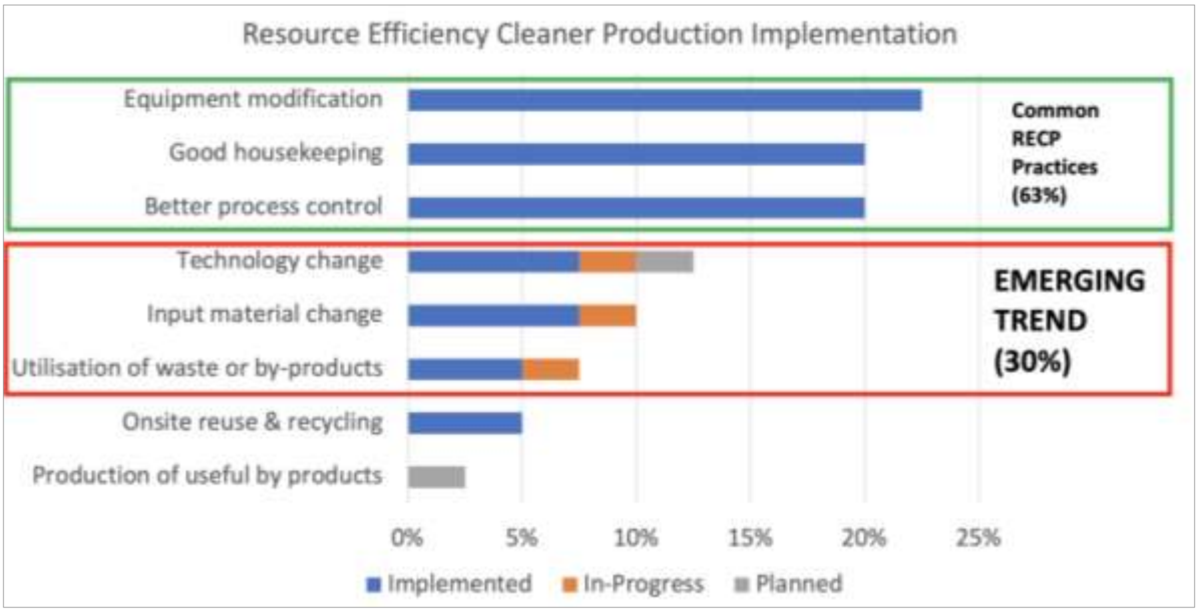


Figure 10 Implementation of RECP practices in the fertilizer industry in Indonesia.

Table highlighted some of the resource efficiency initiatives for energy, GHG emission, and waste/wastewater management generated from the pilot units. A list of resource efficiency initiatives in fertilizer industries and other sectors is also available derived from the participants of the environmental rating award, PROPER (KLHK, 2022).

Table 3 Highlights of Implemented, ongoing, and planned resource efficiency initiatives for energy efficiency, GHG emission, and water/wastewater management by fertilizer industries.

HIGHLIGHTS of Resource Efficiency Initiatives		
Energy Efficiency	**GHG Emission**	**Water/Wastewater**
Minimise discharged gas through compressor modification	Utilisation of SO_3 emission for **Green surfactant plant** (PKG)	Ammonia recovery at a wastewater treatment facility
Reformer maintenance	Utilization of excess CO_2 from ammonia production for **soda ash plant** (PKG) to be used as raw material for NPK	Wastewater material recovery at PUSRI effluent treatment
Purge gas recovery unit	**Established Catalyst plant (Merah Putih)** to support green fuel and reduce imported catalysts	
Utilise electricity from PLN through progressive captive power acquisition to reduce own power generation (PKG)	**Plant revitalisation** at PUSRI	
	Establish liquid CO_2 plant to utilize CO_2 emission (PKC)	
	Gas utilization for **blue ammonia & methanol production** (PIM)	
Note:		
implemented	on-going	planned

Several best practices in the fertilizer industry can help to improve resource efficiency, reduce greenhouse gas emissions, and minimize other negative environmental and social impacts. Some of these best practices can be categorized into the followings:

1. **Energy efficiency**: Improving energy efficiency in fertilizer production facilities can help to reduce greenhouse gas emissions and lower production costs. This can be achieved through a variety of measures, such as upgrading equipment and machinery, optimizing production processes, and using renewable energy sources.
2. **Resource conservation**: Reducing resource consumption and waste in the fertilizer industry can help to conserve resources and reduce environmental impacts. This can be achieved through recycling and reusing materials, such as water and nutrients, and by using closed-loop production processes that minimize waste.
3. **Sustainable sourcing**: Using sustainable sources of raw materials, such as recycled nutrients, can help to reduce the environmental impacts of fertilizer production. It can also help to support local communities and promote economic development.
4. **Responsible use**: Promoting responsible use of fertilizers, such as through education and training programs for farmers and other users, can help to reduce the negative

environmental and social impacts of fertilizers. This can include measures to prevent nutrient runoff and leaching, which can cause water pollution, and to minimize greenhouse gas emissions from fertilizer application.

5. **Transparency and accountability**: Ensuring transparency and accountability in the fertilizer industry can help to build trust and confidence among stakeholders and promote more sustainable practices. This can include disclosing information about production processes and environmental impacts and engaging in dialogue with stakeholders.

The RECP practices implemented, in progress, and planned by the four pilot units can be categorized into global best practices. Energy efficiency (almost 80%) is the focus of RECP implementation, which is within the control of the company (as shown in Figure 13). However, the promotion of responsible use of fertilizer to the farmers has not been addressed by the four pilot units.

Figure 11 RECP practices in the fertilizer industry are classified into best practice categories.

Transparency and accountability

Transparency is considered an important element of best practices in sustainable development because it helps to build trust, accountability, and confidence in a company's sustainability efforts. It enables stakeholders to track a company's progress and hold it accountable for its actions and helps to provide independent assurance of the accuracy and reliability of the information being disclosed. By being transparent about their sustainability efforts and environmental performance, companies demonstrate their commitment to operating responsibly and sustainably.

In recent years, there has been a growing effort among companies to be more transparent about their sustainability efforts. Many companies have started publishing sustainability reports, which provide detailed information about their environmental, social, and governance (ESG) performance. These reports help companies to communicate their efforts to reduce their environmental impact, improve their social responsibility, and enhance their governance practices. The goal of sustainability reporting is to provide stakeholders with a comprehensive understanding of a company's sustainability performance, enabling them to make informed decisions about the company's actions and impact on the world.

Sustainability reporting is also a practice conducted by the four pilot units assessed. The companies have attempted to be transparent in communicating their sustainability efforts. and reported their sustainability practices for more than 4 years. The record shows that PKG has been reported since 2010 (12 years). Details are shown in Figure 12.

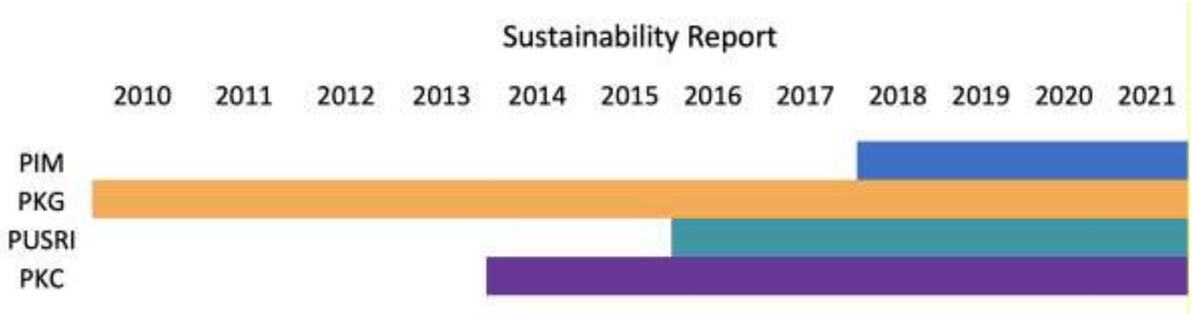


Figure 12 Sustainability report practices of the four RECP pilot units.

Resource Efficiency Beyond the Gate

For many years, the focus on improving efficiency has always been within the gate of operations where the company has direct control. As shown in Figure 13, most of the RECP initiatives were also conducted in the production stage, within the direct control of the company. Few of the initiatives were conducted for the upstream and utilization of the waste.

There have been several studies that have used Life Cycle Assessment (LCA) to evaluate the environmental impacts of fertilizers. Life cycle assessment (LCA) is a tool used to evaluate the environmental impacts of a product or service over its entire life cycle, from raw material extraction to disposal. In the case of fertilizers, LCA can be used to identify the stages of the life cycle that have the greatest environmental impact and to identify opportunities for improving the sustainability of the product.

Many of the LCA studies have found that the biggest environmental impact of fertilizers occurs at the point of use, rather than during the production or transportation of the product. This is because the application of fertilizers can lead to the release of greenhouse gases, such as nitrous oxide, and can contribute to water pollution through the leaching of nutrients into groundwater or surface water (Menegat et al., 2022, Huang et al., 2017, Liu et al., 2021).

To reduce the negative effects of fertilizers on soil, the fertilization industry is working to understand the needs of soil and plants and implementing strategies for managing nutrients. This shift in focus is aimed at increasing resource efficiency and mitigating the environmental impact of fertilizers on soil health.

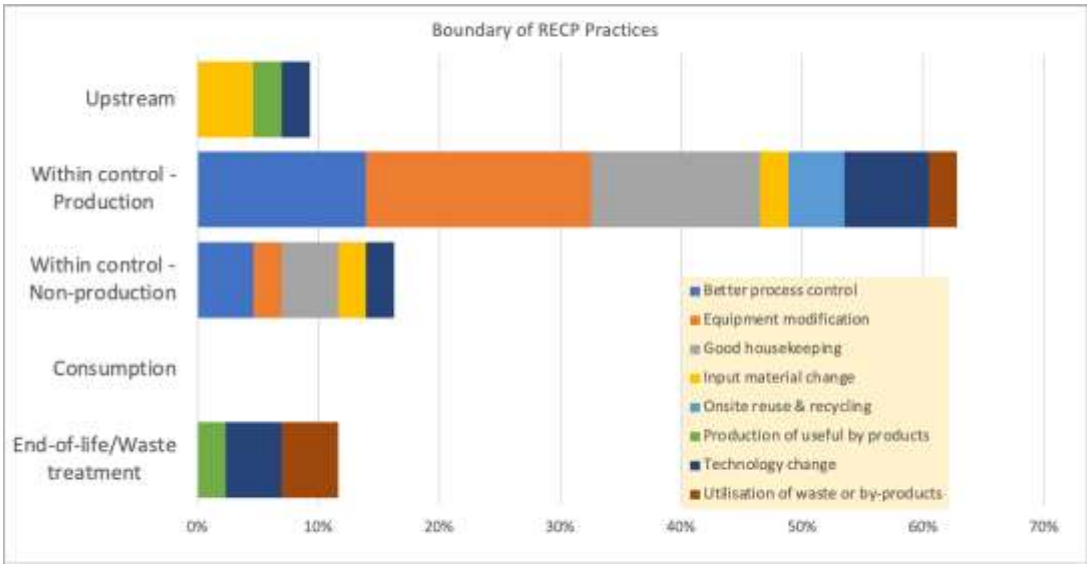


Figure 13 Boundary of RECP practices by the fertilizer industry, based on the RECP pilot units.

It is important to consider the natural conditions of soil and climate when determining the appropriate number of fertilizers to use, as over-fertilization can have negative impacts on crop yields. The trend of fertilizer consumption in Poland from 1985-2008 suggests that even though there was an increase in the average annual consumption of nitrogen fertilizers during this period, grain crop yields were lower (Skowrońska and T. Filipek, 2014).
This could potentially be due to several factors, including the inherent fertility of the soil, the specific crops being grown, and the local climate conditions.

The findings highlighted that **the functional unit of the fertilizer should be transitioned from the weight of the product (e.g. 1 ton of urea) into the weight of the crop (e.g. 1 ton of grain)**, to reflect the efficiency of a production system for a particular crop.

Understanding these natural factors through nutrient management strategies can help farmers to make informed decisions about the use of fertilizers and ensure that they are applied in a way that maximizes crop yields while minimizing negative impacts on the environment.

"The right nutrient source applied at the right rate, at the right time, in the right place."

-International Fertilizer Association, IFA-

Nutrient management strategies aim to optimize the use of fertilizers while minimizing negative environmental effects. This can include techniques such as (Nutrient ESG Report 2022):

- precision fertilization or precision agriculture, which involves applying fertilizers only where and when they are needed.
- incorporating cover crops and other conservation practices that help to maintain soil health.
- utilize digital solutions and agronomy.
- irrigation management and water conservation practices.

In Indonesia, nutrient management has been applied by Pupuk Kaltim through the release of fertilizer products specific to cocoa in collaboration with the Indonesian cocoa industries and stakeholders.


Menu
Bisnis.com
Dukung Produktivitas Kakao Nasional, Pupuk Kaltim Rilis NPK Formula Khusus

The special fertilizer formulation was designed to improve the productivity of cocoa farming. Learning from this success, Pupuk Kaltim aims to plan future fertilizer product development for other commodities such as coffee, rubber, maize, rice, and palm oil (bisnis.com, 2020).

Figure 14 Special cocoa fertilizer using nutrient management approach by Pupuk Kaltim.

Collaborative Approach for Sustainable Funding and Financing in the Implementation of Resource Efficiency and Cleaner Production

The current government policies prioritize sustainable development principles, placing a strong emphasis on adopting the Resource Efficient and Cleaner Production (RECP) concept in various policy domains such as green industry, environmental performance rating (PROPER), and green building. However, effective implementation of these policies necessitates substantial financial investments and financing policies. Long-term technology replacement options require significant funding, thus requiring a comprehensive corporate strategy.

There is a need for collaboration between the company, government agencies, and financial institutions regarding sustainable funding mechanisms to accelerate the implementation of resource efficiency and cleaner production, which can reduce significant greenhouse gas emissions. Key stakeholders include the Ministry of National Development Planning (BAPPENAS), Ministry of Industry, Ministry of Energy and Mineral Resources, Ministry of Environment and Forestry, and fertilizer industry association.

To address the financing needs, The Financial Services Authority (OJK) has released a funding mechanism as stated in the sustainable finance phase II roadmap (2021 – 2025). Some examples of the implementation of sustainable finance include financing for new renewable energy projects such as electricity sourced from hydropower, geothermal power, hydropower, solar power, biogas power, biomass, and other renewable energy sources, energy efficiency, and others.

ISO 14030 on green debt taxonomy identified a list of environmental activities relevant to the fertilizer industry. These activities include the reduction of emissions from the manufacturing activity in the manufacturing of ammonia and nitric acid, as these manufacturing processes are highly carbon intensive, and alternative organic fertilizers from natural resources. To support the implementation of green financing in Indonesia, OJK released green taxonomy.

CONCLUSION AND RECOMMENDATION

There are two types of industries identified during this project: early adopters and the majority. There exists a knowledge gap between the two, and therefore, sharing best practices can play a substantial role in elevating the status of others. However, competition between industries can make this challenging. For instance, knowledge sharing is limited when companies are striving to achieve Proper certification.

In Proper certification, the focus is on creating innovation and competitive advantage within the industry in the same sector. On the other hand, in SIH certification, the focus is on meeting a threshold. Therefore, for the purpose of knowledge sharing, the SIH certification is more suitable. Once an innovation is implemented and reported in the Proper program with a green or gold rating, it can be shared as a best practice and potentially used as a Green Industry Standard for other companies.

Based on the findings of this project, which have been elaborated on in the previous sections, there are 19 future recommendations generated. These recommendations have been discussed with the representatives of the fertilizer industries and stakeholders of this project on some occasions and there were no objections raised from the peers. The 19 recommendations are grouped into 5 categories, based on the relevant aspects, which are:

- Operation (OP) – 4 recommendations;
- Data management (DM) – 4 recommendations;
- Collaboration and industrial synergy (IS) – 2 recommendations;
- Management system (MS) – 5 recommendations; and
- Research and development (RD) – 4 recommendations.

The boundaries on who would be responsible for the target and implementation and the priority of the recommendation is listed in Table 3 based on expert judgment. For example, factory revitalization is within the boundary/gate of the company. However, ensuring that revitalization can happen, requires financing. The priority is then defined based on the importance of factory revitalization and the duration of the implementation. Score 5 represents high importance and the short duration of the implementation. Longer duration will have a score of 1 or 3. The duration also considers whether the industry has already started to implement it or not. The highest score would be the priority for the stakeholders or government to be implemented immediately.

All the items in the recommendation can also serve as a guideline for the financial institution as a focus on financing development for the fertilizer industry.

Nine initiatives are identified as the KEY PRIORITIES for future development of fertilizer industry in Indonesia.

The achievement of low-carbon development requires the collaboration of multiple stakeholders to create synergy. BAPPENAS plays a crucial role in synergizing various stakeholders and coordinating inter-ministerial collaboration. To facilitate the coordination and execution of initiatives, each recommendation presented in Table 4 is mapped to its relevant stakeholders and government ministries in Indonesia. While the recommendations require the support of various stakeholders, including the government within their scope of authority and programs, the specific policy recommendations for such support are not presented in this report as they may vary depending on the government's programs and priority.

Table 4 Recommendation for future development of fertilizer industry in Indonesia: boundary and priority.

No	Recommendation	Boundary						Priority Setting				Internal & External Stakeholders										Government Ministries					
		Cradle/Upstream	Gate	Downstream/EoL	Governance	People	Financing	Importance Rate	Duration	Duration Score	Total Score	Production Site	Management	Employees	Operations	R&D	Financial Institution	Environmental Consultant	Energy Consultant	IT Consultant	Local Communities	Manpower	Research	Energy	Industry	Agriculture	Environment
Operation																											
OP1	Factory revitalization		✓				✓	5	Med/ Long	2	10	✓			✓		✓					✓	✓		✓		
OP2	Utilization of exhaust gas (CO_2, SO_3, etc)		✓				✓	5	Med	3	15	✓			✓		✓	✓					✓				✓
OP3	Improvement of WWTP performance & improvemen		✓				✓	5	Med	3	15	✓			✓		✓	✓					✓				

	t of water recycling facilities																										
OP4	Increased renewable energy utilization (biomass) for the production process and solar PV (for offices)	✓	✓				✓	5	Med	3	15	✓			✓		✓		✓				✓	✓			✓
Data Management																											
DM 1	Operational data digitization system				✓		✓	5	Short / Med	4	20		✓				✓			✓			✓		✓		
DM 2	Innovation in the field of Industrial Waste Monitoring Equipment (gas emissions and liquid waste)		✓		✓		✓	5	Short	3	15						✓	✓			✓		✓				✓
DM 3	Standard implementation using the same GHG calculation approach: Scope 1, Scope 2, and Scope 3 (if possible)		✓		✓		✓	5	Short	5	25		✓				✓	✓						✓			✓
DM 4	Life Cycle Assessment to provide quantitative	✓	✓	✓	✓	✓	✓	5	Med	5	25						✓	✓						✓			✓

	measurement and monitoring throughout the product life cycle																										
Collaboration and Industrial Synergy																											
IS1	Increased interconnection between factories - Industrial Synergy				✓		✓	5	Med	3	15	✓				✓	✓						✓		✓		
IS2	Knowledge sharing between industries for equivalent implementation - Equalization of technology used		✓		✓	✓	✓	5	Short	5	25					✓	✓						✓		✓		
Management System																											
MS1	Implementation of the management system and energy audit throughout the fertilizer industry				✓	✓	✓	5	Short	5	25						✓	✓						✓			
MS2	Employee training and development related to environmental management					✓	✓	5	Short	5	25		✓	✓			✓				✓	✓	✓	✓			✓

MS3	Implementation of environmental management systems throughout the fertilizer industry				✓	✓	✓	5	Short / Med	4	20		✓	✓			✓	✓			✓	✓	✓	✓			✓
MS4	Heat/steam recovery system implementation throughout the fertilizer industry		✓				✓	5	Short / Med	4	20	✓	✓	✓			✓	✓					✓			✓	
MS5	The comprehensive and integrated data collection system				✓	✓	✓	5	Med	3	15		✓	✓			✓						✓		✓		
Research and Development																											
RD1	Expansion of System Boundary from Gate-to-Gate to Cradle-to-Grave	✓		✓	✓			5	Med	3	15	✓	✓	✓			✓	✓					✓	✓			✓
RD2	Developing alternative products on the scale of urea substitutes that are not made from fossils will one day run out and at	✓					✓	3	Med	3	9					✓	✓						✓	✓	✓		

	the same time reduce the effects of the greenhouse gasses caused.																										
RD3	Potential Application of Recycling Packaging Through Unused Packaging Returning Program to Producer as a Form of Implementation of Expanded Producer Responsibility (EPR). - Circular Economy			✓	✓		✓	5	Short	5	25				✓		✓						✓				✓
RD4	Nutrient Stewardship / Precision Agriculture. Development of Research on Nutrition and Land Health - The Ministry of Agriculture to determine the nutrients needed for certain types of soil and plants.			✓			✓	5	Long	2	10						✓						✓			✓	✓

Note:
The importance rate represents the urgency of the initiative to be implemented.

- High importance: 5
- Medium importance : 3
- Low importance: 1

Duration represents the length required to implement the initiative.

- Short-term (1-2 years): score 5
- Medium term (2-5 years): score 3
- Long-term (>5 years): score 1

Total score = Importance rate * Duration Score.

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Appendix

No.	RECP Practices	Type of RECP	Types of Best Practice	Boundary	Implementation	Company
1	Save wasted gas at start-up by modifying the start-up method of the 101-J Compressor to minimize delays for the 101-J online.	Utilisation of waste or by-products	Energy efficiency	Within control - Production	Implemented	PUSRI
2	Save gas by speeding up the start-up process for gas entering the 101E absorber by changing the stages and start-up modes in the P-IB ammonia plant Purification unit.	Better process control	Energy efficiency	Within control - Production	Implemented	PUSRI
3	P-IV Arch Burner Reformer Cleaning	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PUSRI
4	Heater Installation in PB 3007-U P-III	Equipment modification	Energy efficiency	Within control - Production	Implemented	PUSRI
5	Utilization of Loop Process Exhaust Gas as Additional Fuel in Auxiliary Boilers	Onsite reuse & recycling	Resource conservation	Within control - Production	Implemented	PUSRI
6	PGRU (Purge Gas Recovery Unit) functions to recover vent gas containing ammonia and hydrogen to be returned to the unit process	Onsite reuse & recycling	Resource conservation	Within control - Production	Implemented	PUSRI
	Build a green surfactant plant with a capacity of 600 kiloliters (kL) that utilizes SO3 gas from a sulfuric acid plant as raw material through EOR (Enhanced Oil Recovery) technology in 2021	Technology change		End-of-life/Waste treatment		PUSRI
7	Build a green surfactant plant with a capacity of 600 kiloliters (kL) that utilizes SO3 gas from a sulfuric acid plant as raw material through EOR (Enhanced Oil Recovery) technology in 2021	Utilisation of waste or by-products	Resource conservation	End-of-life/Waste treatment	In-progress	PKG

8	Building a soda ash plant with a capacity of 300,000 tons is used as a raw material for products that people need daily, which have been imported so far. The raw material for soda ash is the excess CO_2 produced from the ammonia manufacturing process.	Production of useful by products	Resource conservation	End-of-life/Waste treatment	Planned	PKG
	Building a soda ash plant with a capacity of 300,000 tons is used as a raw material for products that people need daily, which have been imported so far. The raw material for soda ash is the excess CO_2 produced from the ammonia manufacturing process.	Technology change		End-of-life/Waste treatment		PKG
9	The by-product of soda ash in the form of ammonium chloride (NH_4Cl) can be used as a raw material for NPK to reduce the need for imported ZA as a raw material for NPK.	Production of useful by products	Resource conservation	Upstream		PKG
10	Petrokimia Gresik switched to using PLN's 11.4 MW of electricity through the progressive captive power acquisition program in August 2021, which previously relied on its generators and managed to reduce costs by up to 12%.	Input material change	Energy efficiency	Upstream	Implemented	PKG
11	Establishment of a catalyst plant (Katalis Merah Putih) with a production capacity of 800 tons/year with an estimated construction time of 13 months to support the development of green fuel and can reduce dependence on imported catalysts.	Input material change	Sustainable sourcing	Upstream	In-progress	PKG

	Establishment of a **catalyst** plant (Katalis Merah Putih) with a production capacity of 800 tons/year with an estimated construction time of 13 months to support the development of green fuel and can reduce dependence on imported catalysts.	Technology change	Resource conservation			PKC
12	The construction of the **Sriwijaya 3B Pupuk plant** will be conducted soon. The construction of the PUSRI 3B plant replaces the PUSRI 3 and 4 plant, which need to be updated and more efficient.	Technology change	Energy efficiency	Within control - Production	Planned	PUSRI
13	**Construction of a liquid CO2 plant** to utilize excess CO2 gas from the production process of the 1A and 1B cleaver fertilizer plants to produce liquid CO2 products with a sale value.	Utilisation of waste or by-products	Resource conservation	End-of-life/Waste treatment	Implemented	PUSRI
14	**Construction of a liquid CO2 plant** to utilize excess CO2 gas from the production process of the 1A and 1B cleaver fertilizer plants to produce liquid CO2 products with a sale value.	Technology change	Resource conservation			PKC
	PT Pupuk Iskandar Muda and PT Perusahaan Gas Negara (PGN) signed an MoU for mutually beneficial business development between PIM and PGN with the scope of natural gas downstream such as **blue ammonia**, methanol and optimizing the use of PIM gas.	Technology change		Upstream	In-progress	PIM

15	PT Pupuk Iskandar Muda and PT Perusahaan Gas Negara (PGN) signed an MoU for mutually beneficial business development between PIM and PGN with the scope of natural gas downstream such as **blue ammonia**, methanol and optimizing the use of PIM gas.	Input material change	Resource conservation			PIM
16	Management Shutdown**)	Better process control	Energy efficiency	Within control - Production	Implemented	PKC
17	Optimization of the 2007-UA boiler package utility plant Kujang 1A**)	Better process control	Energy efficiency	Within control - Production	Implemented	PKC
18	Optimizing the performance of the 1A ammonia plant primary reformer**)	Better process control	Energy efficiency	Within control - Production	Implemented	PKC
19	Electrical interconnection 1A and 1B**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
20	Addition of one unit of A-107-CA heat exchanger at the 1B ammonia plant**)	Technology change	Energy efficiency	Within control - Production	Implemented	PKC
21	Cleaning of the Plate Heat Exchanger (PHE) in the CO2 removal area (110-C and 107-C) of the K1B Plant to reduce the CO2 temperature of the urea feed.**)	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PKC
22	Optimizing the performance of the 2007-UA boiler control system K1A utility plant by eliminating controller and interlock malfunctions**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
23	Audit Losses (Efficiency in the use of raw materials for making urea) **)	Better process control	Energy efficiency	Within control - Production	Implemented	PKC
24	Replacement of K1B primary reformer catalyst**)	Input material change	Energy efficiency	Within control - Production	Implemented	PKC
25	Cleaning the GB 101-LP rotor and diaphragm and replacing the labyrinth seal**)	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PKC

26	Surface Condenser Performance Improvement with Dropwise System Installation**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
27	Heat Exchanger Leak Repairment 1111-C**)	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PKC
28	Increase the temperature of the HTS inlet process gas by installing a plug on the HE 102-C**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
29	Heat Exchanger Repairment 133-C**)	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PKC
30	Conduct cleaning Heat Exchanger 101-JCA**)	Good housekeeping	Energy efficiency	Within control - Production	Implemented	PKC
31	Reducing UGB-101 CO2 Unscheduled Downtime by Optimizing the Anti Surge System at Urea 1B Plant**)	Better process control	Energy efficiency	Within control - Production	Implemented	PKC
32	Optimization of Steam Kujang 1B by changing the A-101-JT Extraction Sensing from Pressure to Flow**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
33	Modification of Catalyst Charging to Tube Reformer from Single Spring Method to Double Spring Method**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
34	Adapter Bushing Valve On/Off is installed between the actuator and stem body valve to remove oxygen levels in the process Nitrogen PSA System**)	Equipment modification	Energy efficiency	Within control - Production	Implemented	PKC
35	Reducing the Energy Intensity of Ammonia K1B by replacing PHE 110 C**)	Technology change	Energy efficiency	Within control - Production	Implemented	PKC
36	Installing solar cells in the raw material storage warehouse in the laydown area	Technology change	Energy efficiency	Within control - Non-production	Implemented	PKC
37	Modification of the central AC control system and off timer in the Central Administration Building floors 1-5	Better process control	Energy efficiency	Within control - Non-production	Implemented	PKC

38	Replacement of the 175 W mercury lamp in the K1A, K1B, MO area and the KIKC industrial area into LED lamps	Input material change	Energy efficiency	Within control - Non-production	Implemented	PKC
39	Modification of AHU 2 central air conditioning control system in Building 101-K	Equipment modification	Energy efficiency	Within control - Non-production	Implemented	PKC
40	Limiting the use of electricity in the Pupuk Kujang residential area by installing a KwH meter	Good housekeeping	Energy efficiency	Within control - Non-production	Implemented	PKC
41	Modification of the central air conditioning control system at CCB	Better process control	Energy efficiency	Within control - Non-production	Implemented	PKC
42	Changing the transportation system within the plant into a shuttle bus	Good housekeeping	Energy efficiency	Within control - Non-production	Implemented	PKC