



Managing the Prospects of New Renewable Energy (NRE) Development through the Utilization of Green Ammonia in Indonesia: A Complementary Analysis in Addressing the Energy Crisis

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ABSTRACT: Climate change is one of the most pressing global challenges today. Indonesia, as an archipelagic country, is very vulnerable to climate change, and has taken strategic steps to respond to this global dynamic. Indonesia is a country rich in natural resources, especially in terms of mining commodities. To overcome the challenges faced in managing energy resources, one promising approach is the transition from the use of fossil fuels to carbon neutral renewable energy sources. The use of conventional ammonia affects air quality, where as a result of exposure to conventional ammonia the air quality is above the normal threshold. Switching the use of conventional ammonia to green ammonia is a step to reduce air pollution which results in extreme climate change. The use of ammonia must be optimized as an environmentally friendly energy use. It is also important for the government as the regulatory provider to pay attention to the existence of a legal umbrella that regulates green ammonia. Overall, the Indonesian government has issued various policies and regulations to support energy development, especially hydrogen as a raw material for green ammonia and renewable energy.

Keywords: New Renewable Energy; Green Ammonia; Energy Crisis; Climate Change.

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1. Introduction

Indonesia adheres to the concept of a welfare state, as enshrined in the fourth paragraph of the Preamble to the 1945 Constitution of the Republic of Indonesia (UUD NRI 1945). It mandates the state's responsibility to promote the general welfare. Historically, this aligns with the legal maxim "*Salus Populi Suprema Lex*", it means "the welfare and prosperity of the people is the highest law in a state." One crucial role of the state is manifested through the utilization and management of natural resources, as mandated in Article 33, paragraph (3) of the UUD NRI 1945, which states "The land, water, and natural resources within are controlled by the state and utilized to the greatest benefit of the people."

This article clearly emphasizes the significant role of the state in regulating the economy. It also prohibits the control of natural resources by individuals through monopolistic or oligopolistic practices in resource management, which contravenes the principles of Article 33 of the UUD NRI 1945. This aligns with Rachel Carson's statement in her book *Silent Spring*: "But man is a part of nature, and his war against nature is inevitably a war against himself" (Natural Resources Defense Council, 2018). This quote reflects the alarming state of our planet, increasingly plagued by environmental degradation. Therefore, active commitment and state contributions are essential to implement adaptive environmental policies aligned with the transition to sustainable energy.

In 2019, the total primary energy supply worldwide reached 4,410 million tons of oil equivalent (MTOE). According to the International Energy Agency (IEA), global energy demand is projected to face

disruptions of up to 50% by 2030. Currently, over 95% of this demand is met by fossil fuels, which not only fulfill energy requirements but also significantly contribute to global warming and environmental pollution. The exploitation of these energy sources has become a serious issue requiring urgent attention, particularly as threats to the planet's health continue to escalate (Vennapusa et al., 2023).

Climate change has become one of the most urgent global challenges, prompting a range of responses from countries and international organizations. The Geneva Convention held in 1979 marked an early step in recognizing the importance of international cooperation to address environmental issues. The convention emphasized the need for an integrated approach to tackle climate change and its impacts on humans and ecosystems. Consequently, nations began developing policies aimed at efficient environmental management. A significant milestone followed with the Paris Climate Change Conference in 2015, where 196 countries agreed to adopt the Paris Agreement. This agreement aims to limit global temperature increases to below 2 degrees Celsius, with an aspiration to cap the rise at 1.5 degrees Celsius. Under this framework, countries are expected to formulate national plans outlining their commitments to emissions reduction. The agreement acknowledges the critical role of financial and technical support in resolving environmental issues holistically (Kementrian Lingkungan Hidup dan Kehutanan Republik Indonesia, 2024).

As an archipelagic nation highly vulnerable to climate change, Indonesia has taken strategic steps to address this global dynamic. By ratifying the Paris Agreement and other international commitments, Indonesia aims to reduce greenhouse gas emissions by 29% by 2030 through national efforts and up to 41% with international support. In addition, the country has implemented legal and regulatory policies to support international targets. Law No. 32 of 2009 on Environmental Protection and Management underscores the state's commitment to maintaining a healthy and sustainable environment.

Indonesia is endowed with abundant natural resources, particularly in mining commodities, positioning Indonesia as a key player globally. In seventh place worldwide in terms of resource and reserve volumes for various mining commodities, Indonesia's principal resources include coal, nickel, copper, gold, silver, bauxite, and tin. These resources not only present significant economic potential but also solidify Indonesia's role in the global mining market. However, managing these mining resources faces challenges. One major risk is the negative environmental impact of mining activities, which often result in ecosystem degradation, including deforestation, water pollution, and soil quality decline. Such outcomes threaten biodiversity and harm resources vital to local communities and overall ecosystem health (Natural Resources Defense Council, 2015). Therefore, implementing sustainable management practices in the mining industry is crucial to balance economic benefits with environmental preservation.

Table 1 Indonesia's Potential in the Mining Sector

Mineral Mining	Mineral Mining Production	
	2021	2022
Coal	614.058.577	687.402.285
Bauxite	25.781.187	28.808.674
Gold	78.996	85.203
Tin Concentrate	52.467	57.735
Copper Concentrate	3.377.023	3.321.239
Nickel Ore	65.509.854	98.187.963

Source: Indonesia Central Bureau of Statistics (BPS Indonesia), 2022

Based on the data, the primary commodities in Indonesia's mining sector are still dominated by non-renewable resources such as coal, bauxite, gold, copper, nickel, and others. The utilization of these resources has continued to increase from 2021 to 2022. Therefore, if this is not balanced with adequate development concepts and energy reserves, the potential risk of environmental degradation and limited access for future generations will become one of the major challenges the state, as the highest governing authority, must address.

To overcome the challenges in managing energy resources, one promising approach is the transition from fossil fuels to carbon-neutral renewable energy sources. This step is crucial, considering the high dependence on fossil fuels has significantly contributed to environmental pollution and climate change. By shifting to cleaner energy sources, such as wind, solar, and bioenergy, we can not only reduce greenhouse gas emissions but also minimize other negative impacts associated with fossil fuel exploitation. The development and application of renewable energy technologies are key to realizing this transition. Wind energy, for example, harnesses wind power to generate electricity without emissions, while solar energy utilizes abundant sunlight for daily energy needs. Bioenergy, derived from organic materials, also offers a renewable alternative. Through innovation and investment in these technologies, we can meet the growing global energy demand without compromising environmental sustainability.

By prioritizing renewable energy sources, we indirectly create a commitment to a more environmentally friendly future. This transition not only has the potential to reduce dependence on fossil fuels but also fosters more sustainable economic growth. Furthermore, this shift can create new jobs in the renewable energy sector, improve energy resilience, and contribute to global efforts to combat climate change. One of the legal instruments regulating energy resource management can be analyzed through Law No. 30 of 2007 on Energy (Energy Law).

Based on Article 1 point 4 of the Energy Law, new energy sources consist of various types of energy that can be generated through new technologies, both renewable and non-renewable. This encompasses the use of nuclear energy, hydrogen, coal bed methane gas, as well as coal that has undergone liquefaction and gasification processes. Innovations in these technologies aim to enhance efficiency and sustainability in energy utilization, expanding the energy options available to meet societal needs. The presence of this article essentially provides a bridge for the development of new and renewable energy (EBT) as a part of national energy policy. Hence, the government should establish a governance framework for the development of energy such as green ammonia as a complementary solution to addressing climate change.

The concepts of management and utilization are inherently interconnected. Based on the Theory of Planned Behavior (TPB) developed by Fishbein and Ajzen, which is an extension of the Theory of Reasoned Action, this theory aims to predict behavior based on individual attitudes and explains how psychological processes interrelate. Both theories emphasize the importance of intention as the main factor determining whether someone will perform a certain behavior. In this concept, Fishbein and Ajzen added a variable related to perceived behavioral control to expand the scope of the theory. Perceived control refers to an individual's belief about how easy or difficult it is to perform a certain action, taking into account possible obstacles or challenges.

In the context of environmental management and renewable energy, TPB can be used to understand and predict pro-environmental behavior. Attitudes toward behaviors such as the use of EBT will be influenced by individuals' perceptions of the benefits (such as pollution reduction) or disadvantages (such as high initial costs) associated with these behaviors. Additionally, the existence of norms plays a role, where an entity will consider the environmental views of its surroundings in deciding whether to support or reject the use of energy. Perceived behavioral control, such as perceptions about the ease or difficulty of adopting renewable energy technologies, will also affect the intention to switch to more environmentally friendly energy. Thus, TPB provides a comprehensive framework for understanding psychological factors that affect the adoption of behaviors supporting environmental sustainability.

This construction brings us to the current political and legal position of the government. In fact, Indonesia's position cannot be predicted. On one hand, there is a desire for legal certainty to create climate change solutions, but on the other hand, the country is still unable to remove dependence on non-renewable energy. Fundamentally, this will impact the management of renewable energy (EBT), which has not yet received serious attention from the government. Therefore, the coordination between sectors, through institutional frameworks, governance, legal regulations, and compliance from businesses and society, must be aligned with the policies to be implemented. Based on the above explanation, this

assessment highlights two main issues related to the environmental challenges amid the Sustainable Development Constellation, along with projections for the ideal management of green ammonia as a complementary solution to address climate change in Indonesia.

2. Methodology

In this article, the author employed the doctrinal legal research method. The doctrinal or normative juridical research method is based on doctrines and scientific procedures in the field of law, grounded in norms, principles, and values derived from legislation and other legal literature (Bachtiar, 2018). The focus of the research is to examine the practice of environmental management and its implications for climate change. The approaches used in this research consisted of the legislative approach, the comparative approach, and the conceptual approach to analyze the relationship between green ammonia management and accelerating the transition to renewable energy. The data for this research was obtained through library studies and literature reviews, which were analyzed descriptively and qualitatively to provide effective solutions (Peter Mahmud Marzuki, 2005).

3. Discussion

A. Examining Environmental Issues Amidst the Dynamics of Sustainable Development in Indonesia

Environmental issues are a current topic of discussion at local, national, and even international levels. These issues are classified based on the environmental impacts they cause. Environmental challenges we face continue to increase annually, including water and air pollution. The causes are not only industrial activities but also human household activities.

Environmental problems have become a concern for countries around the world. Several nations have shown significant attention to environmental protection aspects. For example, the 1949 Geneva Conventions and the Additional Protocols I and II of 1977, the ENMOD Convention of 1976 prohibiting environmental modification techniques, and several other specific conventions and protocols related to various aspects of warfare, such as limiting or prohibiting biological, chemical, or nuclear weapons (Gray, 2000). Relevant rules in international treaty law regarding environmental protection during armed conflict can be divided into three main categories: rules directly addressing environmental protection issues, general principles of international humanitarian law applicable to environmental protection, and provisions that can be considered as indirectly providing environmental protection during armed conflicts.

Besides the Geneva Conventions, the Paris Agreement commits to reducing greenhouse gas emissions. The Paris Agreement was negotiated by 195 countries and represents a new initiative in global efforts to support climate change mitigation and adaptation. The Paris Agreement offers numerous benefits for the environment, such as increasing protection for areas deemed hazardous and vulnerable to climate change through mitigation strategies; enhancing national understanding of emission reduction, including sustainable forestry practices; developing renewable energy; and involving local and Indigenous communities in climate change control efforts championed by Indonesia. It also facilitates funding, technological advancements, and capacity building for implementing actions and mitigation measures, while fostering the active participation of stakeholders in the Paris Agreement negotiations.

Indonesia also pays attention to environmental issues, aspiring to achieve sustainable development. The issuance of Presidential Regulation of the Republic of Indonesia Number 111 of 2022 concerning the Implementation of the Sustainable Development Goals (SDGs) demonstrates the nation's seriousness in realizing environmental justice. This regulation explains that the purpose of the SDGs, which is referred to as TPB in Indonesia, is a global development agenda aimed at ending poverty, improving well-being, and protecting the planet through the achievement of 17 goals by 2030. The SDGs' goals related to addressing environmental issues include healthy and prosperous lives; clean water and proper sanitation; affordable and clean energy; sustainable cities and settlements; climate change mitigation; ocean ecosystems; and terrestrial ecosystems. Achieving these SDG goals will support the realization of sustainable development.

One of the most pressing environmental issues faced by the global community today is climate change. This change is caused by the excessive use of fossil fuels, land-use changes, deforestation, large-scale industrialization, and other human activities. In the modern era, the rise of industrialization often involves the use of fossil fuels that have been utilized for years, such as coal, natural gas, and petroleum. The use of these fossil energy sources negatively impacts greenhouse gas emissions, as they contain substances like CO₂, HFCs, CH₄, N₂O, SF₆, and PFCs, which are released into the atmosphere, damaging the ozone layer (Pirani et al., 2024).

One of the non-renewable energy sources widely used is conventional ammonia. Conventional ammonia is produced through the Haber-Bosch process, where nitrogen (N₂) from the air reacts with hydrogen (H₂) under high pressure and temperature with the help of a catalyst. The hydrogen used in this process is typically derived from natural gas or other fossil fuels, such as coal, resulting in significant greenhouse gas emissions, primarily carbon dioxide (Ritchie & Roser, 2020). Conventional ammonia has a detrimental impact on the environment, especially in terms of reducing air quality.

Table 2. Air Quality in High-Risk Ammonia Exposure Zones

Air Quality in High-Risk Ammonia Exposure Zones	
Work Unit	Air Quality
Urea Work Unit	35,51 ppm
Ammonia Work Unit	23,33 ppm
Utilities Work Unit	34,0 ppm
Bagging Work Unit	35,07 ppm

Source: Data Processed by the Author

The use of conventional ammonia affects air quality, where exposure to conventional ammonia leads to air quality exceeding normal thresholds. The table illustrates air quality in areas with high exposure to conventional ammonia. Air quality in factory work environments largely exceeds the established limit of 25 ppm. The work units with polluted air quality due to conventional ammonia exposure include the urea unit with a concentration of 35.51 ppm; the ammonia unit with 23.33 ppm; the utility unit with 34.0 ppm; and the bagging unit with 35.07 ppm (Dwirani, 2004). Additionally, other studies indicate that workers in areas exposed to high concentrations of ammonia have a 2.1 times greater risk of experiencing cough-related issues; 1.8 times greater risk of asthma; and 1.1 times greater risk of breathing difficulties compared to workers in areas exposed to lower concentrations of ammonia (Dwirani, 2004). Given these circumstances, an energy transition is necessary to achieve sustainable development. Transitioning from conventional ammonia to green ammonia is a step toward reducing air pollution and mitigating extreme climate change.

B. Establishing Ideal Green Ammonia Management and Utilization in Indonesia's Renewable Energy Sector

The implementation of green ammonia for fertilizer production was highlighted by the President Director of PT Pupuk Indonesia, Bakir Pasaman, who stated that ammonia usage should be optimized as part of environmentally friendly energy utilization since fertilizers are the primary ammonia consumers in Indonesia. If this opportunity is well-managed, Indonesia has the potential to become a leading player in Asia in developing green ammonia as a source of sustainable energy. Between 2040 and 2050, PT Pupuk Indonesia plans to develop a new commercial-scale green ammonia plant to establish an environmentally friendly industry. The production of green ammonia will have outputs across various sectors, including fertilizers, refrigeration, environmentally friendly fuels, sustainable power generation, textiles, and pharmaceuticals. The extensive use of green ammonia provides a significant potential to support energy transformation in line with the goals of Indonesia's National Energy Policy (KEN).

The National Energy Policy (KEN) serves as a series of government strategies and actions to manage and develop the energy sector. This policy is regulated under Government Regulation Number 79

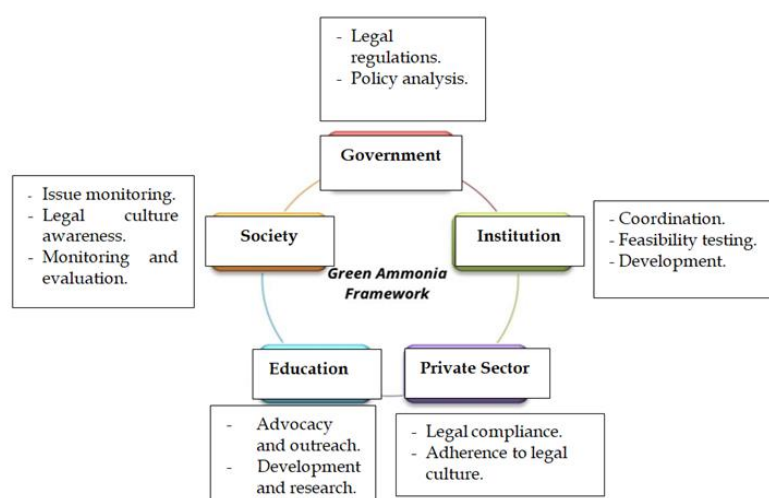
of 2014 concerning the National Energy Policy. According to the 2014 KEN, the national primary energy mix plan aims for renewable energy (RE) to constitute at least 23% of the total primary energy mix by 2025 and at least 31% by 2050. The potential of green ammonia as a clean energy source can help Indonesia achieve these targets, particularly by reducing dependence on fossil fuels in key sectors.

However, considering that green ammonia is a new energy source in Indonesia, its development requires a comprehensive legal approach. Referring to Lawrence Friedman's theory of the legal system, the system consists of three elements: the legal structure, legal substance, and legal culture. The legal structure refers to legal institutions that uphold the legal system. The legal substance encompasses all legal rules, both written and unwritten, including legal principles, norms, and court decisions that guide society and the government within the legal framework. Finally, legal culture represents the ideas, values, thoughts, opinions, and behaviors of community members in applying the law. These elements are essential in illustrating how laws are obeyed, avoided, or misused in society.

From the perspective of legal substance, existing legislation, such as Law Number 30 of 2007 on Energy (Energy Law), has yet to accommodate energy management optimally. The law primarily defines renewable energy sources and addresses energy deficits but lacks clear regulations on green ammonia utilization. Currently, the government is drafting the Renewable Energy Bill (RUU EBT) to incorporate renewable energy aspects. However, this bill has not yet been enacted, resulting in ineffective renewable energy utilization. Moreover, the RUU EBT does not explicitly include green ammonia as a type of renewable energy, even though green ammonia has advantages over conventional ammonia. Therefore, green ammonia requires a legal framework for its development as a recognized form of renewable energy.

In terms of the legal structure, no institution effectively accommodates the utilization of renewable energy (RE) to address the energy crisis and emergencies. Article 6 of the Energy Law (UU Energi) states that energy crises and emergencies are the responsibility of the government, and the authority can be delegated to related sectoral agencies. At the legal cultural level, RE has not yet been maximized in Indonesia because the public is not accustomed to using RE, and its production costs remain relatively high. Public awareness of the importance of transitioning from conventional energy to renewable energy is still very low, necessitating socialization and community empowerment regarding RE. The cultural understanding of energy usage and management must be built upon utility and sustainability principles, considering needs without compromising the current or future generations' quality of life (Pejabat Pengelola Informasi dan Dokumentasi, 2021). The framework for developing green ammonia ideally includes several key aspects: government, institutions, the private sector, education, and the community. A detailed explanation of these aspects is illustrated in the following diagram:

Figure 1. Green Ammonia Development Framework



Source: Compiled by the Author

The government, as the regulatory provider, must ensure the presence of a legal framework governing green ammonia. Overall, the Indonesian government has issued various policies and regulations to support energy development, particularly hydrogen as a raw material for green ammonia and renewable energy. However, concrete steps are still needed in implementing and providing clearer incentives to encourage the growth of the green ammonia sector in Indonesia. Recommendations to accelerate the development of the green ammonia ecosystem in Indonesia include drafting more specific and detailed policies regulating green ammonia development, setting clear targets, fiscal incentives, and more detailed implementation measures.

The implementation of green ammonia production in Indonesia also requires the involvement of state institutions. Several government agencies involved in policy formulation and the development of green ammonia consist of:

1. The Ministry of Energy and Mineral Resources (ESDM) plays a key role in supervising the development of renewable energy (RE), in this context, green ammonia. ESDM establishes energy policies, regulates permits, and provides technical guidance for renewable energy projects. The Ministry of Industry is responsible for developing domestic industries, including the chemical and manufacturing industries related to the production and feasibility of green ammonia.
2. The Ministry of Industry also supports the formulation of regulations to enhance the competitiveness of green industries in Indonesia.
3. The Ministry of Environment and Forestry (KLHK) oversees the environmental aspects of green ammonia production processes, including permits and environmental impact assessments. KLHK also establishes emission standards and ensures industry compliance with environmental regulations.
4. The Investment Coordinating Board (BKPM) facilitates investment in green ammonia projects, particularly by issuing business permits and providing incentives for investors in the renewable energy and green industry sectors.
5. The National Research and Innovation Agency (BRIN) supports the development of green ammonia production technology in Indonesia. BRIN is also involved in research and development to improve the efficiency of green ammonia production.

The government must also set an example, particularly for the private sector as providers or budget holders, by adhering to laws and contractual clauses in the production of green ammonia across various sectors. Additionally, academia plays a role in raising public awareness and analyzing the management of green ammonia development as part of the transition to better energy solutions. The public, as external stakeholders, can also contribute to monitoring through information and data published by the government and improving cultural awareness of the importance of environmentally friendly energy use and the negative impacts of conventional energy usage. The roles of these five elements ultimately support the ideal management and utilization of green ammonia in Indonesia's renewable energy (RE) sector.

C. Strategic Opportunities and Challenges in Developing Green Ammonia Production in Indonesia

Green ammonia presents a potential solution to support the decarbonization of the energy and industrial sectors. As a country rich in renewable energy resources such as solar, wind, water, geothermal, and marine energy, Indonesia has significant opportunities to develop green ammonia on a large scale. Moreover, green ammonia has great potential in the international market as an environmentally friendly fuel and industrial raw material. Global demand for green ammonia is expected to increase in line with other countries' commitments to reducing carbon emissions. Positioned strategically in Southeast Asia, Indonesia has the potential to become a green ammonia exporter, with companies like PT Pupuk Indonesia poised to be a key player in Asia.

The characteristics of green ammonia as clean, environmentally friendly energy make it a crucial

component in achieving net zero emissions by 2060, capable of reducing emissions across sectors such as fertilizer production, electricity, and transportation. This aligns with Indonesia's commitment to the Paris Agreement to reduce greenhouse gas emissions by 29% through its efforts or by 41% with international support by 2030. The development of green ammonia supports government initiatives to build a green economy and enhance the appeal of sustainable investments. Investment in green ammonia projects can create new job opportunities, strengthen energy infrastructure, and drive technological innovation in renewable energy. With a supportive investment environment, Indonesia can attract both local and foreign investors to develop green ammonia production technology.

In addition to the promising opportunities of green ammonia, challenges must be addressed to prepare for the development of green ammonia production and optimize its potential in Indonesia. The production process of green ammonia requires advanced electrolysis technology, which is still costly. Furthermore, the storage and transportation of green ammonia require complex infrastructure, especially regarding the safety of production equipment and workforce. The absence of specific legal frameworks in Indonesia regulating renewable energy (RE) and its implementation poses regulatory and policy hurdles. Currently, government policies on green ammonia remain unspecific and limited. The lack of clear regulations hampers industry development, making supportive regulations and incentives essential to attract investors to help address the significant funding required for green ammonia. Green ammonia demands significant initial investment, particularly in building production facilities utilizing renewable energy resources. To overcome these challenges, partnerships with the private sector and international financial assistance are essential to realize this project.

3. Conclusions

Based on this description, the conclusions of this article include:

1. **Formulation of a Comprehensive Regulatory Framework:** The Indonesian government needs to develop a policy framework that supports the utilization of green ammonia in the RE sector. This regulation should cover licensing, tax incentives, and subsidies for companies interested in investing in green ammonia production. In addition, it should establish safety standards for ammonia storage and distribution to protect the environment and society.
2. **Strengthening Collaboration with Private and International Partners:** The development of green ammonia requires substantial funding and advanced technology. Collaborations with multinational companies, such as those undertaken by Japan and the European Union in green ammonia development, could help Indonesia accelerate the implementation of this technology. International assistance, such as from the IEA or the World Bank, can also be leveraged to support green ammonia infrastructure funding.
3. **Enhancing Domestic Research:** Increasing domestic research capacity in green ammonia production technology is crucial. The government can support universities and research institutions in Indonesia to develop more efficient and cost-effective green ammonia production technologies. This effort will reduce dependency on imported technologies and create job opportunities in renewable energy research and development.
4. **Education and Workforce Development:** The energy transition to green ammonia requires a workforce with specialized skills, particularly in electrochemistry and renewable energy infrastructure. Training programs for technicians, engineers, and project managers are essential to ensure the development of green ammonia progresses smoothly and adheres to international standards.

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