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PERTAMINA ENERGY OUTLOOK 2023

Navigating Indonesia’s Energy Transition: Climate-Related Risks and Opportunities

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FOREWORD

The global crisis that unfolded in 2022 continues to exert its influence in 2023, affecting the energy sector among others. Climate change is beginning to disrupt the supply chain of essential human needs, particularly energy and food. This has raised global concerns regarding energy sustainability, adaptation, and resilience, and Indonesia is no exception. On the other hand, Indonesia must ensure a stable energy supply to facilitate the realization of its vision for "Indonesia Emas 2045", which aims to achieve a per capita income on par with developed nations while upholding its commitment to achieving Net Zero Emissions (NZE) through a transition towards a green energy and economy.

The various challenges outlined above compel Indonesia to plan for a holistic and comprehensive transformation of its energy and economic systems. However, both the energy and economic systems are inherently complex, and the future may unfold in different ways, presenting a significant planning challenge. Therefore, this year, we are updating the Pertamina Energy Outlook with a central theme of "Navigating Indonesia's Energy Transition: Climate-Related Risks and Opportunities". Our aim is to provide insights into various potential futures, each carrying its own set of opportunities and risks, within the context of Indonesia's energy-economic landscape amid global climate change.

In general, PEO 2023 encompasses three scenarios. First, the Ordinary State scenario envisions a condition where economic growth does not deviate significantly from historical trends, as Indonesia needs a structural break to avoid the middle-income trap. Next, the Appropriate Sustainability scenario, where economic growth remains relatively close to historical trends, yet Indonesia remains committed to the energy transition, implementing green technologies, and balancing the needs for economic growth. The last scenario, Economic Renaissance, when Indonesia becomes a high-income country through a structural break that impacts energy demand. On the other hand, the energy transition receives ample support, and technological breakthroughs facilitate the achievement of NZE, enabling a reduction in emissions shortly after Indonesia reaches a high GDP.

We hope that PEO 2023 will serve as a valuable reference for analyzing climate-related risks and opportunities in Indonesia, as well as for formulating future energy-economic policies and plans.

Best regards,

A. Salyadi Saputra

Director of Strategy, Portfolio,
and Business Development,
PT Pertamina (Persero)

EXECUTIVE SUMMARY

Pertamina Energy Outlook 2023 was prepared using energy-economic scenarios, taking into consideration factors such as policies, technological advancements, market preferences, and legal issues as transition risks, as well as climate change as a physical risk. The energy-economic scenarios are modeled using the Low Emissions Analysis Platform (LEAP) to generate quantitative scenarios for primary and final energy demand, energy transformation, and the impacts of emissions. The modeling for PEO 2023 draws on data from the Handbook of Energy & Economic Statistics of Indonesia (HEESI), Indonesian Statistics, the Ministry of Industry, as well as credible data from both national and international institutions.

PEO 2023 encompasses three scenarios: Ordinary State (OS), Appropriate Sustainability (AS), and Economic Renaissance (ER). Some key considerations in formulating these scenarios include the improvement of energy efficiency, utilization of low-carbon fuels and energy sources, sales of electric vehicles, and the transformation of economic structures. The scenario formulation also takes into account the direction and average increase in global temperatures to assess the physical risks of climate change accompanying the national energy-economic system transformation in the future.

Based on modeling results, national final energy consumption in the OS will grow at an average rate of 2.6% per year until 2060. In the AS scenario, the growth is expected to be 2.1% until 2060, and it will be 2.7% in the ER scenario. Both OS and ER scenarios experience nearly identical growth in final energy demand, despite significantly higher economic growth in the ER. The numbers suggest that decoupling energy use from economic growth is still possible, with energy being used much more productively in the ER scenario compared to the AS, owing to increased energy efficiency across various sectors.

To meet electricity demand, the capacity of power generation increases at an average rate of 3.7% per year in the OS scenario, 3.9% in the AS, and at the highest rate: 4.5% in the ER. In the AS and ER scenarios, nuclear energy is integrated into the power generation system.

Regarding emissions, in the OS scenario, emissions from the energy sector will continue to rise, reaching 1,450 million tons by 2060. In the AS scenario, energy sector emissions reach their peak in 2051 at 976 million tons and then decline to 896 million tons by the end of the projection year. Meanwhile, in the ER scenario, energy emissions peak in 2039 at 838 million tons, then decline to 302 million tons by the end of the projection year. The total emissions are related to the global temperature increase. The differing global temperature increases in each scenario are connected to the physical risks of climate change, necessitating preparation for adaptation measures.

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AEs	advanced economies
BECCS	bioenergy with carbon capture and storage
BESS	battery energy storage system
BEV	battery electric vehicle
BMKG-JICA	Meteorology, Climatology, and Geophysical Agency-Japan International Cooperation Agency
BNPB	Badan Nasional Penanggulangan Bencana
BOE	barrel oil equivalent
BOPD	barrel oil per day
BPS	Badan Pusat Statistik
BRICS	Brazil, Russia, India, China, South Africa
BTU	british thermal unit
CAGR	compound annual growth rate
CCS/CCUS	carbon capture storage/carbon capture utilization and storage
CO_2	carbon dioxide
COP	Conference of the Parties
EJ	exajoule
EMDEs	emerging market and developing countries
ESG	environmental, social and governance
EV	electric vehicle
E2W	Electric Two-Wheeler
E4W	Electric Four-Wheeler
FCF	free cash flow
FGD	focus group discussion
FID	final investment decision
GDP	Gross Domestic Product
GHG	green house gas

GW	Gigawatt
GT	Gigaton
HEESI	Handbook of Economy & Energy Statistic Indonesia
HEFA	hydroprocessed esters and fatty acids
HEV	hybrid electric vehicle
HESC	hidrogen energy supply chain
HS	Harmonized System
HVO	hydrotreated vegetable oil
ICEV	Internal Combustion Engine Vehicles
IEA	International Energy Agency
IAEA	International Atomic Energy Agency
IATA	International Air Transport Association
IPCC	Intergovernmental Panel on Climate Change
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Agency
JETP	Just Energy Transition Partnership
KL	kiloliter
kWh	kilowatt hours
LCOE	levelized cost of energy
LEAP	Low Emission Analysis Platform
LNG	liquified natural gas
LPG	liquified petroleum gas
MEMR	Ministry of Energy and Mineral Resources
M&A	merger and acquisition
MTOE	million tonne of oil equivalent
MTPA	million ton per annum
MW	megawatt
MWh	megawatt hour
MWe	megawatt electric
NDC	nationally determined contributions
NRE	New and Renewable Energy
NZE	net zero emission

OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of Petroleum Exporting Countries
PEI	Pertamina Energy Institute
PEO	Pertamina Energy Outlook
PLN	PT Perusahaan Listrik Negara (Persero)
PTA	purified terephthalic acid
PTPN	PT Perkebunan Nusantara
RCP	Representative Concentration Pathway
ROCE	return on capital employed
SAF	sustainable aviation fuel
SPBKLU	public electric vehicle battery exchange stations
SPKLU	public electric vehicle charging stations
SPBG	natural gas filling stations
SPBU	public fuel filling stations
SOE	State-Owned Enterprise
TCF	trillion cubic feet
TFP	total factor productivity
TJ	terajoule
WBG	World Bank Group
WK	Working areas

Chapter I

MACROECONOMIC AND GEOPOLITICAL DEVELOPMENT

I.1 Global Economy

In 2023, the World Bank Group (WBG) conducted a study on long-term growth prospects and found a significant decline in global potential output growth over 2011-2021 period compared to the previous decade, with a rate of 2.6% as opposed to the previous 3.5% annual growth. This decline was observed in both Advanced Economies (AEs) and Emerging Market and Developing Economies (EMDEs), attributed to a reduction in Total Factor Productivity (TFP) growth, a slowdown in investment growth, and a decrease in labor force growth.

Furthermore, a correlation between recessions and potential growth was identified. In the long term, recessions are associated with a reduction in potential growth, which is more evident in EMDEs (1.6 percentage points lower) compared to AEs (1.3 percentage points lower). The impact of recessions is even greater in the medium term compared to other events such as banking crises and epidemics. In banking crises, even though they could lead to a 1.8 percentage points reduction in growth after 2 (two) years, they could be remedied through a rapid increase in investment.

In EMDEs, the recovery of investment after the Covid-19 pandemic was slower compared to the recovery during the 2009 recession after the global financial crises, as nearly three-quarters of EMDEs countries were affected, compared to only half in 2009. The weakening of investment over the past decade was caused by weaker output growth, a reduced net capital flow relative to GDP, slower growth in real private sector credit, and a decline in terms of trade for energy exporters.

Following a strong recovery in 2021, investment growth in 2022-2024 for EMDEs is projected to average only 3.5% per year, half of the average for the 2000-2021 period. Excluding China, the projected investment growth is 4.1% per year, one-fifth below the average in 2000-2021. This indicates that it is unlikely for investment to return to pre-pandemic trends by 2024, presenting a challenge for long-term output, productivity growth, and global trade.

The potential growth is expected to further decline in this decade, averaging 2.2% annually from 2022 to 2030. This is primarily influenced by demographic factors, including population ageing which contributes to a deceleration in workforce growth and a reduction in labor force participation. The decline is even more significant in EMDEs, averaging 4% annually from 2022 to 2030. Meanwhile, AEs experience a smaller decline, averaging 1.2% over the same period.

Climate change is also expected to exert a significant negative impact on growth rate of economic potential output in the forthcoming decade. Historical data reveals that natural disasters have decreased potential growth in affected nations by an average of 0.1 percentage point in the year of the disasters. In the medium term, the extent of the impact varies based on the pace and scale of reconstruction efforts. Climate-related disasters may result in a long-term reduction in TFP growth. Increasing investment in infrastructure to mitigate the impact of climate change can counterbalance these detriments and potentially strengthen global and EMDE potential growth by 0.1 and 0.3 percentage points per year, respectively.

In terms of international trade, both empirical theory and evidence affirm its contributions to long-term economic growth and productivity as it promotes efficient resource allocation, technology spillovers and the accumulation of human resources. These contributions can be made particularly when supported by good institutions and a conducive business environment in exporting countries. Global trade growth is expected to weaken by an additional 0.4 percentage points per year for the rest of this decade due to a deceleration in global output growth and the fading impact of structural factors that previously facilitated rapid trade expansion, such as global supply chains. Disruptions stemming from the pandemic and the conflict in Ukraine may further impede trade growth.

Meanwhile, over the past three decades, the service sector has played a pivotal role in economic growth, contributing to over half of GDP growth and employment in both AEs and EMDEs. However, the composition of the service sector in AEs and EMDEs differs. In AEs, the contribution of high-skilled offshorable[1] services is more dominant, while in EMDEs, low-skilled contact[2] services are more

[1] High-skilled jobs that can be performed remotely in other countries, example: information technology-related jobs.

[2] Low-skilled jobs that require face-to-face interaction, example: retail, hospitality.

prominent. These differences affect future productivity growth, as low-skilled contact services correlate with a slowdown in exports and a deceleration in TFP growth. The increased digitalization during the pandemic may present growth opportunities in the high-skilled offshorable service sector.

Meanwhile, for the 2022-2030 period, the potential growth of the East Asia Pacific (EAP) region is expected to sharply decline, both in aggregate and per capita, averaging 1.6 percentage points per year. This is primarily attributed to slower capital accumulation and TFP growth in China, as the growth model shifts from investment-driven to consumption-driven to reduce financial stability risks associated with credit-driven investment. This aligns with findings from other studies.

According to the World Bank Group's report (2023), countries in EAP have experienced rapid and more stable growth over the past two decades compared to other nations. During such period, they transitioned from low-income to upper-middle-income countries. The driving factors include good macroeconomic management and structural reforms following the Asian financial crises, which entailed limited structural reforms leading to diminished productivity gains. The biggest factor influencing productivity growth has been capital deepening. The trend also intersects with patterns of structural change. Throughout Asian and global financial crises, the share of manufacturing in GDP peaked and began to decline, except in Cambodia and Vietnam.

Sectoral reallocation of labor has no significant effect on productivity growth. In Malaysia, Thailand, Indonesia and China, the shift of labor out of the agricultural sector has slowed since the early 2000s. Instead of transitioning to the manufacturing and business service sectors that have higher productivity, workers have opted for roles in the trade and construction service sectors, which have low productivity. Low productivity in the construction service sector can be attributed to informalization of work and heightened population density due to urbanization.

I.2 Geopolitical Development

Geopolitics has always been an important factor in the energy-economic system. In the past two years, Russia's invasion of Ukraine, followed by the imposition of oil embargoes and the discontinuation of Russian gas supplies to Europe, have had a significant impact on the global energy crisis, subsequently slowing economic recovery.

These events have raised global awareness of the importance of energy and national economic resilience. As a result, the focus of energy policies in several countries has shifted towards strengthening domestic capacities. It can be noticed that various policies have emerged concerning the decoupling and reshoring of energy and green technology supply chains, such as the Inflation Reduction Act (IRA) policy in the U.S., RePowerEU, or the down streaming of minerals in Indonesia. Recently, as many as 22 countries have started to stop food exports due to climate change.

In addition to reshoring policies, friend-shoring[3] policies are starting to emerge, which redirect trade supply chains to countries viewed as political and economically friendly. In 2023, BRICS, which constitutes Brazil, Russia, India, China and South Africa began to extend invitations to various other countries to join. More than 40 countries have expressed their interest in becoming part of this economic bloc.

Some argue that these situations are indicative of geopolitical fragmentation, which may have a negative impact on global cooperation in addressing climate change and accelerating energy transition.

In addition to strengthening domestic energy security, the energy crisis also creates polarization in the energy transition. There is a view that the energy transition should be accelerated to enhance energy resilience. On the other hand, there is a perspective to carry out the energy transition in an orderly way, which means that the pressure on the fossil energy supply side should be balanced with an acceleration of the transition on the demand side. Pushing for the transition of the fossil energy supply side while the demand side continues to grow can result in price volatility and subsequent energy crises.

This perspective is reflected in the OPEC+'s, which has warned the International Energy Agency (IEA) to be cautious in restraining oil investments, as it might lead to future volatility.[4] Additionally, in 2023, the UK has granted over 100 oil and gas licenses, Germany

3 https://www.weforum.org/agenda/2023/02/friendshoring-global-trade-buzzwords/

4 https://www.reuters.com/business/energy/opec-sec-gen-iea-should-be-very-careful-about-undermining-key-oil-investments-2023-04-27/

and China have secured long-term LNG supply contracts, and the global energy company BP has also adjusted its strategy to increase oil and gas investments while continuing to boost investments in NRE.

Regarding the energy transition, critical minerals essential for various green technologies are becoming increasingly strategic. In the last five years, the critical minerals market has doubled, reaching $320 billion, and it is expected to double again before the end of this decade.

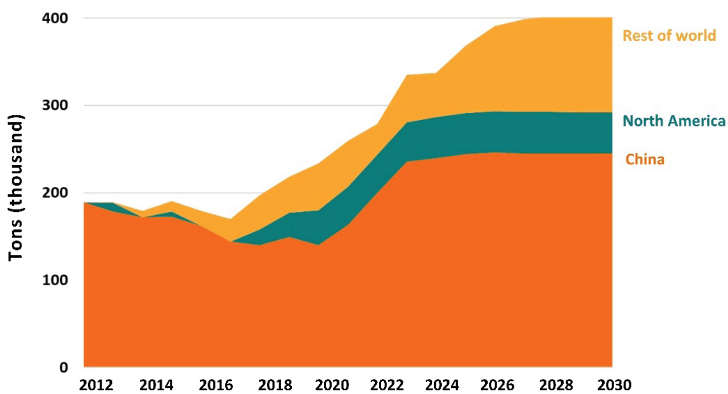


Figure 1. 1 Global Critical Mineral Production
Source: Goldman Sachs Global Investment Research (2022)

In terms of mining, processing and manufacturing critical minerals, China holds a strong position. Globally, China controls approximately 85-90% of rare earth metal processing, 68% of cobalt refining, 65% of nickel processing, and 60% of lithium processing with the required quality for electric vehicle batteries. About 75% of batteries and most electric vehicles worldwide are produced in China. This situation becomes one of the reasons for reshoring in several countries, particularly the US, due to geopolitical concerns with China.

Regarding future geopolitical risks, in 2023, S&P Global identified several primary geopolitical challenges, including energy security, deglobalization, NATO-Russia conflict, debt crises, future pandemic threat, climate change, cyber-attacks and tension in US-China relations.

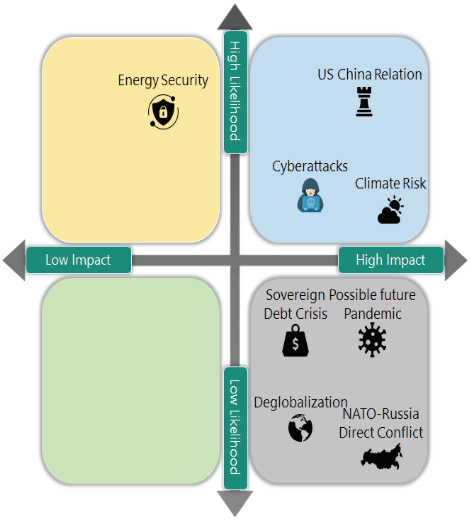


Figure 1.2 Top Geopolitical Rankings of 2023
Source: S&P Global (2023)

Amid global geopolitical uncertainties, Indonesia, along with ASEAN countries, can play a strategic role in enhancing regional energy-economic resilience and accelerating the energy transition. Increased cooperation in infrastructure financing, economic transformation, and energy transition will stimulate investment and trade flows in the ASEAN region.

Chapter II

TECHNOLOGICAL DEVELOPMENT AND INDONESIA'S ENERGY LANDSCAPE

II.1 Technological Development

II.1.1 Nuclear SMR

In line with the commitment to transition towards low-carbon and clean energy, the utilization of New and Renewable Energy (NRE) continues to rise. Most of these NRE sources are derived from nature, including wind, solar, hydropower, geothermal energy, and others. However, these natural NRE sources are inherently intermittent and depend on nature such as seasons and weather conditions, as evident in solar and wind energy. Given these dependencies, there is a need for alternative new sources of energy that can replace fossil energy while supporting the energy transition, one of which is nuclear energy.

Nuclear energy falls into the category of new energy sources within NRE, the widespread utilization of which is not yet fully realised. Consequently, a majority of the population remains largely uninformed about nuclear energy. Currently, the use of nuclear energy remains limited to developed countries such as Germany, France, China, and Japan. In practice, these developed countries implement nuclear energy through nuclear power plants (NPPs) employing various nuclear reactor technologies. Some types of nuclear reactors commonly used include the Pressurized Water Reactor (PWR), Pressurized Heavy-Water Reactor (PHWR), and Fast Breeder Reactor (FBR) (PRIS, 2022).

Table 2. 1 Type & Characteristics of Nuclear Reactors
Source: PRIS – IAEA (2022) (processed)

Reactor Type	*Reactor Type Descriptive Name*	*Total Net Electrical Capacity (MWe)*
HTGR	High Temperature Gas cooled Reactor	200
FBR	Fast Breeder Reactor	1,400
GCR	Gas Cooled, graphite moderated Reactor	4,685
LWGR	Light-Water cooled, Graphite moderated Reactor	7,433
PHWR	Pressurized Heavy-Water moderated and cooled Reactor	24,314

Reactor Type	Reactor Type Descriptive Name	Total Net Electrical Capacity (MWe)
PWR	Pressurized light-Water moderated and cooled Reactor	291,723
BWR	Boiling light-Water cooled and moderated Reactor	53,041
SMR	Small Medium Reactor	300

Each reactor has different characteristics, capacities, strengths, and weaknesses. With technological advancements, new reactors are currently being developed with cutting-edge technology that has garnered global attention, known as Small and Medium Reactors (SMRs). SMRs are fourth-generation nuclear reactors that have been widely used in NPPs in countries around the world, located on nearly every continent.

Figure 2. 1 Countries Developing SMRs
Source: IAEA (processed)

According to the International Atomic Energy Agency (IAEA) as quoted by Warstek Media, SMRs are low-power reactors with a maximum power output of 300Mwe. Generally, SMRs are smaller compared to conventional reactors, making them more flexible in their operations. The design of SMRs is as follows:

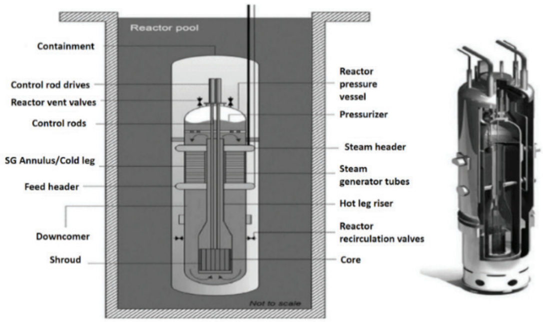


Figure 2.2 Design of SMR Technology
Sumber: Warstek Media

The simplified design of SMRs as power generators is considered superior compared to other energy generators. In addition to their smaller design, SMRs offer many other advantages, including shorter construction period, lower operational maintenance costs, durability, user-friendly operation. Further details can be seen in the following.

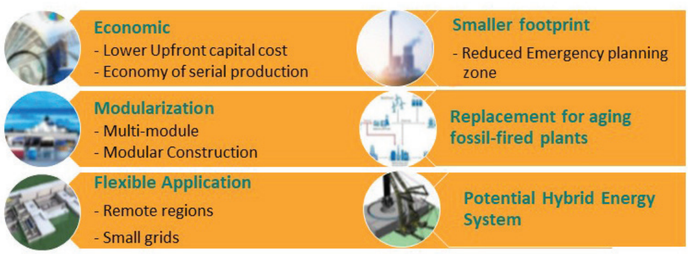


Figure 2.3 Strengths of SMR Reactors
Source: PRIS-IAEA (processed)

In terms of power flexibility, SMRs can be tailored according to specific demand. For instance, if a region needs more electrical power than is currently available, the power supply from SMRs can be increased by adding power modules to the same reactor system. In terms of costs, SMR technology is designed to be low-powered, resulting in a relatively low cost per kWh compared to several conventional reactors. SMR's cost per kWh competes favorably with the prices of conventional reactors, including geothermal power generators. A comparison of overnight costs and electricity costs among various power generators can be seen in the following figure.

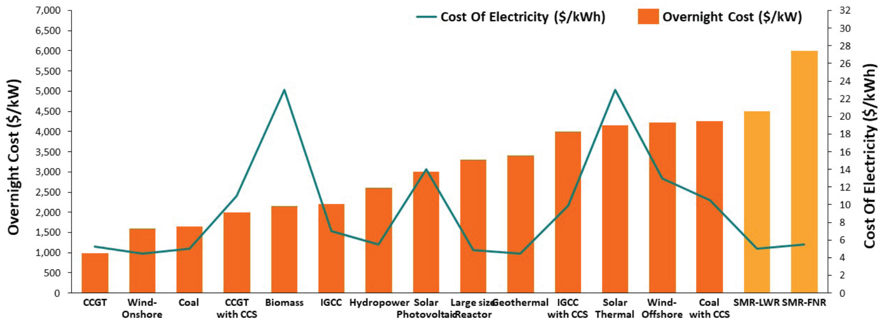


Figure 2.4 Electricity Cost Comparison Across Various Generators
Source: Warstek Media (processed)

Given its advantages and reliability, SMRs are highly suitable for implementation in countries in the Southeast Asian region with distinctive geographical characteristics, such as Indonesia. Geographically, Indonesia is an archipelagic and maritime nation consisting of many islands and remote regions, making it an ideal candidate for the construction of SMRs as a source of electrical energy for remote and isolated areas, especially those far from the power grid. Furthermore, within the maritime scope, SMRs can also be used on ships as a source of power for aircraft carriers or submarines. Therefore, SMRs can serve as an early alternative solution in the development of nuclear energy in Indonesia, including addressing electricity grid issues in remote areas.

II.1.2 Hydrogen

Decarbonization efforts in hard-to-abate sectors, such as heavy industry and long-distance transportation, cannot be achieved solely by relying on renewable electricity. One solution that has been recognized by many countries around the world to complement this decarbonization is the development of hydrogen. With abundant potential in renewable energy resources, but relatively low utilization, the opportunity to develop the hydrogen industry in Indonesia remains highly promising. The potential of 3.689 GW of NRE has the potential to produce green hydrogen, proven natural gas reserves of 41.62 TCF have the potential to produce blue hydrogen, and coal reserves of 38.84 billion tons have the potential to produce brown hydrogen (KESDM, 2023).

Hydrogen can be used as an energy source, energy storage, energy carrier, and for infrastructure purposes. Hydrogen can also serve as a raw material for ammonia production and an energy source for fuel cells. Currently, several countries have invested in hydrogen energy, including Japan, Germany, the United States (US), Australia, the European Union, Saudi Arabia, and Portugal. The German government supports the use of hydrogen as a clean alternative fuel by launching the world's first hydrogen-powered passenger train in August 2022. In early July 2021, Estonia operated the world's first autonomous hydrogen-powered bus. NEOM Green Hydrogen Company from Saudi Arabia will construct a hydrogen production facility worth US$8.4 billion. This plant will produce carbon-free hydrogen at a rate of 600 tons per day by the end of 2026 using 4 GW of solar energy.

In late 2020, Japan and Australia launched a joint project known as The Hydrogen Energy Supply Chain (HESC). This AUD$500 million pilot project, located in the Latrobe Valley, aims to demonstrate an integrated hydrogen supply chain encompassing production, storage, and transportation of liquid hydrogen to Japan, with a commercial target of 225,000 tonnes of liquid hydrogen per year by 2030 (HyResource, 2022). The U.S. Department of Energy also announced US$48 million in funding for 16 research, development, and demonstration projects focused on environmentally friendly hydrogen technology across 13 states (DOE, 2023).

Currently, around 0.8 MTPA of clean hydrogen supply is operational worldwide. Most of the operational capacity is located in North America, with China being the largest market for operational green hydrogen projects. A total of 3 MTPA of clean hydrogen capacity has passed the final investment decision (FID), including 0.8 MTPA in operation, with North America contributing 70% of the committed volume (mostly low-carbon hydrogen). Over 9 GW of electrolysis capacity has received FID, with China accounting for approximately 40% of the committed capacity for implementation (Hydrogen Council, 2023).

Global hydrogen demand is expected to increase from 93 MTPA in 2025 to 380 MTPA in 2050, with Asia accounting for 50% of this global growth. Out of the projected 93 MTPA demand, by 2025, over 95% will come from refineries and the chemical industry, while the remainder will come from the transportation sector and the steel industry. However, as green hydrogen technology advances, hydrogen demand from refineries and the chemical industry is expected to decrease to 40% by 2050, with 60% originating from the transportation sector, followed by the industrial and construction sector, the steel industry, and power plants (McKinsey, 2022).

Indonesia has utilized hydrogen in the industrial sector, mainly as a raw material for fertilizer. Currently, Indonesia's hydrogen consumption is approximately 1.75 million tonnes per year, with the majority used in urea production (88%), followed by ammonia (4%), and oil refineries (2%).

With its enormous potential of renewable energy resources and position as a country located in the international trade routes, Indonesia has the chance to become a global hydrogen hub. Pertamina Power Indonesia (Pertamina NRE), together with Keppel New Energy Pte. Ltd. and Chevron New Energies International Pte. Ltd. have signed a Joint Study Agreement (JSA) during the Business 20 (B20) Investment Forum in Bali in November 2022. The JSA aims to explore certain development projects of green hydrogen and green ammonia, utilizing renewable energy in Sumatra (CNBC Indonesia, 2022).

In August 2023, PT PLN (Persero) and PT Pupuk Iskandar Muda, in collaboration with Augustus Global Investment (AGI), signed a memorandum of understanding regarding investment in green hydrogen production in Indonesia. AGI plans to construct a green hydrogen Production Plant with an annual capacity of 35 thousand tonnes, which requires 50 hectares of land. This project will be located in the Special Economic Zone (SEZ) of Arun Lhokseumawe, Aceh (Bisnis.com, 2023).

As a continuation of the national hydrogen strategy, the Ministry of Energy and Mineral Resources is preparing a national road map for hydrogen and ammonia, encompassing plans for implementing hydrogen in Indonesia up to 2060. The road map will also include regulations, standards, infrastructure, technology, supply-demand, and other relevant regulations.

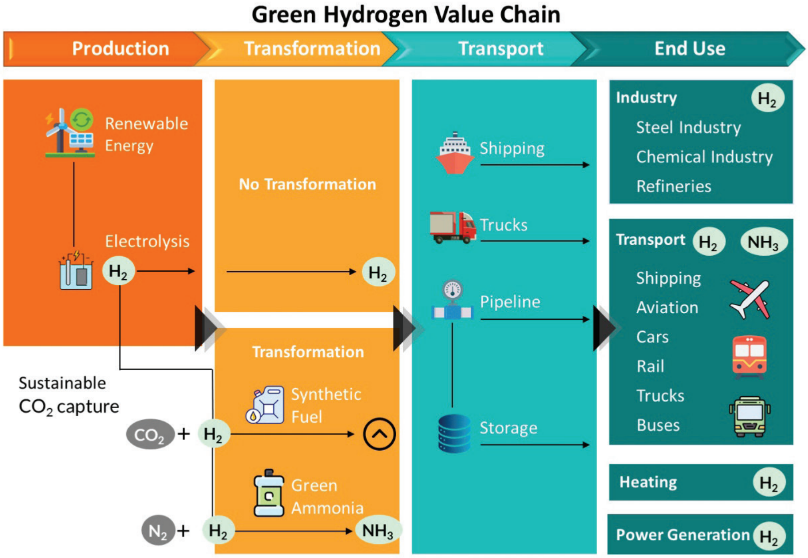


Figure 2.5 Green Hydrogen Production, Conversion and End Uses Across the Energy System
Source: IRENA (2021)

The main challenges to the acceleration of hydrogen development include the current dominance of coal and natural gas as sources of hydrogen production, the high cost of producing green hydrogen, limited infrastructure (transportation, storage, distribution), technological mastery, limited access to investment and financing, and the necessity for policy and regulatory support to make hydrogen development commercially viable. Addressing these challenges requires strategic steps, including setting up regulations and road map for green hydrogen, developing new and renewable energy sources to reduce electricity costs and domestic electrolyzer technology, gradually promoting hydrogen production from NRE, constructing integrated infrastructure to support hydrogen utilization in the industrial and transportation sectors, and fostering collaboration among stakeholders to provide innovative financing schemes. Additionally, hydrogen development should be accompanied by policy prioritie such as development of the domestic market, integration of hydrogen infrastructure, decarbonization of mobility applications with hydrogen, the global hydrogen market, and decarbonization in the industrial sector.

Renewable energy and gas projects in Indonesia offer opportunities for future hydrogen production. Pre-feasibility studies on hydrogen technology have been conducted in Sumatra, Kalimantan, Sulawesi, Java, Sumba, East Nusa Tenggara and Papua for several industrial projects. Taking into consideration the production cost of hydrogen from renewable energy electricity, the cost of environmentally friendly hydrogen production is still relatively high. However, with technological advancement leading to cost efficiency, blue hydrogen may become more economically viable in the medium term (2030-2040), and green hydrogen is likely to become competitive after 2040.

II.1.3 Biofuel

Biofuels play a pivotal role in decarbonizing transportation by providing low-carbon solutions for vehicles, including two-wheelers, four-wheelers, ships, and airplanes. In essence, biofuels are fuels derived from biomass or materials originating from plants and animals. There are several mechanisms for producing biofuels, depending on their respective types. One of them is bioethanol, produced through the fermentation of corn or sugarcane, while biodiesel is produced using crude palm oil through the transesterification process, which chemically reacts with alcohol.

Global biofuels production in 2022 reached 174 million kiloliters (KL), marking a 7% increase from the 162 million KL in 2021. It comprises 114 million KL of bioethanol and 60 million KL of biodiesel. By region, bioethanol production is dominated by the United States, Brazil and India, while biodiesel production is dominated by Europe, the United States and Indonesia (IEA, 2022).

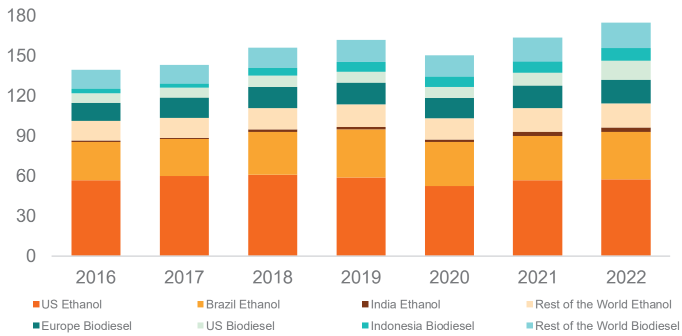


Figure 2.6 Global Biofuel Production (billion liters)
Source: IEA (2022)

The global trend in biofuels utilization is steadily increasing, driven in part by their lower emissions compared to fossil fuels. The use of biofuels has increased by almost 6% over the past five years, except for 2020 due to the pandemic. In fact, the demand for biofuel reached its highest record in 2022 at 4.3 EJ, (170,000 million liters), surpassing the levels seen in 2019 prior to the pandemic. Even in the NZE scenario, the contribution of biofuels to transportation is projected to rise to 9% by 2030, a twofold increase compared to 2022 (IEA, 2023).

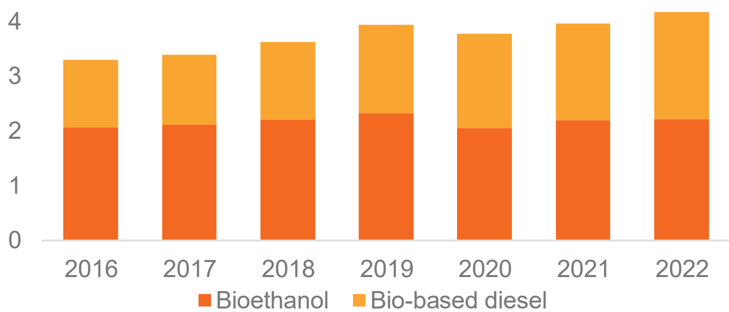


Figure 2.7 Global Biofuel Demand in the Transportation Sector in the NZE IEA Scenario (EJ)
Source: IEA (2022)

Almost universally, mandates for blending biofuels remain the most common policy for advancing renewable fuels in the transportation sector. In 2022, a total of 56 countries had implemented regulations for biofuels blending, with some of them updating their policies. Four countries, namely Argentina, India, Indonesia and South Korea, increased their biofuels blending mandates or targets in 2022.

India is working to reduce its dependence on oil imports, which has led to a change in its national biofuel policy, aiming to increase the ethanol blend in gasoline to 20% by 2025-2026, five years earlier than initially planned. Additionally, South Korea raised its biofuels blending mandate for road transportation from 3% to 3.5% (REN21, 2023).

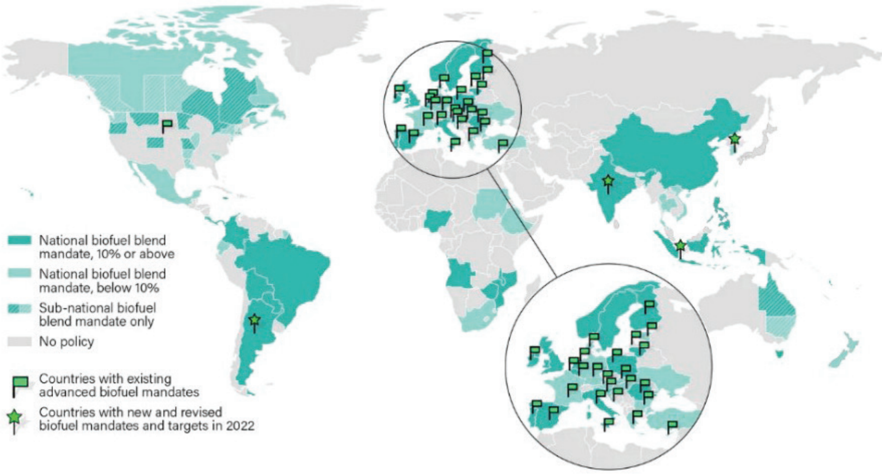


Figure 2.8 Global Biofuel Policies
Source: REN21 (2023)

In Indonesia, the utilization of biofuels is one of the strategies championed by the Government. This is reflected in policies to reduce gasoline imports and the issuance of Presidential Regulation No. 40 of 2023 on the Acceleration of National Sugar Self-Sufficiency and the Provision of Bioethanol as Biofuel. According to the Presidential Regulation, the road map for accelerating sugar self-sufficiency in 2028-2030 encompasses, among others, the addition of sugarcane fields covering 700,000 ha, an ethanol production capacity of 1,200,000 KL/per year by 2028 for consumption needs and by 2030 for industrial needs, as well as an increase in yield[1] by 11.2%.

[1] Yield refers to the quantity of methyl ester (biodiesel) produced in the reaction process per unit of raw material utilized

In line with this regulation, in 2023, the Government, through Pertamina, has taken a step to implement Pertamax Green 95 fuel, referring to the Letter of the Director General of New and Renewable Energy and Energy Conservation No. B-1348/EK.05/DJE.B/2023 dated March 30, 2023 concerning the Implementation of E5 at the TBBM Integrated Terminal Surabaya Owned by PT Pertamina Patra Niaga (PT PPN). Through PT PPN, Pertamina has offered Pertamax Green 95 in 10 gas stations in Surabaya and 5 in Jakarta, with plans for further expansion in the future.

Moreover, Sustainable Aviation Fuel (SAF) has a promising prospect that warrants consideration. SAF is a liquid fuel that could significantly reduce CO_2

emissions in commercial aviation. In the future, the achievement of NZE targets in the aviation sector will revolve around the use of SAF. Currently, 38 leading global airlines have committed to achieve NZE by 2050 or even earlier. Nearly 30 countries have established SAF implementation goals, including attaining 10% of aviation fuel consumption with SAF by 2030 (BNEF, 2023).

Nevertheless, the current hurdle lies in the substantial price gap between avtur and SAF that impacts flight operation costs, which in turn affects ticket prices and consumer purchasing power. This challenge is further compounded by potential supply constraints in the future, which could impede long-term growth. According to IATA data, there have been 57 SAF offtake agreements since 2022 and 30 million liters of SAF produced in 2022.

II.1.4 CCS/CCUS

Carbon capture storage/ carbon capture utilization and storage (CCS/CCUS) technology play a pivotal role in achieving climate targets. The application of CCS/CCUS technology is expected to not only directly reduce emissions in specific sectors but also to remove CO_2 from the atmosphere, which can be achieved either through direct air capture of CO_2 or the combination of CCS/ CCUS with bioenergy (BECCS) for subsequent storage (IEA, 2020).

Currently, there are 20 commercially operational CCS/ CCUS technology implementations across the world, and no fewer than 30 plans for new CCS/CCUS facilities have been announced in recent years. Several projects have already reached the final investment decision (FID) stage, involving an investment budget of approximately US$27 billion (IEA, 2020).

Table 2.2 Large-Scale Operational CCUS Projects as of 2020
Source: IEA (2020)

Country	Project	Year of Operation	CO_2 Source	Capacity CO_2 Capture (Mt/year)	Primary Storage Type
U.S.	Terrel Natural Gas Plants (formerly Val Verde)	1972	Natural Gas Processing	0.5	EOR
U.S.	Enid Fertilizer	1982	Production of Fertilizer	0.7	EOR

Country	Project	Year of Operation	CO_2 Source	Capacity CO_2 Capture (Mt/year)	Primary Storage Type
U.S.	Gas Processing Facilities Shute Creek	1986	Natural Gas Processing	7	EOR
Norway	Sleipner CO2 Storage Facility Project	1996	Natural Gas Processing	1	Dedicated
U.S./ Canada	Great Plains Synfuels (Weyburn/ Midale)	2000	Synthetic gas	3	EOR

Here are some examples of the roles of CCS/CCUS technology in the energy sector (IEA, 2020):

1. Handling emissions from existing energy infrastructure. CCS/CCUS can be added as a new feature to existing infrastructure such as factories or power plants.
2. Providing a solution for some hard-to-abate sectors. Heavy industries currently account for nearly 20% of global CO_2 emissions. CCS/ CCUS is currently the only technology that can offer a solution for reducing hard-to-abate emissions, such as in the production of cement, iron and steel, and some other chemical industries, including the production of synthetic fuels for long-distance transportation, primarily in the aviation sector. Currently, CCUS facilities in hard-to-abate industries are still in the early stages of development, with not many alternative solutions to handle emissions.
3. CCS technology can support the development and acceleration of low-carbon hydrogen technology. CCS can support the fossil energy-based hydrogen production by capturing and storing the carbon emissions generated during the production process.
4. Removing carbon emissions from the atmosphere, especially for sectors where emissions cannot be reduced or avoided. CCS/ CCUS technology can be used to eliminate CO_2 from the atmosphere, including by combining CCS with bioenergy, known as BECCS.

An example of BECCS application is using CCS to capture and store CO_2 in biomass-based power plants.

The implementation of CCS/CCUS in the energy sector currently requires various support from both technological and policy factors. Here are some examples of supports that can drive the implementation of CCS/CCUS in the future (IEA,2020):

- Creating a conducive green investment climate and implementing carbon pricing.
- Developing CCS hubs that can utilize infrastructures through open-access mechanism to enhance economies of scale and economy.
- Identifying and promoting development of CO_2 storage in specific regions near major emission sources.
- Encouraging CCS technology innovation to reduce costs and make CCS technology more commercially feasible.
- Developing CCUS systems by utilizing CO_2 to increase oil production.

II.1.5 Electric Vehicle

Based on IEA data (2002), emissions from the transportation sector account for approximately 23% of global CO_2 emissions, equivalent to 7.98 Gt.

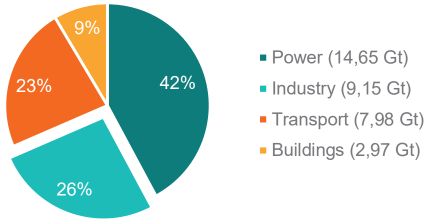


Figure 2.9 Global CO_2 Emissions by Sector in 2022
Source: IEA (2022)

Globally, electric vehicles are considered a key technology for decarbonizing the transportation sector, especially in the road subsector. In Indonesia, the government has set the following targets for electric vehicles adoption by 2025: 2,200 units electric cars, 711,900 units hybrid cars, and 2,130,000 units electric motorcycles. By 2050, the aim is to have 4,200,000 units electric cars, 8,050,000 units hybrid cars, and 13,300,000 units electric motorcycles (National General Energy Plan, 2017).On a national scale, electric vehicles sales have been increasing in recent years. In the first half of 2023, sales of four-wheeled electric vehicles reached 23,260 units, marking a 557.99% increase from the 3,535 units sold during the same period in 2022 (Gaikindo, 2023).

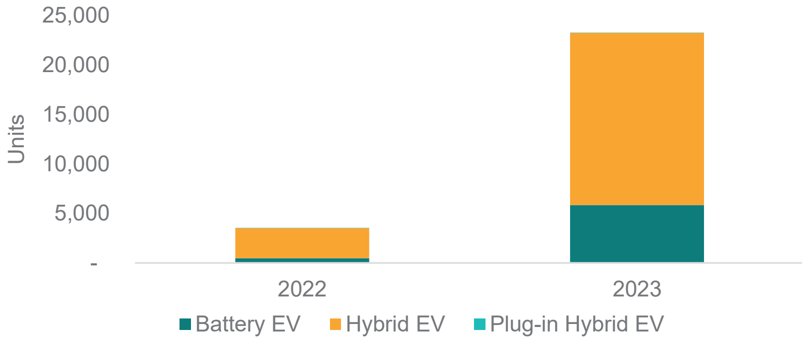


Figure 2.10 Sales of Electric Four-Wheeled Vehicles in Semester I of 2022 and 2023 in Indonesia (Units)
Source: Gaikindo (2023)

However, it's important to note that electric vehicles have not yet become a global phenomenon, especially in developing countries, due to the relatively high prices and lack of electric charging infrastructure. Therefore, stimulus from the Government in the form of supportive ecosystems and policies for electric vehicle adoption is needed (IEA, 2023).

The government of Indonesia has issued Regulation of the Minister of Finance (PMK) No. 38 of 2023 concerning Value Added Tax on the Handover of Certain Four-Wheeled Battery Electric Vehicles and Certain Bus Battery Electric Vehicles Afforded by the Government in the 2023 Fiscal Year (PMK PPN DTP of Electric Vehicles) to incentivize the use of electric vehicles, including two-wheelers, four-wheelers, and buses. This regulation will be in effect from April 2023 until December 2023 tax period for the 2023 fiscal year. The PMK states that the VAT payable on the handover of Certain Four-Wheeled Battery Electric Vehicles and Certain Bus Battery Electric Vehicles is 11% of the Selling Price, while the VAT covered by the Government for the handover of Certain Four-Wheeled Battery Electric Vehicles and Certain Bus Battery Electric Vehicles that meet the TDKN (domestic component level) criteria is 10% of the Selling Price for the tax period starting from April 2023 to December 2023.

Furthermore, the government also focuses on the electric vehicle conversion program regulated by the Regulation of the Minister of Energy and Mineral Resources No. 3 of 2023. Article 2 of the regulation states that the beneficiaries are individuals who receive assistance through conversion workshops certified by the Ministry of Transportation.

In paragraphs 3 and 4 of Article 3, it is explained that the conversion cost is capped at a maximum of Rp17 million for motorcycles with an engine capacity of 110 cc, along with a conversion discount of up to Rp7 million. The assistance for electric motor conversion for 2023 fiscal year is limited to a maximum of 50,000 units of electric motorcycles, and for the 2024 fiscal year, it is set at 150,000 units, with the quantity of electric motorcycles available for conversion subject to annual review and evaluation (KESDM, 2023).

The regulations of the Minister of Energy and Mineral Resources and Minister of Finance above align with the road map for the acceleration of battery electric vehicles and refer to Presidential Regulation No. 55 of 2019. Government-borne VAT incentives are granted for electric cars and electric buses meeting certain TDKN criteria.

From the infrastructure perspective, by the end of 2019, there were already 50 electric vehicle charging infrastructure units in Indonesia. This number has significantly increased to 1,415 units by the end of 2022. At least until the end of 2022, compared to the target, the realization of electric vehicle charging infrastructure in Indonesia has reached 204.18%.

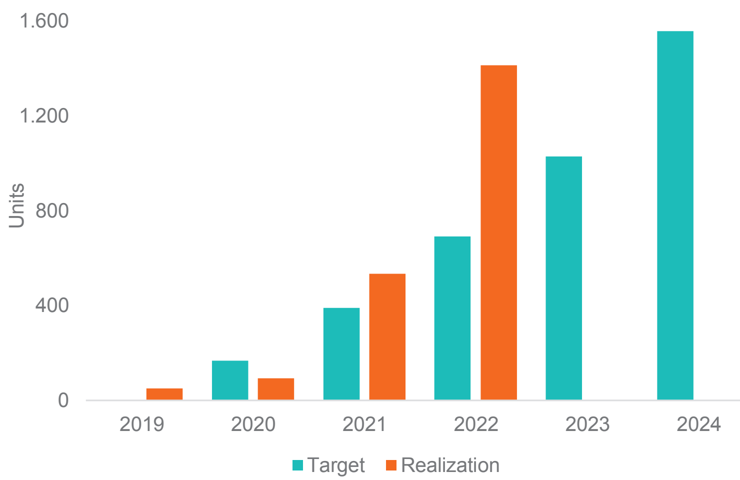


Figure 2. 11 Number of Electric Vehicle Charging Infrastructure in Indonesia (Cumulative Including SPKLU, SPBKLU, and Private Charging Station)
Source: Directorate General of Electricity of MEMR (2023)

In the development of electric vehicle charging infrastructure, the government requires three main points. For safety standards, the following are necessary: compliance with electrical safety regulations, operation worthiness certificate from technical inspection agencies, and certificate of compliance with product standards from product certification agencies. In terms of electrical regulations, the infrastructure must be accessible, has dedicated parking areas, and poses no harm to safety, order, and flow of traffic. Lastly, the electricity fare must refer to prevailing regulations from the Minister of Energy and Mineral Resources.

In 2023, a new policy was issued for the development of electric vehicle charging infrastructure in the form of Regulation of the Minister of Energy and Mineral Resources No. 1 of 2023 concerning the Provision of Battery Electric Vehicles Charging Infrastructure, which contains several provisions. The types of recharging technologies available at electric vehicle charging stations include slow charging, medium and fast charging. Furthermore, recharging technology is distributed around seven locations, namely residential areas, office spaces, malls and other shopping centers, arterial roads, highway rest areas, gas stations and other parking/open areas. Meanwhile, battery electric vehicle charging infrastructure encompasses (i) recharging facilities comprising at least power supply equipment, current and voltage control systems, communication systems, as well as protection and security systems, or (ii) battery exchange facilities.

Apart from Indonesia, other countries, particularly in Asia, have implemented quite advanced regulations regarding electric vehicles to encourage electric vehicle ownership and usage within their respective countries, as detailed below.

Table 2.3 Electric Vehicle Policies in Asia
Source: IESR, McKinsey (2023)

Country	EV Targets	Ban/ Restrictions/ Disincentives on ICEV	Incentives: Tax Exemptions (TE), TaxReductions (TR) and/or Cost Reductions (CR)	Charging Infrastructures (Units)
China	100% EV by 2035	2035 ICEV ban (50% EV : 50% hybrid)	CR: USD1,500 – 3,600 TR: 50% vehicle registration fee TE: USD 1,000s CR: USD 72,000 for FCEV bus/truck	1.1 million in 2022

Country	EV Targets	Ban/ Restrictions/ Disincentives on ICEV	Incentives: Tax Exemptions (TE), TaxReductions (TR) and/or Cost Reductions (CR)	Charging Infrastructures (Units)
Singapore	100% vehicle running on cleaner energy by 2040 100% zero-emission vehicle sales by 2030	2040 ICEV ban Stopped issuing licenses for diesel-powered cars & taxes in 2025	CR: USD 34,000 TR: 34% road taxes for 90 - 230kW EV	3,000 in 2022 60,000 by 2030
South Korea	33.3% EV by 2030 (3.62 million units)	2035 ICEV ban	CR: USD 7,867 - 23,601	170,000 in 2022 1.8 million by 2030
India	E4W: 30% by 2030 E2W: 40% by 2030	2030 ICEV ban	CR: USD 244 each for 100,000 E2Ws CR: USD 1,800 for 35,000 E4Ws CR: USD 158 - 244 for HEVs	1,640 in 2022 23,524 by 2030
Thailand	5.4 million units by 2030 50% of total Evs are domestically produced by 2030	2035 ICEV ban	CR: USD 2,100 (10 - 30 kWh) - 4.500 (>30 kWh) for E4W CR: USD 550 for E2W	2,572 in 2022 12,000 by 2030
Malaysia	Undefined	Undefined	TE: for Completely Built Up (2023) and Completely Knock Down (2025) TR: USD 590	700 in 2022 10,000 by 2025

Country	EV Targets	Ban/ Restrictions/ Disincentives on ICEV	Incentives: Tax Exemptions (TE), TaxReductions (TR) and/or Cost Reductions (CR)	Charging Infrastructures (Units)
Vietnam	3.5 million units by 2040	Motorbike restrictions in major cities in 2030 50% ICEV registration fee increase by 2027 Nationwide ICEV ban by 2050	TE: Registration fee exemption until 2027	40,000 in 2022 150,000 target
Indonesia	E4W: 13 million units by 2030 E2W: 2 million units by 2030	Undefined	TE: Luxury Goods Tax CR: USD 470 for E2W	570 in 2022 25,000 by 2030

II.1.6 Petrochemicals

Petrochemicals are materials or products derived from the processing of oil and natural gas (hydrocarbons). Generally, hydrocarbons processing in petrochemical industries is conducted through various complex stages, starting from the processing of raw materials, semi-finished products and ultimately finished products. In terms of usefulness, this industry is considered one of the strategic sectors, alongside other hydrocarbons-related industries. The demand for petrochemical products continues to increase year by year, and industry growth is projected to continue in the coming years. According to the analysis and projections from Precedence Research (2022), global petrochemical industry is expected to continue to grow, reaching a market size of US$1.041.79 billion by 2032, with a compound annual growth rate (CAGR) of 6% from 2023 to 2032.

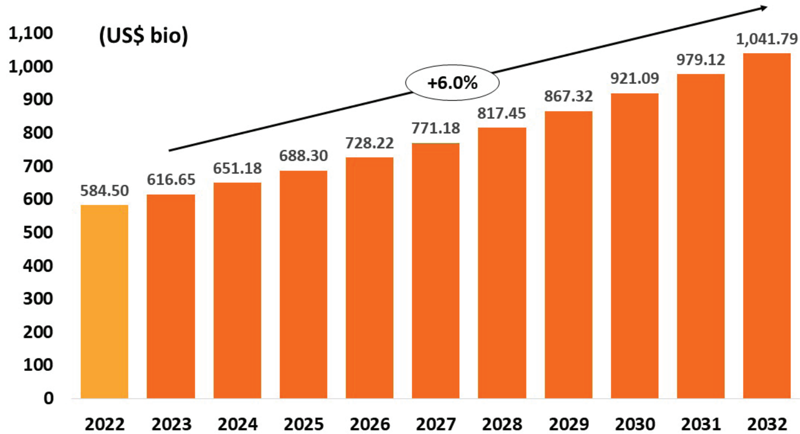


Figure 2. 12 Trend of Global Petrochemical Industry Growth
Source: Precedence Research (processed)

In general, the global petrochemical market is projected to continue to grow and expand in the future. The global petrochemical market is still dominated by Asia, followed by Europe and North America. In the Asian region, the petrochemical business is centered in China, India and several Southeast Asian countries, including Indonesia. In line with the global growth, the petrochemical industry in Indonesia is also projected to continue to grow and develop.

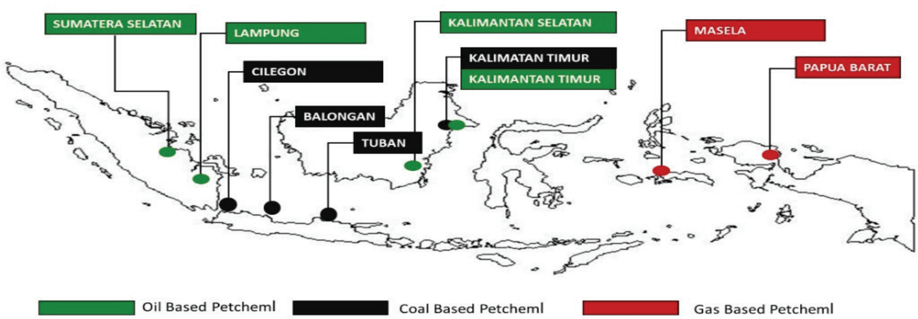


Figure 2. 13 Indonesian Petrochemical Industry Development Clusters
Source: Inaplas; various source (processed)

Petrochemical industry in Indonesia i distributed across almost all regions, from Sabang to Merauke. The Distribution of the industry covers three main clusters, namely oil, gas and coal-based petrochemical clusters. Moreover, within these cluster categories, companies in this industry consist of two types: upstream petrochemical companies that process raw materials into semi-finished products and downstream sectors that further process semi-finished products into finished products. Some examples of upstream petrochemical companies are PT Chandra Asri and PT Titan Petrokimia Nusantara. On the other hand, downstream petrochemical companies include Pacific Indomas, Risjad Brasali Styrindo, PT Lotte Chemical Indonesia (LCI), and The Indonesia Olefin, Aromatic and Plastic Industry Association (Inaplas).

The increasing spread of the petrochemical industry will boost the demand for feedstock materials for each petrochemical company. Each company has different feedstock requirements, some of which are produced internally, some are supplied by other companies, and some are imported from abroad.

In Indonesia, the supply of raw materials for petrochemical companies, especially in the downstream sector, is partly provided by Pertamina. In addition to dominating the oil and gas sector, Pertamina also has a petrochemical business in Indonesia. Some examples include a methanol plant in Pulau Bunyu, East Kalimantan (oil and natural gas-based), purified terephthalic acid (PTA) and polypropylene (Polytam) plants in Plaju, South Sumatra, and paraxylene and benzene plants in Cilacap, Central Java. Indonesia's petrochemical raw materials come from within and outside the country. Based on data from the Central Statistics Agency (BPS), the demand for imported petrochemical products in Indonesia in 2022 was still relatively high. Currently, the Indonesian petrochemical industry can only meet approximately 30% of the domestic downstream industry's needs, with the remaining 70% having to be met through imports. In terms of product types, the imports are still dominated by semi-finished products such as polypropylene, methanol, polyethylene, and ethylene.

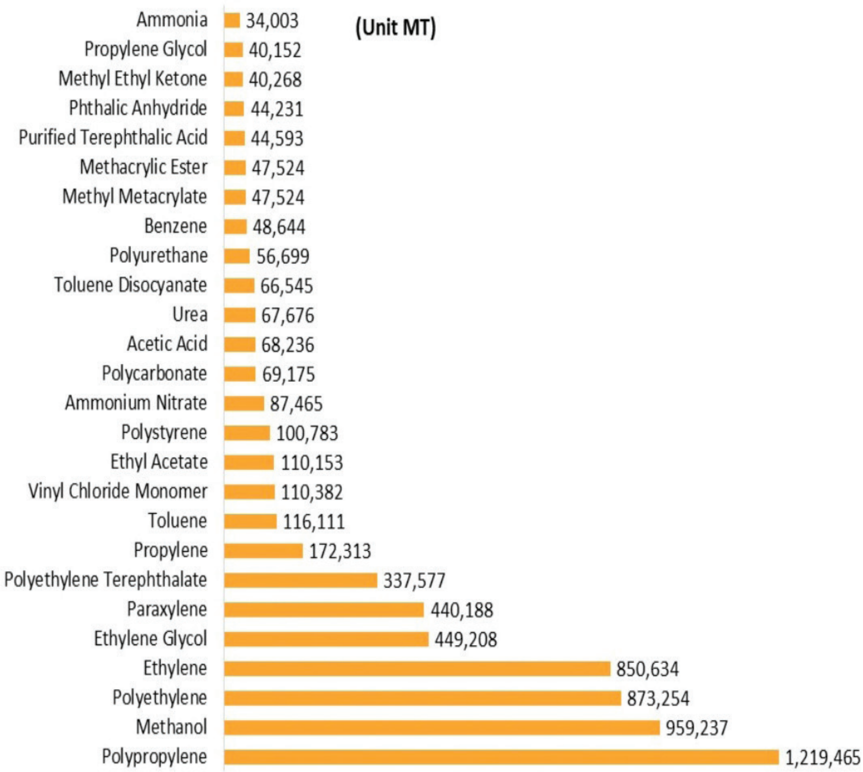


Figure 2.14 Volume of Indonesia's Petrochemical Product Imports in 2022
Source: Central Statistics Agency, 2022 (processed)

Indonesia's imports of petrochemical products have increased since 2015. For example, Polypropylene is still the most imported product from year to year with an average increase of 6% per year. This implies an increase in demand for domestic petrochemical products, especially products from the upstream industry.

Regarding the types of goods imported in this petrochemical industry, they can be identified as industrial machinery, including equipment such as taps, valves, and similar devices for pipes, boilers, and other items that fall under the Harmonized System (HS) code 848180. There are also imports of finished products, particularly plastic articles with the HS code 4011940. In terms of volume, Indonesia's petrochemical product imports in 2022 reached 6.5 million tons. It is estimated that this import volume will continue to increase in the future, in line with the growing demand for raw materials and products in the petrochemical industry.

II.2 Indonesia's Energy Landscape

II.2.1 Historical Trends in Indonesia's Energy Demand

II.2.1.1 Primary Energy Mix

According to the 2022 Handbook of Energy & Economic Statistics of Indonesia, Indonesia's primary energy consumption in 2022 reached 1,759 million barrel of oil equivalent (BOE)—excluding traditional biomass. This marked an increase from 1.559 million BOE in 2019 and 1.465 million BOE in 2018. Based on this data, it is evident that the 2022 consumption has exceeded that of 2019, which was before the pandemic. This indicates a post-pandemic recovery in economic, industrial, and household activities. However, the primary energy needs in 2022, totaling 1.759 million BOE or equivalent to 257 MTOE, still fall far short of the primary energy supply target stipulated in Government Regulation No. 79 of 2014 concerning the National Energy Policy (KEN) for 2025, which is set at 400 MTOE.

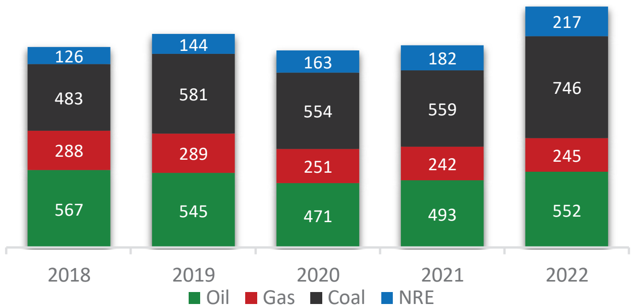


Figure 2.15 Primary Energy Demand (million BOE)
Source: MEMR (2022)

In the last 5 (five) years, fossil energy (oil, gas and coal) still dominates and plays important role in energy supply in Indonesia. During 2018-2022 period, coal contributed 39% on average, and oil contributed up to 34%. On the other hand, the share of NRE is only 12% of total primary energy mix in 2022, although its utilization increases every year, from 126 million BOE in 2017, to 216 million BOE in 2022. The NRE mix is still far from KEN target of 23% by 2025. Several things hindered the growth of NRE in line with the target, among others, oversupply of electricity was hampering the development or expansion in NRE-based power plant capacity, higher NRE prices compared to fossil energy, the absence of domestic NRE component industry ecosystem, and unavailability of low-interest funding support for domestic NRE component industry.

II.2.1.2 Final Energy Mix

In general, domestic final energy consumption relatively escalated every year, except in 2020-2021, when Covid-19 pandemic hit. In 2018, final energy consumption reached 938 million BOE, which then increased by 26% to 1,185 million BOE in 2022. During this period, energy sources still depended on oil and its derivatives.

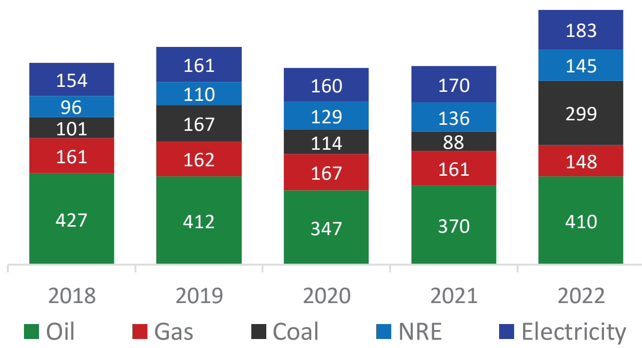


Figure 2.16 Final Energy Demand (million BOE)
Source: MEMR (2022)

By sector, in 2022, the largest energy consumers are industries (43%), transportations (38%), households and commercials (17%), and others (1%).

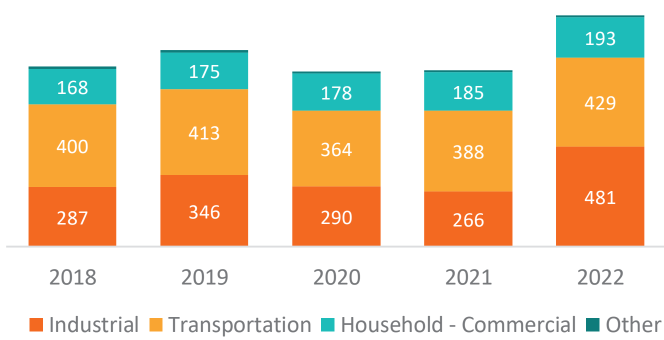


Figure 2.17 Final Energy Demand by Sectors (million BOE)
Source: MEMR (2022)

II.2.1.3 Industrial Sector Energy Demand

This growth aligns with the increasing demand for coal as an energy source in the industrial sector, rising from 87 million BOE in 2021 to 299 million BOE in 2022. This is in line with the policies of industrialization and the downstream processing of mineral commodities, through the construction of processing and refining facilities (smelters), with approximately 28 smelters operational by the end of 2022, primarily fueled by coal energy for boilers. There is a target to build 53 smelters by 2024, with a substantial energy requirement of up to 5.6 GW. (Ministry of Energy and Mineral Resources, 2022). The government continues to encourage industrialization as part of efforts to escape the middle-income trap. The strategy could also augment energy consumption in the industrial sector.

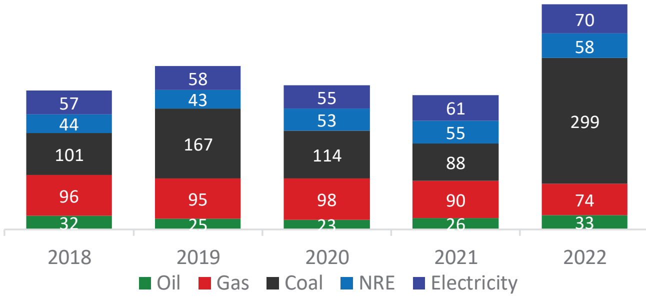


Figure 2.18 Final Energy Demand in the Industrial Sector (million BOE)
Source: MEMR (2022)

II.2.1.4 Transportation Sector Energy Demand

The transportation sector also constitutes a significant energy consumer each year, still predominantly relying on fossil fuels (99% of the total energy consumption in the transportation sector), despite government efforts to promote the use of electric vehicles. The growth of motor vehicles, population increase, and infrastructure improvements in line with the national economic growth are factors influencing the rising energy consumption in the transportation sector. In parallel with the increasing consumption of fossil fuels in the transportation sector, the consumption of biofuels as a blending agent for fossil fuels, especially biodiesel, has also increased in line with the trend of fossil fuel consumption growth.

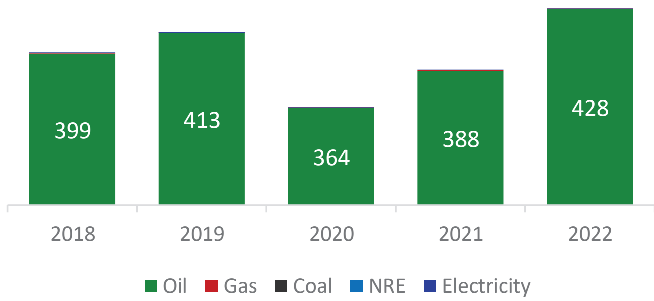


Figure 2.19 Final Energy Demand in the Transportation Sectors (million BOE)
Source: MEMR (2022)

II.2.1.5 Household and Commercial Sector Energy Demand

The largest energy consumption in the household sector is electricity, as most household activities rely on electrical energy, such as lighting, refrigeration, air conditioning, and electronic devices. Following this, the second largest energy consumption in the household sector is liquefied petroleum gas (LPG), which is used for cooking. The kerosene-to-LPG conversion program initiated since 2007 has led to an increase in LPG demand and a decrease in kerosene consumption. There is also the use of renewable energy from traditional biomass, such as firewood, for cooking. In the commercial sector, electricity consumption dominates over other energy sources, contributing more than 80% on average during the period from 2018 to 2022.

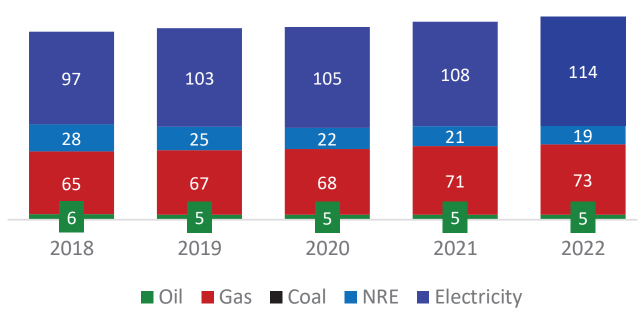


Figure 2.20 Final Energy Demand in the Household and Commercial Sectors (million BOE)
Source: MEMR (2022)

II.2.2 Policies/Regulations Impacting Energy Demand

The following are several policies issued in the last 2 (two) years that have an impact on the energy transition and increased energy demand in Indonesia. During this period, existing regulatory trends have focused on the development of electric vehicles, development of new energy and renewable energy (NRE), implementation of carbon market in Indonesia, and implementation of CCS/CCUS policies.

1. Development of *Electric Vehicle* (EV)

a. Presidential Instruction No. 7 of 2022 concerning the Use of Battery Electric Vehicles (BEV) as Operational Official Vehicles and/or Private Official Vehicles for Central Government and Regional Government Agencies; with the main regulation instructing Ministers, state officials at Ministerial level, Governors, Regents/Mayors to use EVs as operational official vehicles.

b. Regulation of the Minister of Energy and Mineral Resources No. 1 of 2023 concerning the Provision of Electric Charging Infrastructure for Battery Electric Vehicles; with the following main regulations:

- Accelerating the EV program through the provision of SPKLU/ SPBKLU at SPBU, SPBG, government offices, shopping areas, and public parking locations.
- Charging facilities can be provided by SOEs and/or the private sector through the provision of SPKLU, as well as private electricity installations.
- PT PLN is assigned to develop a roadmap for the provision of SPKLU.
- Charging rate: bulk rate multiplied by Q factor (1.01).

c. Regulation of the Minister of Energy and Mineral Resources No.3 of 2023 concerning the General Guidelines for Government Assistance in the Conversion Program of Motorbikes with Fuel Motor Drivers to Battery Electric Motorbikes; with the following main regulations:

- Conventional motorbikes that will be converted to electric-powered vehicles receive a subsidy of Rp7 million per unit
- Conversion cost is limited to a maximum of Rp17 million per unit.

- The quota of subsidy recipients in 2023 is 50,000 motorbikes, while in 2024 is 150,000 motorbikes.

d. Regulation of the Minister of Industry No. 21 of 2023 concerning Amendments to Minister of Industry Regulation No. 6 of 2023 concerning Guidelines for Government Assistance for the Purchase of Two-wheeled KBLBB (Battery-powered Electric Motor Vehicles); with the following main regulations:
   - Subsidy for the purchase of electric motorbikes is given to each NIK (National ID Number) holder for one motorbike.
   - The amount of subsidy is Rp. 7 million per motorbike.

e. Regulation of Minister of Home Affairs Number 6 of 2023 concerning the Basis for the Imposition of 2023 Motor Vehicle Tax, Duty on the Transfer of Motor Vehicle Ownership, and Heavy Equipment Tax; with the main regulations including: The imposition of Motor Vehicle Tax and Duty on the Transfer of Motor Vehicle Ownership of KBLBB is set at zero percent of the basic imposition of Motor Vehicle Tax and Duty on the Transfer of Motor Vehicle Ownership.

Based on data from the Association of Indonesia Motorcycle Industry (AISI), as of July 2023, there are around 54.000 electric motorbikes and 17.000 4-wheeled electric vehicles. Meanwhile, 842 units of SPKLU and 1,331 units of SPBKLU charging facilities have been operating. With attractive incentive policies for EV consumers, such as purchase incentives and tax exemptions, as well as charging facilities that continue to increase, EV sales is expected to increase in the future and thereby reducing sales of conventional vehicles.

2. NRE Development

a. Presidential Regulation no. 112 of 2022 concerning the Acceleration of Renewable Energy Development for Power Supply with the following main regulations:
   - Preparation of The National Electricity Supply Business Plan (RUPTL) which prioritizes the use of NRE.
   - Prohibition of the development of new PLTUs other than those specified in the RUPTL or PLTUs that meet the criteria stipulated in the Presidential Regulation.

- PLTU whose operational period has ended, if necessary, can be replaced with an NRE plants by considering the conditions of electricity supply and demand.
- Determination of ceiling price and agreed price for the purchase of electricity sourced from NRE plants.

b. Presidential Regulation No. 40 of 2023 on the Acceleration of National Sugar Self-Sufficiency and Bioethanol Supply as a Biofuel; with the main regulation: preparation of a roadmap for bioethanol production from sugar cane up to 1.2 million KL by 2030.

c. Minister of Energy and Mineral Resources Decree No. 208.K/EK.05/DJE/2022, which regulates the implementation of B35 as of February 1, 2023.

One of the most widely used NREs in Indonesia is biofuels. Biodiesel-type biofuel has been used since 2006 with a mixture of 2.5% (B2.5). Meanwhile, currently, the mandatory biodiesel mixture has been increased to B35 starting from February 1, 2023, an increase from B30 which has been mandatory since 2020. Meanwhile, the biodiesel distribution target is approximately 13.15 million KL for the B35 program in 2023. In line with the Government's policy to increase the utilization of biofuels, at the end of July 2023, Pertamina launched Pertamax Green 95, gasoline with a 5% Bioethanol mixture that produces fuel oil with RON 95. This type of gasoline is sold at five gas stations in Jakarta and ten gas stations in Surabaya. Pertamina estimates that the demand for Pertamax Green 95 in Java could reach more than 90,000 KL per year, and the ethanol requirement for this projection is 4,800 - 5,000 KL per year.

3. Implementation of Carbon Market

a. Regulation of Minister of Energy and Mineral Resources No. 16 of 2022 concerning Procedures for the Implementation of Carbon Economic Value for Power Generation Subsector, with the following main regulations:
   - Carbon trading must be in accordance with Technical Agreement for Upper Emission Limit for Business Actors (PTBAE-PU) and/or GHG emission reduction certificate (SPE-GRK).
   - PTBAE-PU allocation for PLTU in 2023 is 100%. The allocation after 2023 is according to the results of previous carbon trading transactions at a minimum of 85%,

while allocation for business actors who do not participate in carbon trading and are deemed not to have submitted GHG emissions reports is 75%.

- Carbon trading can be done domestically or internationally. Domestic carbon trading is carried out based on the carbon trading road map for the power generation subsector with emissions trading and GHG emission offset mechanisms. Meanwhile, international carbon trading is carried out through carbon markets and/or direct trading.

b. Regulation of the Minister of Environment and Forestry No. 21 of 2022 on the Procedure for Implementation of Carbon Pricing with the following main regulations:

- Carbon trading is implemented in NDC sectors and subsectors, with carbon pricing implementation mechanisms: carbon trading, result-based payment, carbon levy and/or other mechanisms in accordance with the development of science and technology.
- The carbon pricing mechanism is divided into trading and non-trading. Trading mechanism: Emission Trading System where entities that emit more must buy emission permits from those that emit less, and Crediting Mechanism where entities that perform emission reduction activities might help reduce emissions elsewhere.
- Non-trading mechanism consists of Carbon Tax which is imposed on carbon content or carbon-emitting activities, as well as Result based payments, an incentive or payment received from GHG emissions reduction.

On February 22 2023, carbon trading for the power generation subsector was launched at the Ministry of Energy and Mineral Resources, and a memorandum of understanding was signed between the Directorate General of Electricity and the Indonesian Stock Exchange (BEI). In 2023, the Ministry of Energy and Mineral Resources has determined the value of Technical Agreement for Upper Emission Limit for Business Actors (PTBAE-PU) for 99 coal-fired power plants (42 companies) that will become carbon trading participants with a total installed capacity of 33,569 MW.The carbon trading period starts from the receipt of PTBAE-PU until April 20, 2024, and is mandatory. There has been no carbon trading transaction in the power generation subsector because the carbon trading period still lasts until April 20, 2024. Besides, actual emission data for 2023 will only be available in January 2024.

4. Implementation of CCS/CCUS

a. Regulation of Minister of Energy and Mineral Resources No. 2 of 2023 concerning the Implementation of Carbon Capture and Storage, as well as Carbon Capture, Utilization, and Storage in Upstream Oil and Gas Business Activities; with the following main regulations:
The implementation of CCS/CCUS in upstream oil and gas business activities consists of capture, transportation, injection, storage, and utilization (specifically for CCUS), with regulations on technical aspects, business scenarios, legal aspects, and economic aspects.

- Technical aspects regulate capture, transportation, injection, storage up to monitoring measurement, reporting, and verification. The business scenario regulates cooperation contracts in oil and gas working areas, as well as CO2 sources that not only come from oil and gas WK, but from other industries (specifically CCUS) through a business-to-business mechanism with oil and gas WK Contractors.
- In the legal aspect, the proposed CCS/CCUS activities by Cooperation Contract Contractors (KKKS) are part of the Plan of Development (PoD). The economic aspect regulates the funding potential of other parties and the potential for carbon credit monetization based on Presidential Regulation No. 98 of 2021.

Based on data from the Ministry of Energy and Mineral Resources, 15 CCS and CCUS projects in Indonesia are currently in the study/preparation stage. Eight of these projects are expected to come onstream before 2030. It is estimated that the total potential of CCS/CCUS in 2030 - 2035 reaches around 25.5 - 68.2 million tonnes of CO_2. Currently, Pertamina is developing CCS/CCUS projects in Gundih and Sukowati. BP Tangguh also plans a CO_2-EGR project at

Tangguh Field. Other potential projects include the development of CCS/CCUS project for Banggai Ammonia Plant in Central Sulawesi by Panca Amara Utama, JOGMEC, Mitsubishi, and ITB, the CCS Study project in Sakakemang by Repsol, and the CCS/CCUS project in Abadi Field by Inpex, to Blue Ammonia Production which uses CO_2 sequestration by Toyo Engineering Corporation, Pupuk Kalimantan Timur, and Pertamina Hulu Indonesia.

Chapter III

INDONESIA'S ENERGY *OUTLOOK*

III.1 Methodology and Scenario Modeling

III.1.1 Scenario Preparation

In Pertamina Enmergy Outlook (PEO) 2023, Pertamina Energy Institute (PEI) made several improvements to the development of energy outlook. First, PEI utilized Low Emission Analysis Platform (LEAP) software to develop in-house modelling in order to generate quantitative scenarios of primary and final energy demand, energy transformation, and emission impacts.

Second, PEI uses an energy-economy scenario development approach by considering policy factors, technological developments, market preferences, legal issues as transition risks, and climate change as a physical risk. To assess the risk, climate change is modeled nationally and by region by Pertamina's HSSE team.

Third, historical data base for quantitative modeling comes from HEESI (Handbook of Energy & Economic Statistic of Indonesia), the Central Statistics Agency, data from the Ministry of Industry, as well as other data from various credible national and international institutions.

Finally, PEI fine-tuned the scenario by conducting focus group discussions and direct discussions with various national and international experts and institutions, as well as fine-tuning for quantitative modeling by evaluating other outlook data such as the Draft Government Regulation on National Energy Policy (RPP-KEN), National Development Planning Agency's draft on Indonesia's 2045 vision, and outlooks from international institutions.

In this outlook, the focal question underlying the PEO 2023 scenarios is how Indonesia will achieve climate targets, energy targets, and economic targets in the future. Based on this question, a range of scenarios are grouped into four scenario matrices as follows:

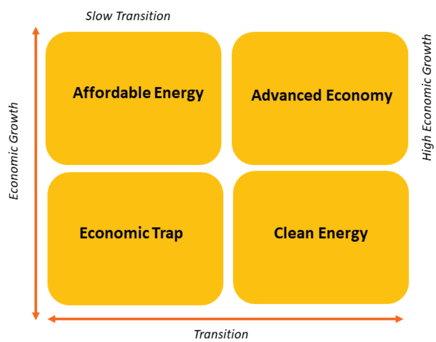


Figure 3. 1 Scenario Matrix
Source: PEI Analysis (2023)

- *Economic Trap*: Indonesia cannot escape middle-income trap and uses cheap and abundant energy sources with slow energy transition.

- *Clean Energy*: Indonesia focuses on energy sustainability; the economy focuses on transforming the energy system which requires large funding.
- *Secure and Affordable Energy*: Indonesia focuses on cheap and abundant energy sources, while growing the economy.
- *Advanced Economy*: Indonesia is able to escape middle-income trap and realize the vision of a 2045 golden Indonesia, while reducing emissions through green economic transformation.

In addition to the combination of specific energy-economic scenarios, considering various challenges/opportunities that Indonesia will face as a developing country, PEO 2023 recognizes that Indonesia is in a situation of global climate change, influenced by the Earth's rising temperatures. The physical risks of climate change will accompany the transformation of the national energy-economic system in the future.

Based on the scenario matrix and alignment of physical climate change risks, energy-economic outlook scenarios are developed, namely Ordinary State (OS), Appropriate Sustainability (AS), and Economic Renaissance (ER) scenarios with the following explanations:

Ordinary State (OS)

In this scenario, Indonesia's economic growth is not too different from the historical trend. This is because Indonesia needs a structural break and a strong effort to escape middle income trap. Indonesia still prioritizes economic growth and energy sovereignty and needs cheap energy to support economic growth.

Appropriate Sustainability (AS)

In this scenario, Indonesia's economic growth is not too different from historical trends. However, Indonesia continues its commitment to carry out a stronger energy transition. Mature and economically viable green technologies are implemented, and the energy transition is carried out by balancing energy security and affordability.

Economic Renaissance (ER)

In this scenario, Indonesia succeeds in becoming a high-income country through a structural transformation that affects the increase in energy demand. On the other hand, energy transition also receives various supports and technological breakthroughs to achieve NZE, so that the increase in GDP and the transformation to a green economy can be achieved.

III.1.2 Key Drivers Scenario

The cause of the difference in global temperature increase is generally due to the achievement of global NZE targets. Achieving the global NZE target can restrain the lowest temperature increase rate of each scenario, while not achieving the NZE target, and the hardest part, the global focus on utilizing fossil energy to support economic growth, will cause a higher global temperature increase. By not achieving the target of the global temperature limit, climate risks will increase, and macroeconomic and microeconomic systems will be disrupted. Therefore, in addition to mitigation actions, adaptation actions to address the impacts of occurring climate change are needed.

In PEO 2023, the key drivers of the national energy landscape and the assumptions of each key driver for each scenario are mapped. Key drivers are the main factors that influence the energy outlook in each scenario. In general, some of the key drivers in the energy sector are improvements in energy efficiency, utilization of low-carbon fuels and energy sources, sales of electric vehicles, and plastic recycling rates (specifically for non-energy use of crude oil). In addition, each scenario also assumes the use of carbon capture to reduce emissions.

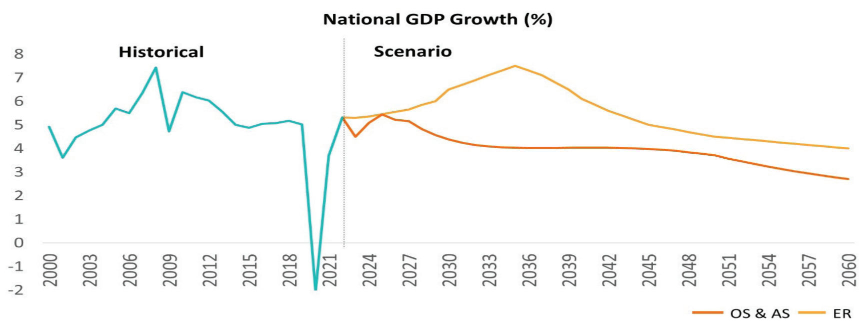


Figure 3. 2 National GDP Growth (%)
Source: PEI Analysis (2023), EIU (historical data and outlook until 2050 for OS & AS)

ER Economic Scenario

This scenario is in line with the government's aspirations to achieve Indonesia's 2045 Vision, namely escaping middle-income trap and becoming a high-income country. The stages to achieve the vision include:

- **Stage 1 (2024-2029)** with an average economic growth of 5.7% focusing on strengthening the foundation of transformation by focusing on the quality of human resources, research and innovation development, and sustainable development.
- **Stage 2 (2030-2034)** with an average economic growth of 6.9% by accelerating transformation to achieve high, inclusive, and sustainable economic growth.
- **Stage 3 (2035-2039)** with an average economic growth of 7.0% by carrying out global expansion to strengthen the transformation that results in internationally competitive and sustainable economic powerhouse.
- **Stage 4 (2040-2045)** with an average economic growth of 5.5% by strengthening the transformation to realize the "Indonesia Emas 2045".

In preparing this long-term growth projection, several considerations, including demographic structure, productivity improvement, economic structure, and competitiveness, as well as the achievement of NZE targets exist. In terms of demographic structure, optimal utilization of the demographic bonus is needed, especially in 2028-2037, by creating job opportunities to support economic transformation with an average of 2.75 million households/year and taking into account that the poor population is dominated by the elderly who are not ready for retirement. In addition, investment in human resources in the young population to prepare a productive workforce with a longer working life is needed.

In addition, an increase in the number of middle-class jobs from the current 18% to 80%, and an increase in the number of skilled workers who match the skill sets required in the labor market are needed. As the aging global population trend is expected to decrease the demand for commodities, especially coal, the utilization of this demographic bonus needs to be done immediately.

In terms of productivity, Indonesia's TFP contributes negatively to economic growth when compared to other countries such as Hong Kong, South Korea, China, Malaysia, Singapore, Thailand, the Philippines, and Vietnam. To achieve Indonesia's 2045 vision, an increase in productivity is required.

In terms of economic structure, Indonesia might experience early deindustrialization that can occur when GDP per capita still relatively low. Currently, Indonesia's exports are still dominated by mining and agricultural commodities that have not been further processed with relatively low complexity. In the long term, economic development is expected to focus on the manufacturing sector with high value-added so the role of the manufacturing sector can increase to 26.3% in 2045 with an average growth of 6.8%, higher than the growth in 2021 which was only 19.3%. The services sector is also expected to increase to 52.0% in 2045, higher than the increase in 2021 which was only 42.8%. However, the agricultural sector is expected to decline along with the downstream process that makes the agricultural sector a raw material input.

In terms of achievement of NZE target, transformative policy directions are needed, one of which is the implementation of a green economy (2025-2045 RPJPN Draft as of May 19, 2023), namely:

- Acceleration of the energy transition towards the utilization of new and renewable energy.
- Development of smart grids including interconnection networks within and between islands and isolated grids.
- Development of battery/ energy storage system technology.
- Development of environmentally friendly transportation.
- Implementation of circular economy.
- Strengthening the implementation of fiscal and non-fiscal incentive and disincentive systems to encourage green products.
- Development of green financing and implementation of carbon pricing to support green investment.
- Implementation of green economy principles in every sector.

OS and AS Economic Scenario

This scenario is adopted from the outlook of The Economist Intelligence Unit until 2050. In the scenario, Indonesian economy in 2023 is expected to slow down compared to 2022. One of the contributing factors is limited investment due to high interest rates. In addition, growth in the volume of goods exports could be maintained in 2023 if private investment remains strong. Investment in the metal processing sector is also anticipated to support export growth in the medium term. In the tourism sector, potential for recovery in 2023-2024 exists, especially after China reopens the doors for its citizen to visit Indonesia.

Economic growth projections show an increase in 2024-2025, follow by a decrease in 2026-2027. This could be caused by revision of the job creation law. The regulation itself is expected to encourage private investment, especially in infrastructure and mining sectors during 2024-2027. While Indonesia may face challenges in competing for foreign investment in labor-intensive manufacturing sectors, proper industrial policies can provide benefits in the medium term for capital-intensive sectors such as metals, chemicals, electronic components and automotive manufacturing.

During 2023-2027, private consumption is expected to remain as main driver of Indonesia's economic growth. In addition, sectoral growth is expected to be driven largely by the industrial and services sectors, which are expected to contribute to nearly 90% of total GDP.

However, there is a possibility for economic growth to slow down, then stabilize after 2030s. It is affected by intensified trade competition and changes in wages and living standards in Indonesia. The condition could alter Indonesia's role as a low-cost, labor-intensive industrial center. A slowdown possibility in economic growth, which is a common trend in many developing countries, could also occur in the 2040s.

In the scenario, it is expected that inflation will slow down in 2023 due to the stabilization of global food and fuel prices. Subsequently, consumer price inflation is expected to become more moderate in 2024 due to falling global commodity prices as well as tighter monetary policy in 2022-2023.

The projected trade in goods in the medium term may decline, although it remains higher than historical data in 2023-2024 due to the high volume of commodity shipments which may offset the decline in global prices. Meanwhile, the recovery in the tourism sector is expected to reduce the deficit in the services sector after reaching a record high in 2021-2022. Nonetheless, the current account may return to deficit starting from 2025, but the decline in GDP percentage is expected to be less significant compared to previous years. This is largely due to increased activity in the processing and manufacturing sectors that boost domestic value-added.

III.2 Primary Energy Outlook

After increasing by 2% in 2021 due to the government's successful vaccination program, which drove economic recovery, national primary energy demand increased more strongly in 2022 by 18%, primarily driven by a 33%

increase in coal energy, a 119% increase in solar energy (including solar power plants, street lighting, and energy-saving lamps), and a 146% increase in industrial biomass. This increase in primary energy demand had a positive correlation with the national GDP growth in 2022, which was 5.3% compared to the previous year's 3.7%.

In the future, primary energy demand is projected to increase from 2022 to 2060 in all scenarios, with the average annual growth rate of primary energy demand in each scenario being 2.8% (OS), 2.7% (AS), and 3.6% (ER) from the base year of 2019 to the end of the projection period in 2060. These three scenarios have different assumptions and narrative bases, with the goal of presenting these scenarios being to provide perspectives on different future alternatives.

The ER scenario provides a perspective on the future if Indonesia succeeds in achieving energy transition and economic transformation, in line with the government's vision. Meanwhile, the OS and AS scenarios offer perspectives if economic transformation does not proceed as envisioned by the government. Furthermore, in the AS scenario, the commitment to energy transition continues, and energy transition policies are implemented more strongly than in the OS scenario. In the AS scenario, it is evident that oil and coal decline in line with the increase in NRE and the utilization of gas. In each scenario, gas continues to increase as a greener transition fuel compared to coal and can also be used to ensure energy system reliability.

The impact of each scenario on primary energy demand can be seen in the following figure:

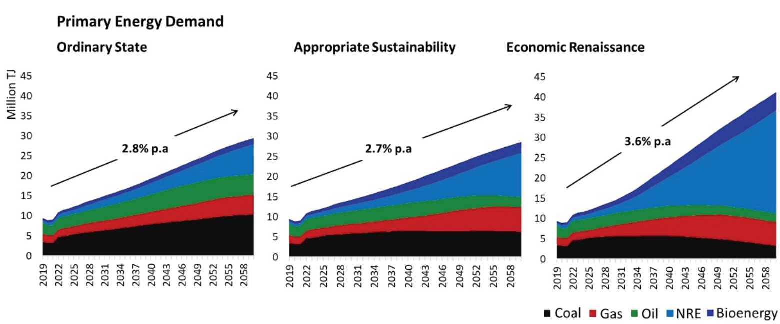


Figure 3. 3 Primary Energy Mix Projections
Source: PEI Analysis (2023)

Fossil energy still dominates in both the OS and AS scenarios. They show that the transformation to green energy still faces great challenges, especially in terms of energy affordability and security. Since the Russia-Ukraine conflict, the world has been facing energy security and supply chain issues. Thus, various policies that are reshoring or pulling the supply chain into the country began to emerge. Apart from strengthening the supply chain from geopolitical disruptions due to conflicts originating from other countries, these policies also aim to strengthen the domestic economy. Various policies are stipulated to recover economic conditions in the period 2022 to early 2023.

Apart from the pressure of the global situation that strengthens fossil energy utilization, a surge in national coal utilization in 2022 as seen in Figure 3.3 above also occurred. Based on the report of the Ministry of Energy and Mineral Resources (2023), the surge in coal utilization occurred due to demand from the industrial and smelter sectors. Besides, coal exports still dominate the trade balance data. This shows that the demand for fossil energy in Indonesia is still strong, despite the implementation of the energy transition policy.

However, the government's commitment expressed in policies and their implementations, as well as future developments in green technology, may provide a different future from the OS and AS scenarios, namely the ER scenario. In the ER, there is a much greater increase in primary energy demand (3.6% compared to 2.8% and 2.7%) compared to the OS and AS. This is because Indonesia needs a large amount of energy to achieve per capita income at par with developed countries while achieving the NZE target in this scenario.

To achieve the NZE target, the NRE capacity needs to be increased significantly. Due to the low capacity factor of NRE energy sources, a large primary energy capacity to meet the final energy demand is required. The following is an explanation of the types of primary energy.

III.2.1 Oil Primary Energy Outlook

In the long term, national oil demand is projected to peak and slow down by the end of the projected year. In the OS scenario, oil demand will increase to 877 million BOE in 2053 and decrease to 858 million BOE in 2060. In the AS, national oil demand will peak in 2041, at 609 million BOE, then fall to 423 million BOE in 2060. National oil demand in the ER will peak in 2031 at 496 million BOE and decrease to 348 million BOE in 2060. The long-term decline in oil demand is mainly due to vehicle electrification.

III.2.2 Gas Primary Energy Outlook

In each scenario, gas will be a transitional fuel in line with energy transition commitments, the portion of which will be slightly replaced by NRE in the long term. The largest demand for gas primary energy comes from two sectors: industry and power generation. In the OS scenario, gas demand will increase to 4,637 trillion british termal unit (BTU) in 2060, with around 47% of demand coming from the power generation sector. Meanwhile, for the AS scenario, national gas demand is higher at 5,786 trillion BTU in 2058 and slightly falls to 5,773 trillion BTU in 2060, with about 47% of demand coming from the power generation sector.

In the ER scenario, gas demand is 5,750 trillion BTU in 2052 and decreases to 5,541 trillion BTU in 2060. In this scenario, the share of gas for power generation is very small (around 5%) compared to the share of gas in other scenarios because the ER scenario considers green transformation in the energy system. The share of NRE will further increase to replace fossil energy in generating electricity.

Meanwhile, gas becomes more needed in hard-to-abate industrial sectors such as cement and base metals, as it is used to replace coal in the heating process which requires large energy. Therefore, gas utilization for industries in the ER is around 2.3 times higher than in the OS and 1.6 times higher than in the AS scenario.

III.2.3 Coal Primary Energy Outlook

Coal still plays an important role in economic growth and energy needs not only in Indonesia but also in other countries such as India and China. Even Indonesia's coal exports to other countries are still quite high throughout 2022-2023. However, with the increased commitment to energy transition, coal will begin to be replaced with greener energy in the future. This is mainly because coal plants produce air polluting elements such as particulates, nitrogen oxides, carbon dioxide, mercury, and other emissions. For this purpose, at the G20 forum in 2022, the Indonesian government succeeded in obtaining commitments from other countries to implement the JETP (Just Energy Transition Partnership) mechanism, of which the secretariat and implementation mechanism began to be prepared in 2023.

In the future, JETP is expected to help Indonesia reduce the share of coal in its energy system. Despite the plan to reduce coal, it is estimated that coal demand will still grow, although at a relatively small and even negative growth rate. In the OS scenario, coal will continue to grow at around 2.6% with a demand of 433 million tonnes in 2060. Meanwhile, in the AS scenario, coal demand is around 1.4% and peaks in 2053 at 270 million tonnes. The ER scenario, with green economy transformation, experiences a negative coal demand rate of -0.1%, with demand peaking in 2038 at 241 million tonnes. The largest coal utilization is in the OS scenario, assuming that coal will still be the cheapest energy source to support economic growth due to the slow cost reduction of renewable energy sources and the lack of disincentive policies for dirty energy sources.

III.2.4 NRE Primary Energy Outlook

The utilization of NRE and bioenergy in each scenario is projected to continue to increase nationally, but at different growth rates. In the OS scenario, the share of NRE in the energy mix is 15% in 2040 or 2.8 million TJ and increases to 26% or 7.6 million TJ in 2060, while bioenergy is 6% or 1 million TJ and decreases to 5% or 1.5 million TJ. Bioenergy demand is projected to fall due to the continued use of coal in the primary energy mix. Meanwhile, the share of energy from bioenergy does not change much due to the limited utilization of biodiesel, namely B35.

In the AS scenario, the share of NRE in the energy mix is 16% in 2040 or 3 million TJ and increases to 38% or 11 million TJ in 2060, while bioenergy is 11% or 2 million TJ and drops to 9%. However, bioenergy utilization increases to 2.6 million TJ. In this scenario, NRE and gas continue to grow and dominate the national primary energy mix, causing the share of bioenergy to decrease, although its utilization has increased. The increased utilization of bioenergy is partly due to the plan to increase the utilization of biodiesel to B40.

Meanwhile, in the ER scenario, the share of NRE in the energy mix is 31% in 2040 or 7 million TJ and increases to 62% or 25.6 million TJ in 2060, while bioenergy is 12% or 2.7 million TJ and decreases to 10.7%. However, bioenergy utilization increases to 4.4 million TJ. In this scenario, the utilization of NRE is much higher than the other two scenarios due to government policies and the better economic value of NRE. The increased utilization of bioenergy is partly due to the plan to increase the utilization of biodiesel to B50 in 2035.

III.3 Final Energy Outlook

The final energy outlook in PEO 2023 is categorized by sector and fuel type. The main sector groups are industries, transportations, households, commercials, industrial raw materials, and other sectors. Based on the scenarios developed in the energy outlook modeling, final energy consumption for the OS scenario will grow nationally by an average of 2.6% per year until 2060. Meanwhile, in the AS scenario, final energy consumption grows by 2.1% until 2060, and in the ER scenario, it grows by 2.7%.

In the OS and ER, final energy demand growth is almost the same, although economic growth is much higher in the ER. It shows that the energy used in the ER is much more productive than in the OS, due to energy efficiency improvements in various aspects, some of which are through vehicle electrification. If not accompanied by a green transformation in the energy-economy system, the ER economic growth scenario will require even more energy. Therefore, it is quite important to balance energy system transformation and economic structural transformation to sustain economic growth to become a developed country.

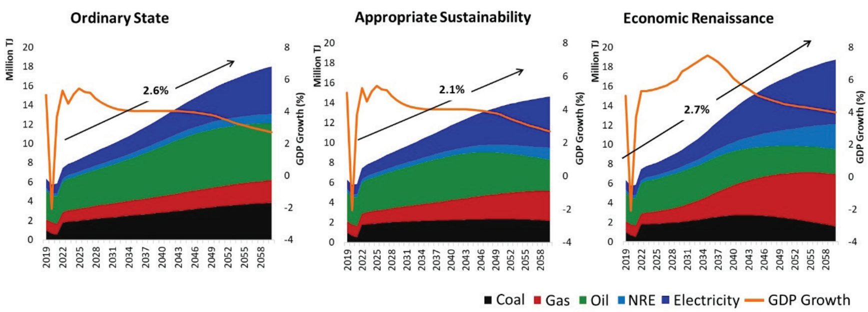


Figure 3.4 Final Energy Demand Projections
Source: PEI Analysis (2023)

III.3.1 Final Energy Outlook in the Transportation Sector

Final energy consumption in the transportation sector depends heavily on the success of vehicle electrification and engine efficiency improvements. As seen in Figure 3.5, the OS scenario, with a much slower economic growth rate compared to the ER scenario, has a significantly higher energy demand because the transportation sector, especially land transport, is slower to transition to electric vehicles and has lower engine efficiency. These three scenarios present different risks and opportunities in the energy transition in the transportation sector, which can impact businesses in various industries related to transportation, including the government, which needs to ensure national energy resilience.

The ER scenario shows that the concept of decoupling between economic growth and energy can occur with the implementation of appropriate policies. Meanwhile, the OS scenario demonstrates that without strong energy transition policies, energy demand in the transportation sector will be very high but economically unproductive. In the AS scenario, a slow energy transition will increase long-term energy demand growth, although it will decrease toward the NZE achievement target. Such a transition pattern will increase emissions accumulation from the transportation sector, even though NZE is achieved by 2060.

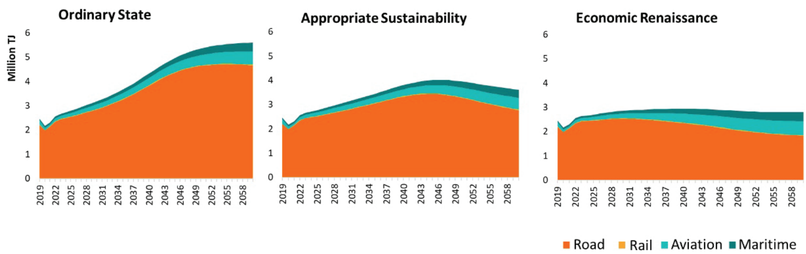


Figure 3.5 Final Energy Demand Projections in the Transportation Sectors
Source: PEI Analysis (2023)

III.3.1.1 Land Transportation

Land transportation has the highest energy consumption among all transportation subsectors, including air and maritime, although with the smallest growth rate. In each scenario, energy consumption for the land transportation sector peaks before 2060. In the OS scenario, the peak energy consumption for the land transportation sector occurs in 2055, in the AS it occurs in 2045, and in the ER it occurs in 2030.

In terms of energy mix, electric vehicles are still seen to have varying penetration levels, depending on the policy support, both in fiscal and non-fiscal, as well as the achievement of price parity and vehicle reliability. Some countries, such as Norway, China, and the US, have managed to achieve high penetration rates of electric vehicles. However, the penetration of electric vehicles still faces various obstacles globally. Some of these obstacles are supply chains that increase vehicle prices, battery reliability, and the availability of charging infrastructure.

In Indonesia, based on the results of a survey conducted by Pertamina Energy Institute and Research and Development Center of PLN at the end of 2022, cost is a major concern for many people, followed by range anxiety, and several other factors such as vehicle brand familiarity. The public's concern about range anxiety aligns with the findings of several studies, which mention that range anxiety is one of the barriers to adopting electric vehicles in the community. Therefore, to encourage the penetration of electric vehicles in Indonesia, it is also necessary to support battery reliability and electric vehicle charging facilities to overcome the problem of range anxiety.

Hydrogen fuel has been considered in land transportation scenario. However, since the technology is still an emerging technology with a high level of uncertainty, the scenario for hydrogen vehicles will only occur in the long-term period with a small number. Currently, the application of hydrogen energy for transportation in the world is still constrained by costs, both the cost of hydrogen production, especially green hydrogen, and the cost of hydrogen vehicles themselves. Although the hydrogen vehicle refueling system is not much different from the conventional vehicle refueling system. Based on data from IEA[1] and IRENA[2], Indonesia's hydrogen potential is the smallest in the Asia-Oceania region, with high green hydrogen production costs. The lowest green hydrogen production cost in Indonesia is (<USD 2/Kg), the location of which is in fairly small locations such as Nusa Tenggara. Therefore, hydrogen development at an economic scale is quite challenging, coupled with the challenge of abundant supply from other regions such as Australia which has large production capacity at low production costs.

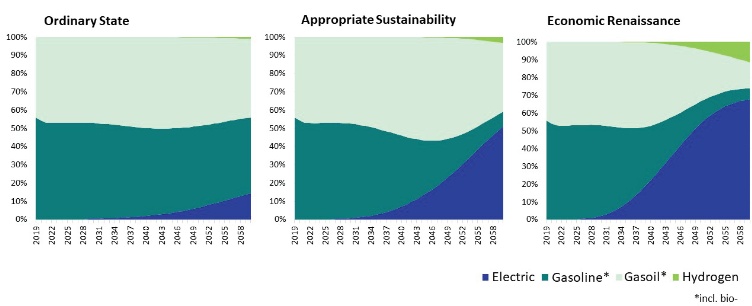


Figure 3. 6 Land Transportation Energy Mix Projections
Source: PEI Analysis (2023)

1 https://www.iea.org/reports/an-energy-sector-roadmap-to-net-zero-emissions-in-indonesia

2 https://www.irena.org/publications/2022/Oct/Indonesia-Energy-Transition-Outlook

III.3.1.2 Air Transportation

The growth rate of final energy consumption in the air transportation sector per is 2.7% (OS), 2.5% (AS) and 2.8% (ER). In PEO 2023, the implementation of SAF (sustainable aviation fuel) is included in the ER scenario with the structural transformation of the green energy system and aviation fuel efficiency. Meanwhile, SAF is not yet included in the other scenarios, although the AS has better levels of fuel efficiency than the OS.

The implementation of SAF in developing countries remains uncertain. Although there have been trials and commitments to its implementation, the target for large-scale implementation is still quite far away. In developed countries, it is estimated that SAF will be included as early as around 2035.

The types of SAF that have the potential to be used in the future are bioavtur based on HVO (hydrotreated vegetable oil) and HEFA (hydroprocessed esters and fatty acids). The availability of feedstock in the form of used cooking oil is still a problem for SAF. Meanwhile, the readiness of hydrogen as a raw material whose production costs are still expensive is still a problem for synthetic fuels.

III.3.1.3 Maritime Transportation

The growth of maritime transportation energy consumption per year is around 4% in the OS scenario, 3.7% in AS, and 4.2% in AR. For fuel utilization, the OS and AS scenarios are dominated by gasoil and biogasoil. Meanwhile, other types of fuels namely, hydrogen, ammonia, electricity, gas, and synthetic fuels are only included in the ER scenario. This is because the utilization of low-carbon alternative fuels for the maritime sector requires the energy transition policies and will not be economical without achieving price parity either through a high carbon price or a decrease in alternative fuel production costs.

III.3.2 Final Energy Outlook in the Industrial Sector

In the OS scenario, energy consumption in the national industrial sector is projected to grow by an average of 2.9% per year with a total consumption of 7.6 million TJ in 2060. Meanwhile in the AS scenario, it is around 2.6% per year and the ER scenario, it is 4% per year, the highest compared to other scenarios. The high growth of energy consumption in the industrial sector for the ER scenario occurs because industry is a pillar of the high economic growth needed to achieve the 2045 golden Indonesia. In addition, to support the food needs of a growing population in the future, the food and fertilizer industries require large amounts of energy.

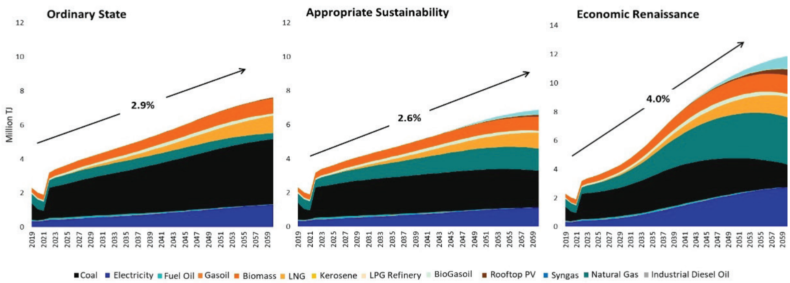


Figure 3.7 Industrial Sectors Energy Demand Projections
Source: PEI Analysis (2023)

In terms of energy mix, coal, electricity, and gas will support the energy demand in the industrial sector. In all three scenarios, even for the ER scenario that factors in green energy transformation, coal is still difficult to replace in hard-to-abate industrial sectors such as the cement and steel base metal industries, due to the need for heating process that requires large and stable energy. Coal for heating process has the potential to be replaced by gas in the future, especially if gas infrastructure can be connected to new industrial centers such as smelters located outside Java.

In addition, CCS also has the potential to reduce emissions in the hard-to-abate sector. With limited decarbonization options in this sector, CCS Hub is the best opportunity for this sector to reduce emissions, especially after all energy efficiency options are taken. However, CCS hubs still require technological breakthroughs to lower the cost of capturing emissions, carbon economic value policies, and other policies to encourage CCS implementation.

Furthermore, the green energy type, hydrogen, still has a high level of uncertainty in Indonesia, mainly due to the energy sources used to produce hydrogen and the production costs. Therefore, green hydrogen is only present in the AS and ER scenarios in the distant future and with a relatively small number. Hydrogen-related policies and a decrease in cost of hydrogen technology will be the determining factors for the use of green hydrogen in Indonesia.

III.3.3 Final Energy Outlook in the Commercial & Household Sectors

Currently, the commercial and household sectors use electricity and gas as their main energy sources. As the energy transition progresses and people's living standards improve, electricity will increasingly dominate the final energy consumption in these two sectors. The source of electricity for these two sectors will also increase in the future, especially those derived from solar energy or rooftop solar panels.

The commercial sector includes services sectors such as offices, schools, hospitals, entertainment venues, warehouses, hotels, and shops. It is a sector that will grow with population growth and urbanization. Buildings in the commercial sector require energy to operate air conditioners, elevators and escalators, lighting, etc. Most of this equipment requires electrical energy, so it is understandable that electricity is the most dominant type of energy in the commercial sector.

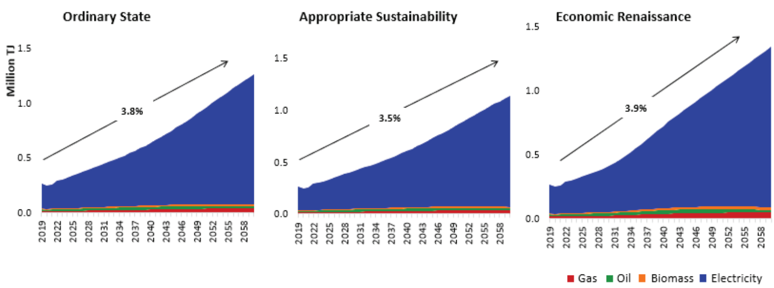


Figure 3.8 Commercial Sector Energy Demand Projections
Source: PEI Analysis (2023)

Currently, in Indonesia, the use of traditional biomass in the household sector, especially for cooking, is still common. In the ER scenario, the demand for traditional biomass will decrease by about 7.1% per year. This is the highest rate of decline compared to -6.2% in the AS scenario and -6.0% in the OS scenario. This happens because the high growth in GDP per capita has an impact on improving people's welfare, thereby increasing the use of more advanced technology. For example, electric stoves are more commonly used today compared to traditional firewood or charcoal-fueled stoves.

Apart from this transition, the improvement of people's living standards will also increase the use of technologies such as air conditioners or refrigerators. In the ER scenario, the energy efficiency of various home devices increases, so the amount of electricity in the energy mix also increases, although the increase is lower than in other scenarios with lower energy efficiency improvements such as in the AS or OS scenarios. The ER scenario shows that a just energy transition for the entire community is still possible without increasing energy demand. This can be achieved if the energy transition policies are implemented in conjunction with energy efficiency improvements. This is in line with the IEA recommendation that energy efficiency is the first fuel in the energy transition[3].

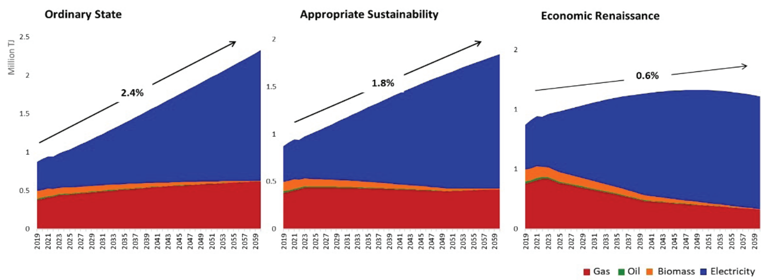


Figure 3.9 Household Sectors Energy Demand Projections
Source: PEI Analysis (2023)

III.4 Power Generation Sector Outlook

To meet electricity needs, power generation capacity will increase under the OS scenario by an average of 3.7% per year, AS by 3.9%, and the highest ER by 4.5%. The high power generation capacity requirement in the ER scenario is due to the utilization of intermittent solar power in the generation sector, as well as increased electrification in the final consumption sector. To offset the increased use of intermittent NRE generation, energy storage technology in the form of battery energy storage system (BESS) is required. Therefore, the number of BESS in the ER scenario increases. Meanwhile, nuclear power has been included in the generation system in the AS and ER scenarios. Nuclear in the form of SMR is one of the energy source options that can be used as baseload and can serve as a substitute for coal plants. In Indonesia, it is expected that nuclear plants will start operating around 2031 at the earliest (DEN, 2023).

3 https://www.iea.org/energy-system/energy-efficiency-and-demand/energy-efficiency.

In addition to the utilization of nuclear energy, CCS can also reduce emissions in the power generation sector. However, the addition of CCS will increase the operational cost of the plant. With the current cost of CCS still above US$100-130 per ton, CCS technology still needs to be further developed and major breakthroughs in the future are also needed. Therefore, the utilization of CCS in the power sector will occur if there is a transformation of the economic system that increases the parity between the cost of carbon reduction using CCS and carbon economic value (CAV). Thus, there is a need for fiscal and non-fiscal support from the government for CCS implementation, as well as technological breakthroughs that can reduce the cost of CCS.

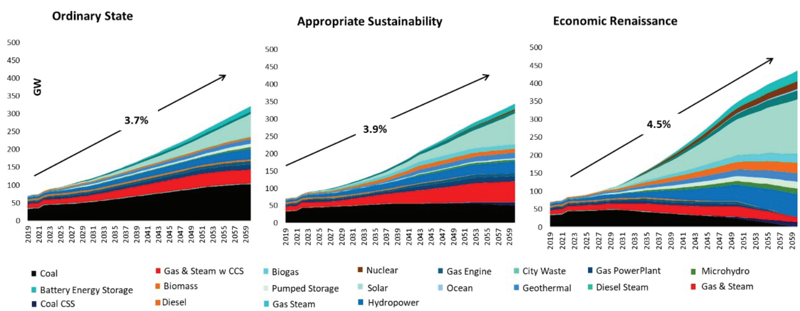


Figure 3.10 Energy Mix and Capacity in the Power Generation Sector
Source: PEI Analysis (2023)

III.5 Energy Sector Emission Outlook

Based on the modeling results, an increase in population and living standards will be followed by an increase in energy demand. Therefore, if not balanced with the utilization of low-emission fuels, energy efficiency improvements, and the use of environmentally friendly technologies, economic improvement will have an impact on the high growth rate of CO2 emissions resulting from the combustion of energy sources. The release of a certain amount of CO2 emissions resulting from energy utilization in the commercial, household, industrial, transportation, and power generation sectors into the atmosphere will have an impact on global warming. The amount of CO2 emissions is also contributed by energy production and processing, such as oil and gas production or mining areas, oil refineries, LPG refineries, LNG refineries, and biofuel refineries.

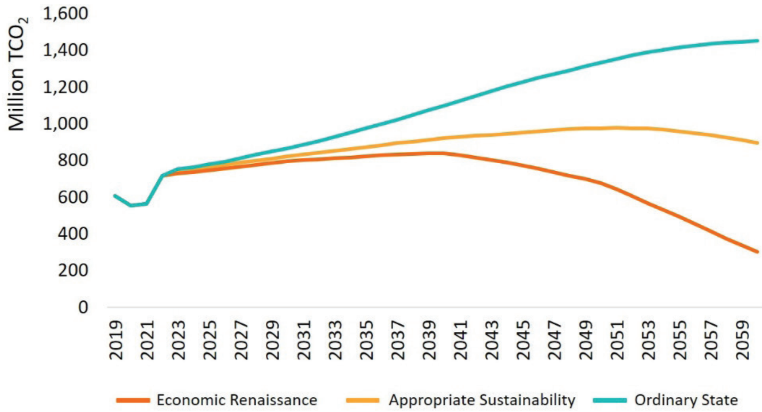


Figure 3. 11 Energy Sector Carbon Emissions
Source: PEI Analysis (2023)

In the OS scenario, emissions from the energy sector will continue to increase to 1,450 million tonnes by 2060. In the AS scenario, emissions from the energy sector peak in 2051 at 976 million tonnes and then reach 896 million tonnes by the end of the projection year. Meanwhile, in the ER scenario, energy emissions peak in 2039 at 838 million tonnes, then decline by the end of the projection year at 302 million tonnes. In this scenario, emissions in the power generation sector have reached NZE in 2060. The remaining emissions are then offset using natural sinks and full Net Zero Emission is achieved.

By sector, the largest contributor to emissions is the power generation sector, where most of the energy sources come from coal with a high carbon content. The share of net emissions from power plants to total net emissions in the AS and OS scenarios in 2060 is around 45%. Due to the massive utilization of NRE and CCS/CCUS in the power generation sector in the ER scenario, NZE is achieved in the power generation sector. The industrial sector is the second largest contributor to net emissions, followed by the transportation sector. Meanwhile, the household, commercial, and other sectors have the lowest emission levels. Going forward, emission reduction in the transportation sector can be done in various ways, some of which are through vehicle engine efficiency, biofuel utilization, and vehicle electrification. However, reducing emissions is not easy for the industrial sector, especially those that are hard-to-abate.

To reduce emissions, penetration of low-carbon technologies is needed across all energy-using sectors. A long-term energy management strategy roadmap needs to be developed so that the achievement of carbon reduction can bring benefits, not only for the government, but also for businesses. PEO 2023 provides an overview of the energy utilization roadmap adjusted to market and technology readiness. In the AS scenario, electrification in various sectors and utilization of various types of NRE are needed to halt the rate of emission increase. Meanwhile, in the ER scenario, in addition to electrification in various sectors and utilization of NRE, carbon capture technologies such as CCS/CCUS are also needed to reduce emissions until NZE is achieved. In both the MD and GT scenarios, carbon offsets are required to ensure that emissions can be further reduced.

Therefore, nature-based solutions such as rainforests and mangroves are needed. As Indonesia has enormous marine potential, utilization of ocean-based solutions such as blue carbon or tidal energy also needs to be developed. In addition, to achieve electrification and the utilization of NRE, policies such as the coal-fired power plants phase-out and the replacement of conventional vehicles with low-carbon vehicles such as electric or biofuel vehicles are needed. The development of hydrogen either as a direct fuel, as energy storage such as fuel cells, or as a material to produce synthetic fuels also needs to be developed further.

Chapter IV

CLIMATE-RELATED RISKS AND OPPORTUNITIES

IV.1 Transition Risks and Opportunities

IV.1.1 Policy and Legal Impact

Transition risks from policy and legal perspectives are analyzed both in terms of policy and regulation that are waiting to be stipulated by the government, therefore potentially posing a risk to energy transition and increase in national energy demand, as well as from the policy and regulation that could promote energy transition, with results as follows:

Table 4. 1 Policy Transition and Legal Risk Matrix

Risk & Opportunity	Current Condition	Potential Impact
National		
1. 2025 - 2045 National Long-Term Development Plan (*Rencana Pembangunan Jangka Panjang Nasional/ RPJPN*)	2025 – 2045 RPJPN Concept a. Carbon emissions intensity decreases toward net zero emissions • Accelerating energy transition toward NRE • Developing off-island and national power grids • Environmentally friendly transportation • Reforming integrated waste management from upstream to downstream • Controlling deforestation b. NRE portion in the primary energy mix: 2025 baseline: 20%; 2045 target: 70% c. Energy security index: 2025 baseline: 6.61; 2045 target: 8.24	Determining the 2025 - 2045 agenda and development direction, namely economic transformation by applying a green economy in achieving Golden Indonesia 2045 Vision
2. Draft Law on the New and Renewable Energy	Inventory List of Issues in the NRE Draft Law a. Arrangement of the energy transition and roadmap. Energy transition and roadmap are adjusted to the order of substances, starting from the energy mix target referring to the National Energy Policy, roadmap in the energy transition both in the medium term and long term, as well as implementation of the energy transition. b. The government agrees on the definition related to energy, renewable energy, and energy sources, renewable energy sources, and non-renewable energy sources.	Comprehensive regulations to create a sustainable and just NRE development environment, alongside achieving nationally determined contribution and net-zero emissions targets, and supporting the development of the green industry and national economic growth

Risk & Opportunity	Current Condition	Potential Impact
	c. The government agrees on the establishment of Majelis Tenaga Nuklir (MTN) and proposes MTN's authority related to the assessment of monitoring and evaluation implementation policy, as well as the formulation of policy recommendations. d. The government proposes NRE business licensing, including risk-based nuclear as a legality given to the business actors to run NRE business. Therefore, it is expected to give legal certainty, increased investments, increased Domestic Component Level, NRE acceleration, and as the legal framework in guiding and monitoring NRE business activities.	
3. Revision of Law on Oil and Natural Gas	Revision concept of Law on Oil and Gas a. Control and commercialize the upstream sector, one of which is by establishing the Oil and Gas Special Executive Agency (BUK) as the holder of all mining authority through upstream business licensing. b. License simplification, by automatizing the approval for spatial utilization according to the working area determined by the Minister and facilitating the licensing settlement to the upstream oil and gas by the oil and gas Special Executive Agency. c. Business certainty and easiness, by restoring the principles of assume and discharge and applying country basis scheme to calculate income tax. d. Decarbonization efforts through CCS/CCUS policy in the upstream oil and gas sector. e. Oil and gas fund earmarked to improve and develop oil and gas business activities, originating from the state revenue. f. Control and commercialization of the downstream sector in ensuring the availability, smooth distribution, and affordability of natural gas, fuel oil, and gas fuel.	It is expected to improve the oil and gas investment climate.

<table>
<tr><th>Risk & Opportunity</th><th>Current Condition</th><th>Potential Impact</th></tr>
<tr>
<td>4. National Energy Policy Revision</td>
<td>Revision concept of Government’s Law Number 79 of 2014 on National Energy Policy
a. National Energy Policy is implemented until 2060
b. Adjustment of the national energy policy targets from initially achieving an optimal primary energy mix with at least 23% of new and renewable energy by 2025 and at least 31% by 2050, as long as it is economically feasible, to 25% by 2030 and 62%-63% by 2060
c. National energy policy targets:
<table>
<tr><th>Target</th><th>Unit</th><th>2030</th><th>2040</th><th>2050</th><th>2060</th></tr>
<tr><td>Final Energy Provision</td><td>Million TOE</td><td>261-263</td><td>3-46-393</td><td>415-470</td><td>445-495</td></tr>
<tr><td>Final Energy Provision per sector:</td><td rowspan="5">Million TOE</td><td></td><td></td><td></td><td></td></tr>
<tr><td>a. Industry</td><td>116-117</td><td>165-189</td><td>214-239</td><td>241-272</td></tr>
<tr><td>b. Transportation</td><td>101</td><td>134-142</td><td>155-172</td><td>158-169</td></tr>
<tr><td>c. Commercial</td><td>10</td><td>11-15</td><td>12-16</td><td>13-17</td></tr>
<tr><td>d. Household</td><td>34-35</td><td>36-46</td><td>35-43</td><td>34-40</td></tr>
<tr><td>Final Energy Provision per Energy type:</td><td rowspan="6">Million TOE</td><td></td><td></td><td></td><td></td></tr>
<tr><td>a. Fuel oil</td><td>90</td><td>84-89</td><td>56-63</td><td>42-44</td></tr>
<tr><td>b. Gas</td><td>32</td><td>41-56</td><td>43-54</td><td>44-49</td></tr>
<tr><td>c. EBT</td><td>48</td><td>60-68</td><td>71-79</td><td>84-92</td></tr>
<tr><td>d. Coal</td><td>56,4</td><td>76,8-87,8</td><td>117,8-136,8</td><td>118,3-124,3</td></tr>
<tr><td>e. Electricity</td><td>35-37</td><td>76-100</td><td>115-145</td><td>157-187</td></tr>
<tr><td>Final Energy Utilization per capita</td><td>TOE</td><td>0.9</td><td>1.1-1.3</td><td>1.3-1.4</td><td>1.4-1.5</td></tr>
<tr><td>Power Energy need</td><td>TWh</td><td>404-428</td><td>889-1,160</td><td>1,338-1,690</td><td>1,830-2,173</td></tr>
<tr><td>Power Energy Consumption per capita</td><td>KWh</td><td>1,373-1,455</td><td>2,844-3,712</td><td>4,132-5,216</td><td>5,539-6,577</td></tr>
<tr><td>Primary Energy Provision</td><td>Million TOE</td><td>350-359</td><td>509-610</td><td>657-820</td><td>851-930</td></tr>
<tr><td>EBT Mix in Primary Energy</td><td>%</td><td>25</td><td>37</td><td>53</td><td>62-63</td></tr>
<tr><td>Primary Energy Provision per capita</td><td>TOE</td><td>1.2</td><td>1.6-2.0</td><td>2.1-2.5</td><td>2.6-2.8</td></tr>
<tr><td>Primary Energy Intensity</td><td>TOE/ million USD</td><td>189-190</td><td>1.6-2.0</td><td>2.1-2.5</td><td>2.6-2.8</td></tr>
</table>
</td>
<td>Providing the national energy policy direction that is aligned with:
a. The actual developments in energy consumption and supply, including the primary energy mix.
b. Changes in the strategic environment, both nationally and globally, including the target for economic growth to become a developed country by 2045 and the energy sector's contribution to fulfilling the national commitment to achieving net-zero emissions by 2060</td>
</tr>
<tr>
<td>5. Draft of Presidential Regulation on Energy Buffer Reserves (CPE)</td>
<td>Concept of Presidential Regulation on CPE
a. CPE type, amount, time, and location
• CPE type is prioritized for the energy imported by Indonesia
• CPE amount is aligned with the number of days of import
• CPE time is adapted to the state’s financial condition
• CPE location meets the technical and eligibility requirements</td>
<td>To ensure national energy security</td>
</tr>
</table>

Risk & Opportunity	Current Condition	Potential Impact
	b. Management of CPE by the government and may include SOEs, Business Enterprises, and/or Permanent Establishment c. Utilization of CPE is conducted at the time of energy crisis and/or energy emergency d. CPE funding originates from the State Budget and other legitimate sources e. CPE Guidance and Monitoring by the government	
6. Carbon Pricing	Financial Services Authority Regulation Number 14 of 2023 on Carbon Trading through Carbon Exchange: a. Carbon Units traded through the Carbon Exchange are Securities and must first be registered in the National Registry System for Climate Change Management and Carbon Exchange Operators. b. The party that is qualified to engage in business operations as a Carbon Exchange is a market operator who already possesses a business license as a Carbon Exchange Operator from the Financial Services Authority.	The availability of a legal framework in supporting the government to carry out climate change control programs through greenhouse gas emission reduction, as stated in the Paris Agreement's commitment.
Power Energy Sector		
Just Energy Transition Partnership (JETP)	a. JETP is an energy transition funding commitment of USD 20 billion or around Rp 310 trillion initiated by the G20 Summit in Bali, in November 2022. b. The funding commitment originates from G7+ countries and several renowned international banks within the Glasgow Financial Alliance for Net Zero (GFANZ). c. CIPP (Comprehensive Investment and Policy Plan) JETP will include a technical roadmap within the emission reduction in the power sector, as well as serve as the framework for a fair energy transition.	JETP Target: a. Greenhouse gas emissions are reduced to 290 Mt CO2 and reach a renewable energy mix of 34% by 2030. b. Carbon neutrality by 2050. c. Strategy through early retirement of PLTU before 2030.

Risk & Opportunity	Current Condition	Potential Impact
Transportation Sector		
Bioethanol	Through Presidential Regulation Number 40 of 2023 on the Acceleration of National Sugar Self-Sufficiency and the Use of Bioethanol as Biofuel, a roadmap was drawn up as follows: a. Increased sugarcane productivity by 93 tons per hectare through agriculture practices improvement in the form of seedling, planting, crop husbandry, and logging, loading, and transport b. New additional sugarcane plantation area of 700,000 hectares originating from plantation area, people's sugarcane plantation, and forest area c. Improved efficiency, utilization, and capacity of sugar plants to achieve a yield of 11.2% d. Sugarcane farmers' improved welfare e. Increased bioethanol production of at least 1,200,000 KL sourced from sugarcane crops	The achievement of national sugar self-sufficiency to ensure national food security, the availability of raw material, and industrial supporting material, to promote the improvement of sugarcane farmers' welfare, as well as to realize energy security and the implementation of clean energy through biofuel utilization
Household and Commercial Sector		
Effective 3 kg LPG Distribution Program	a. As of March 1, 2023, the government through Pertamina has registered or collected the data of 3 kg LPG users in the sub-distributors into a website-based system as the early stage of the effective 3 kg LPG distribution program. b. Starting from January 1, 2024, only registered users are allowed to purchase 3 kg LPG. There is no limitation to the purchase of 3 kg LPG in this registry. c. The buyers in the sub-distributors only need to bring an Identity Card and/or family register, and if registered in the system, only an Identity Card is required to bring for the following purchases. An additional self-picture in the business place is specifically required for micro business actors.	Promoting effective subsidy transformation for 3 kg LPG so that LPG subsidy is received by those who are in need

Risk & Opportunity	Current Condition	Potential Impact
Industrial Sector		
Revision of the 2015 - 2035 National Industry Development Master Plan (*Rencana Induk Pembangunan Industri Nasional/ RIPIN*)	Concept of 2015 - 2035 RIPIN revision Targets within the 2015 - 2035 RIPIN covers, specifically for the year 2025: a. The growth of the non-oil and gas processing industry sector is targeted at 6.4 percent, downfrom initially 9.1 percent b. The contribution of the non-oil and gas processing industry to the GDP is targeted to be 19.2 percent (or achieve 20 percent), down from initially 27.4 percent c. The contribution of the export of non-oil and gas processing industry is targeted to reach 78 percent, up from initially 73.5 percent d. The number of workers in the non-oil and gas processing industry is targeted to be 22.6 million people, up from initially 21.7 million people e. Imports of raw materials for the industrial sector as a percentage of the GDP of the non-oil and gas processing industry is targeted at 35 percent, up from initially 23 percent f. The investment value in the non-oil and gas processing industry reaches Rp 882 trillion, down from initially Rp 1,000 trillion	In order for Indonesia to break free from the middle income trap, it needs to improve the performance of the industrial sector as part of economic transformation. The manufacturing sector serves as the key to Indonesia's economy since increased productivity will be followed by people's increased income per capital

IV.1.2 Technology (Research and Development, Cost reduction)

The commitment of several countries in the world to combat ongoing climate change has pushed other countries to set their own Net Zero Emission (NZE) targets by reducing and curbing emissions. One of the key things currently happening aggressively worldwide is the use of renewable energy sources in power generation to replace fossil fuels.

The economics of renewable energy sources continue to compete and most specifically in Western countries, they are cheaper than fossil energy sources. The global levelized cost of energy (LCOE) originating from solar and wind energy today is cheaper than energy sourced from gas or coal. Moreover, the global LCOE for offshore wind is now equal to coal energy, which is US$74/MWh. It is projected that with the increasingly advanced technologies in the future, offshore wind will be more affordable (BNEF, 2023).

In general, renewable energy still struggles to compete with fossil energy sources in terms of their economic viability. Meanwhile, China is currently the country with the best-performing renewable energy economy. For instance, the cost of electricity production from solar energy is at US$39/MWh, onshore wind power at US$34/MWh, and offshore wind power at US$66/MWh (BNEF, 2023).

The increasing competitiveness of the economics of renewable energy sources is integral to several factors, namely the availability of raw materials, local government policies to shift to the use of renewable energy, and geographical location (relating to wind and solar energy sources).

Biofuel is a type of NRE that has the potential for continuous development in Indonesia. Oil and gas companies mainly focus on supplying fuel for transportation have begun to increase their investments in the clean fuel or environmentally friendly fuel sector in recent years.

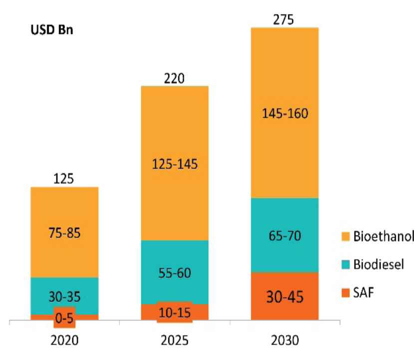


Figure 4. 1 Global Biofuel Market
Source: PEI Analysis (2023)

Biofuels plays a crucial role in decarbonizing the transportation sector, with a growth of roughly

8% per year (globally) until 2030, particularly influenced by bioethanol which reaches approximately 60% of the total demand. Bioethanol growth is projected to be 5% per year until 2030, promoted by the biofuel mandate (specifically in the US and EU).

Today, more than 99% of bioethanol needs come from the the first generation (1G) dominated by hydrolysis/fermentation of corn or sugarcane. The second generation (2G) or more known as advanced biofuels is still in the development stage. The 2G type requires higher cost than the 1G type but can produce lower emissions and is more sustainable. The 2G bioethanol is predicted to grow significantly in the next 5 years, along with the prevailing technological developments. The following is a comparison of mandates and regulations regarding the use of bioethanol in several countries.

Table 4. 2 Comparison of Ethanol Blending Mandates in Several Countries
Source: modified from various sources

				
Prohibiting pure gasoline sale (must be with ethanol blend) Ethanol is set to be at the volume of 18-27%, adjusted every year through coordination with relevant industries	10% of the biofuel blending mandate for gasoline Many states own additional mandate or additional incentive to increase the use of biofuel	At least 14% of fuel has utilized renewable energy sources by 2030 in all member countries. No uniform mandate imposed to EU-28, mandate is handed to each member country.	The addition of 10% of ethanol blending to gasoline was obligated in 2017 and in 2020, a regulation was issued that raw materials for producing ethanol originate from corn and cassava.	Regulation of the Minister of Energy and Mineral Resources No. 12 of 2015 Mandate of biodiesel, bioethanol, and biofuel blending to fuel oil Presidential Regulation No. 40 of 2023 on the Acceleration of National Sugar Self-Sufficiency and the Use of Bioethanol as Biofuel

Indonesia also faces challenges in adopting bioethanol in the transportation sector due to the limited availability of raw materials. In this case, a collaboration between the government and business is critical to increase bioethanol adoption in the national fuel mix. The government needs to create a roadmap for bioethanol development by increasing the availability of feedstock from bioethanol-producing crops and providing incentives for the development of 1G and 2G, while also encouraging automobile manufacturers in Indonesia to incorporate ethanol blends into the technical specifications of the engines they develop.

For business actors, cross-sector collaboration is necessary to open the bioethanol market. SOEs could lead in this development, e.g. Pertamina and PTPN can collaborate on feedstock supply and bioethanol processing. Indonesia also needs to establish partnerships with global investors to to accelerate capacity development and increased investment in 2G bioethanol technology, as well as the development of supporting infrastructure.

The following are three benefits of utilizing bioethanol as a transportation fuel:

1. Strengthening energy resilience
   a. Producing bioethanol domestically (using domestic raw materials) could reduce fuel imports
   b. Higher yield potential for refineries (by producing lower octane fuel, as well as high octane bioethanol)
2. Adding economic value to the agricultural sector
   a. Increasing the demand for feedstock from food crops (e.g. corn, sugar, cassava)
   b. Potential synergy with other food sectors (e.g. utilization of waste, such as bagasse, as a raw material, utilization of corn waste as a cattle feed).
3. Improving the quality of fuel
   a. Higher octane level, improving engine performance and efficiency.
   b. Producing lower emissions compared to fossil-based fuels.

IV.1.3 Market Preferences

PEO 2023 focuses on the shareholders' preferences toward ESG issues in the fossil energy sector, which contain roles of banks and investors in tackling climate change, the shift from *growth investor* to *value investor,* capital flows to fossil energy companies, a big company's decision to change strategies.

a. Roles of Banks and Investors in Tackling Climate Change

   Some of the largest banks have set the target to reduce the funding in fossil fuel sectors and increase the one for renewable energy. For example, HSBC has announced that they no longer funded new oil and gas fields along with the global trend toward net-zero clean emissions by 2050. However, those banks will continue to fund the existing fields. ING Groep NV has also ceased funding on new oil and gas projects as encouraged by the International Energy Agency (IEA). Aside from that, the investors who managed assets of more than US$1.5 trillion have also given warning to the European banks, including Barclays, BNP Paribas, Credit Agricole, Deutsche Bank, and Societe Generale (Reuters, 2023).

Institutional investors have key roles in promoting changes to oil and gas companies. However, institutional investors and companies have different preferences regarding technology that should be prioritized. Based on a study by Deloitte as cited by Valle (2023), institutional investors in the oil and gas sector are willing to receive lower dividends and less buyback to allocate more funds to energy transition projects. Oil and gas companies have distributed a substantial amount to shareholders, with a total sum of dividends and buyback of 8% in 2022, led by Majors, such as Exxon Mobil, Chevron, BP, Equinor, Shell, and TotalEnergies. However, it drew criticism since it was not accompanied by more investments in energy transition. Investors with equity of $2.3 trillion in the global oil and gas industry changed their expectations by promoting lower carbon technology with lower return, which is 3%. Furthermore, 75% of them were willing to continue holding their shares for this purpose.

Unlike this type of investor, 60% of the surveyed executives indicated that they will only make investments in low-carbon projects if the internal return rate exceeds 12% up to 15%. Additionally, there is a study by PWC (2019) that also discussed value investors who wish for dividends of at least 5%.

Also, regarding the different preferences in expenditures, executives concentrate on hydrogen and CCS technologies, meanwhile, investors prefer “more transformative technology”, such as transportation electrification, power charging stations, and battery storage.

2. The shift from *Growth Investor to Value Investor*

A study by PWC (2019) discovered that oil and gas companies were facing difficulties in attracting investors. Oil prices continued to fluctuate and the energy landscape kept on changing. The stock performance in this sector for the last five years has consistently fallen behind the S&P 500. Those who used to invest in oil and gas, e.g. growth investors, no longer found this industry attractive. Meanwhile, the investors who were more focused on environmental, social, and governance (ESG) aspects were never drawn to oil and gas as their focal point lies in carbon reduction and other related issues. This means the only one left is the value investor. Value investors are the ones with the highest concern about stable and risk-free dividend rates. Pension funds, foundation funds, sovereign wealth funds, insurance funds, and others, are aimed to maintain the value of their funds and tackle inflation. Value investors tend to look for minimum volatility and a stable return rate. What companies could do is ensure revenues through free cash flow (FCF), return on capital employed (ROCE), and maintained dividends, even amid low oil prices.

This shift is seen not only in oil and gas companies but also in coal companies. For instance, in the United States, Kuykendall (2022) cited several perspectives of individual investors who bought sectors they dislike, which refers to coal in the energy sector. The stock price of Alpha Metallurgical Resources Inc., the largest coal producer in the United States, soared by 986.2% year on year on April 27, 2022. And so did nine coal mining companies analyzed by S&P Global Commodity Insights, where all of their stock prices increased during that year with several times equity multipliers.

Individual investors in the United States contributed 10% to coal company ownership. These investors seek "value", as seen from some investors who switched from technology companies to commodities. The substantial free cash flow and limited capital expenditure are what draw investors in.

3. Capital Flow to Fossil Energy Companies

The Economist (2022) revealed that despite several fossil energy companies selling fossil fuel assets of US$44 billion since 2018 due to the pressures exerted by multiple parties, active private equity companies acquire oil, gas, and coal assets beyond their investment in renewable energy. As well as private infrastructure funds that acquire midstream assets, like gas pipes which is considered safe and profitable. In addition, SOEs and sovereign funds are also included even in ways that are not apparent.

Regarding investments by several companies, Ross (2023) argued that asset owners and managers need to reject pressure for divestments without prior engagement. The fund owners and managers must voice out more opinions related to climate resolution, and more actively ask the companies to take responsibility for their actions that affect climate, because engagement is more effective than divestment in making real changes to tackle climate issues. This idea is also backed by a study by Stanford Graduate School of Business which shows that divestment has limited impacts on the capital costs of fossil energy companies.

Some efforts required to increase engagement are increasing transparency in the voting track record of institutional investors in climate resolution. The Financial services authority is currently considering how to facilitate the asset owners to be aware of what efforts their asset managers make while managing the assets.

4. Change in Oil and Gas Company Strategy and Its Impacts on the Stock Price

BP announced its updated strategy on February 7, 2023, to be more focused on oil and gas production than renewable energy and carbon reduction as they mentioned before. They plan to increase oil and gas production to 2 million barrels of oil equivalent per day by 2030, rising from the prior target of 1.5 million, although still 25% lower than in 2019. They will invest more in the oil and gas sector, driven by a more positive view toward prices. The carbon reduction target has been adjusted, with a 20-30% decline in the Scope 3 emissions by 2030, compared to the prior target of 35-40%. However, they still aim to reduce half of the scope 1 & 2 emissions by 2030 and achieve zero emissions for all scopes by 2050.

BP will invest US$10 billion less in renewable energy by 2030 but still plans to develop a clean capacity of 50 GW by emphasizing the integration of green hydrogen, low-carbon fuels, electric vehicle charging, and power trading. They will also allocate more capital for convenience store business, electric vehicle charging, bioenergy, and hydrogen.

This change in strategy raised questions about BP's consistency and credibility. However, it seems to receive support from investors because BP's shares have increased since the change occurred. This finding aligns with a study by Deloitte as mentioned before, where transportation electrification is one of the investors' preferences.

IV.1.4 Energy Sector Reputation

It is argued that the upstream oil and gas industry has shown its resilience with a robust recovery from the Covid-19 pandemic. However, there remains a huge challenge ahead for the oil and gas business actors, namely to prove their sustainability and ability to fulfill energy demand along with economic recovery and production activities. Further driven by the global energy transition trend occurring in many countries throughout the world, it is certain that demands for oil and gas products will be suppressed in the future. Considering the dynamics of oil prices throughout 2023, it is evident that the world's oil price remains above the average of USD 70/barrel.

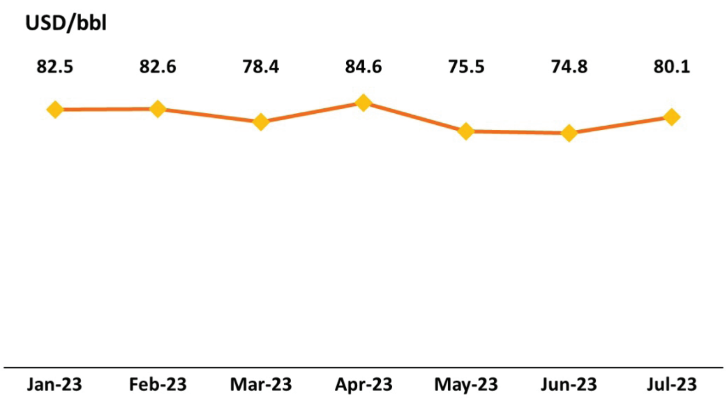


Figure 4.2 Dated Brent Prices in 2023
Source: statista.com (2023)

Currently, the world's oil and gas companies are also demanded to become one of the driving wheels in promoting the acceleration of the global energy transition. Oil and gas companies in Europe, such as Total, ENI, and BP have added renewable energy investments to their business portfolio. There are several driving factors for the world's oil and gas companies to engage in the energy transition, as follows:

a. Decarbonization Pressure: Reducing operational emissions, developing CCS/CCUS, and promoting the use of low-carbon fuels.
b. Diversification in energy business: Investing in NRE to support a sustainable business portfolio in the future.

It is evident that the world's oil and gas companies' investments are projected to become increasingly diversified with the decline of investments in the upstream sectors and are replaced by the increase in renewable or low-carbon energy investments, aiming to build a sustainable company business portfolio.

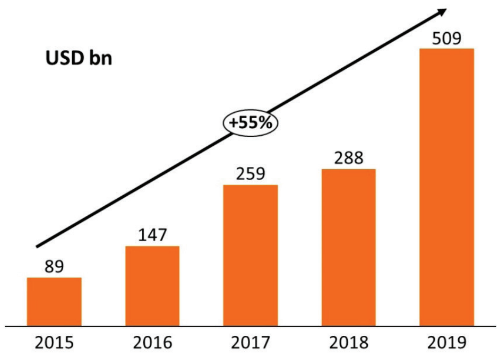


Figure 4.3 Global Invesment in Sustainability Project
Source: PEI Analysis (2022)

The amount of investment in the renewable or low-carbon energy sector in oil and gas companies today is dominated by European oil and gas companies, with four large companies, i.e. Shell, BP, TotalEnergies, and ENI having investment portion in the low-carbon sector of more than 15% of the company's total capital expenditure.

IV.1.5 Benchmark of Energy Transition at IOC-NOC

According to McKinsey's Global Energy Perspective (2022), fossil fuels such as oil and natural gas will remain to be a significant part of the global energy mix in 2050. Supply accessibility and security factors are not easy to be completely replaced with renewable energy.

However, along with the low-carbon business that increasingly grows to be economically competitive, investments in the low-carbon energy sector have risen significantly in the last few years.

In 2022, the total investment for the M&A of the low-carbon project has significantly exceeded the total investment for the upstream M&A projects. The investment value of the M&A is not only limited to the oil and gas companies but constitutes the total M&A investment in the companies all around the world. The relatively high oil price throughout 2022 also contributed to encouraging the M&A investment in the low-carbon sector.

Energy transition creates a wide range of new opportunities for oil and gas companies. In their research on energy transition, Rystad Energy mentioned three pillars of energy transition that will hold strategic roles in the upstream oil and gas industry, namely: Energy Diversification, Portfolio Resilience, and Decarbonization.

Energy diversification covers investment diversification in the new energy market, non-exploration and production sectors, and renewable energy. In terms of Portfolio Resilience, gas serves as a vital contributor to energy transition as elaborated in previous chapters. Lastly, as for decarbonization, more emphasis is put upon the emission reduction in the oil and gas companies' operational activities, such as:

- Efficiency of energy intensity, e.g. improving furnace efficiency or optimizing steam and utility.
- Nonroutine emissions, e.g. flare gas recovery, and zero routine flarings.
- Low-carbon power plant utilization, such as utilizing utility-scale solar PV in the Company's operational area.
- Low carbon heat, e.g. replacing liquid combustion with natural gas.

The above points could assist oil and gas companies in reducing emissions from their daily operational activities and will surely encourage the achievement of the companies' NZE target in the future.

European oil and gas companies are taking aggressive actions in developing low-carbon business. For instance, in a report issued by BloombergNEF (2023), TotalEnergies, Shell, and Equinor currently already have installed renewable energy capacity of more than 5 GW. Meanwhile, for transportation sectors, Shell, TotalEnergies, and BP are actively developing the EV ecosystems with each company already owning 10,000 EV charging points. This is much more aggressive compared to the penetration of renewable energy capacity by oil companies outside of Europe.

IV.2 Physical Climate Risks and Opportunities

IV.2.1 Outlook on Global Temperature Increase

Climate is defined as a statistical condition (average and variability) of weather parameters (rainfall, temperature, humidity, etc.) in a relatively long period, for example for 30 years. When changes occur to the mean of these climate characteristics, e.g. temperature or rainfall changes, it is safe to say that a climate change has taken place. Meehl et al (2000) stated that climate change occurs when mean and/or climate parameter variance observed in a climate period undergoes a change compared to the previous climate period. Global warming is considered the key factor of climate change and has impacts on various life and development sectors. Essentially, global warming is a phenomenon of increasing temperature from year to year due to the effects of greenhouse gas (GHG), resulting from increased GHG emissions, such as carbon dioxide (CO2), methane (CH4), nitrogen oxide (N2O), and chlorofluorocarbon (CFC) on the earth's atmosphere.

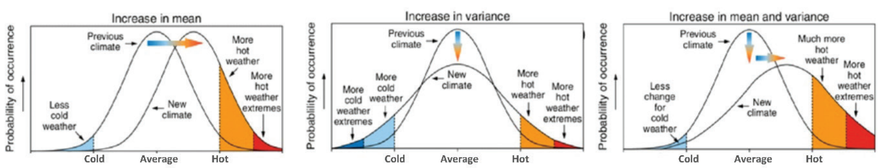


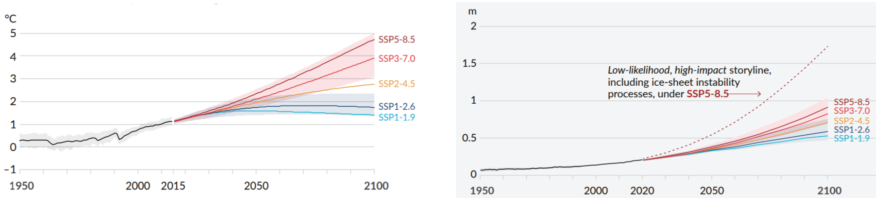
Figure 4. 4 Climate Change in the Form of (A) Average Change; (B) Variance Change; and (C) Average and Variance Change
Source: Hadi (2023)

Based on the sixth Intergovernmental for Climate Change Assessment Report (IPCC-AR6) in 2021, the temperature increase in the atmosphere, sea, and land was caused by human influence. A comparison of average reconstructions per decade of global surface temperature over the last 2,000 years with the temperature observation result for the last 200 years showed an unprecedented massive temperature increase. The global temperature has risen more rapidly since the 1970s than in other periods of 50 years over at least the last 2,000 years, with the temperature in this decade (2011 until 2020) exceeding the warm period of the last multi-century around 6,500 years ago (0.2°C s.d. 1°C relative to 1850 until 1900). Based on all emission scenarios, the global temperature is projected to continue to rise at least until the next half-century.

Global warming of 1,5°C and 2°C will occur and pass in the 21st century, thus efforts to reduce greenhouse gas emissions must be carried out immediately. It is estimated that the average global temperature will rise by 1°C to 1.8°C (according to the very low greenhouse gas emission scenario/ SSP1-1.9), 2,1°C to 3,5°C (according to the intermediate greenhouse gas emission scenario/SSP2-4.5), up to 3.3°C to 5.7°C (according to the very high greenhouse gas emission scenario/SSP5-8.5) by 2081 until 2100 compared to in 1850 until 1900.

(a) Global surface temprature change relative to 1850-1900

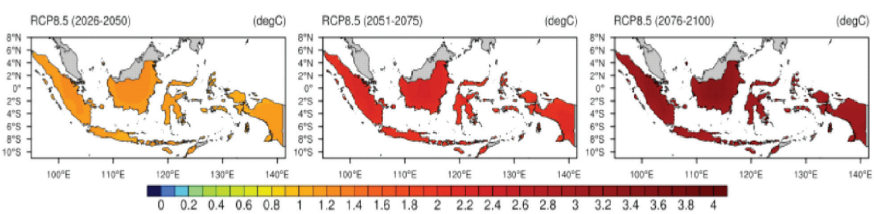
(b) Global mean sea level chage relative to 1900



Keterangan: SPPx-y merujuk pada Shared Socio-economic Pathway tipe x (tren sosial ekonomi yang mendasari skenario) dengan perkiraan level radiative forcing sebesar y W/m2 akibat skenario pada tahun 2100.

Figure 4. 5 Global Temperature and Sea Level Increase from 1950-2100 Based on 5 Scenarios
Source: AR6 IPCC, 2021

In Indonesia, climate change can be analyzed through the following overview of temperature and mean annual rainfall pattern based on the RCP8.5 ensemble global climate model projection (SSP5-8.5) as follows.



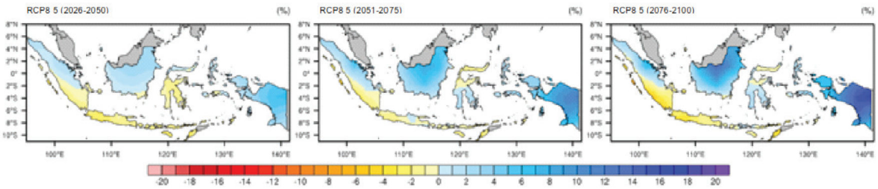


Figure 4. 6 Change (in %) in a) average annual temperature and b) average annual rainfall (calculated from ensemble of 24 Global Climate Models - CMIPS GCMs for RCP 8.5 climate scenario with 3 separate projection periods). These changes are relative to the baseline observation conditions (1981-2005 period) using CHIRPS v2.0 dataset

Source: 3rd National Communication Indonesia under UNFCCC (2017)

Special Report on the Ocean and Cryosphere by IPCC (2019) supported the research findings of Wester et al (2019) in the Hindu Kush Himalaya region, that the global warming rate in the high mountain regions is faster than the mean global rate. The phenomenon is referred to as elevation-dependent warming where the increase in temperature in the high mountain regions occurs more rapidly than in lower lands. This phenomenon also occurs in Indonesia as shown through a regional climate model with a 5-kilometer spatial resolution from BMKG-JICA, for example in the Bukit Barisan region in Sumatra Island and Jayawijaya region in Papua Island. The physical process of this phenomenon is identified to be relatively similar to the warming process in the polar regions where the sensitivity of temperature to radiative forcing rises at low temperatures common in polar and mountain environments. However, overall, the driving factor of this phenomenon is still being researched further.

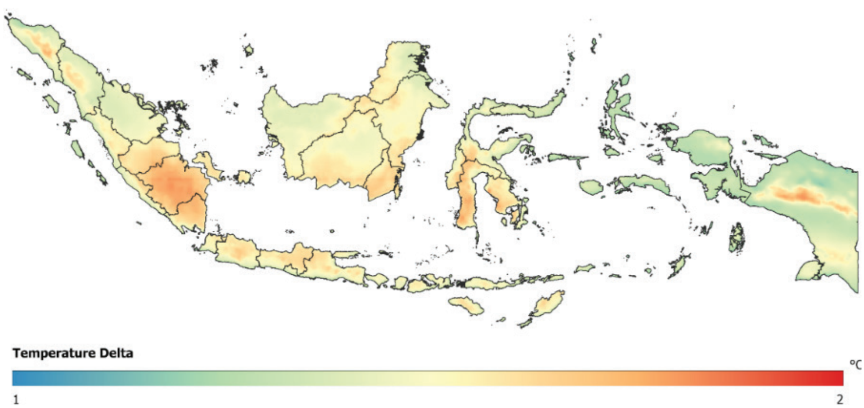


Figure 4. 7 Average Temperature Increase Simulated Using Regional Climate Model of BMKG-JICA Representing Climate Change from Baseline Conditions (1980-2001) towards Future Projected Conditions (2034-2024)

Source: IPCC (2019)

IV.2.2 Extreme Weather and Its Impact on the Energy Sector

Components of climate change affecting human activities consist of two categories: climate drivers and climate hazards. Climate drivers are factors that contribute to the change in a climate system, both natural and anthropogenic factors. Natural factors cover changes in temperature, intensity, and frequency of rainfall, sea currents, wind speed, and other variables with the potential to cause climate hazards. Climate hazard is a disaster that occurs due to climate change and has direct and indirect impacts on humans and the ecosystem, which might be in the form of short-term extreme weather phenomena, such as floods, coastal floods, landslides, drought, heat waves, and even long-term extreme weather phenomena. This short-term event is known as extreme weather which brings immediate impacts upon the occurrence. Meanwhile, the long-term event is widely known as a slow onset or a gradual change with accumulative impacts that occur in the future over a relatively long period of time.

Table 4. 3 Climate Driver and Climate Hazard
Source: Katopodis (2019)

Climate Driver	Climate Hazard
Extreme weather: strong winds, lightning strikes, storm surges, high tides, heat waves, high rainfall ***Slow onset:*** increased global temperature, changes in the level and pattern of rainfall, changes in humidity level, sea level rise, El Nińo Southern Oscillation	***Extreme weather***: forest and land fire, flood, coastal flood, landslide ***Slow onset***: drought

The national energy sector faces various threats due to climate change, particularly issues related to extreme weather (Table 2). The ability to adapt and mitigate the impacts of climate change will be of high necessity for the continuity of energy sector operations, the ability of the energy sector to realize national energy security, and the capability of the energy sector to reduce vulnerability and risks brought by extreme weather events.

Table 4. 4 Phenomena and Impacts of Extreme Weather
Sumber: Analisis Internal (2023)

Extreme Weather Phenomenon	Category of Disaster	General Impact of Extreme Weather
Wet Hydrometeorological Disaster	Flood, coastal flood, landslide, high tides, ocean storm surge, and tornado	• Vulnerability on the land structure and the construction of operational and production infrastructures, refinery and processing, as well as pipelines for oil and natural gas products due to both erosion/abrasion and continuously being exposed to water. • Vulnerability on tanker fleets due to suffering the impacts of both high tides and storm surges, thus needing to find a safer cruise lane.
Dry Hydrometeorological Disaster	Heatwaves, drought, land degradation, forest and land fire, and water scarcity	• Forest and land fires will result in damage to operational facilities/ infrastructures and oil and natural gas production, including causing human health issues due to smoke and ashes. • Vulnerability to the process of exploration, drilling, and extraction of oil and natural gas which uses a large quantity of water resources.

Extreme Weather Phenomenon	Category of Disaster	General Impact of Extreme Weather
Increased Global Temperature	Sea level rise due to the melting of polar ice caps	• Sea level rise may adversely impact operational and production activities of oil and natural gas around c oastal regions since natural buffer zones may suffer degradation due to seawater intrusion to lands.
ENSO (El Nińo Southern Oscillation)	Climate disruptions (El Nińo as the trigger of dry climate anomaly, and La Nina as the trigger of wet climate anomaly)	• The duration of a longer dry season than the rainy season may cause workers health issues.

IV.2.3 Disasters and Their Impact on the Energy Sector

In tackling climate change, an adaptation strategy is developed to increase system resiliency with the purpose of reducing risks of climate change hazards. Adapting to climate change can be defined as a system's ability to adjust to climate change by reducing damages incurred, reaping benefits, or dealing with the changes and their impacts. However, it is difficult for this effort to effectively give benefits if the climate change rate exceeds the ability to adapt. Therefore, the adaptation strategy must be balanced with the "mitigation strategy", that is by reducing GHG emission sources.

To identify climate change impacts and adaptation actions, categories of disaster in the energy sector are divided based on two types of climates, namely atmospheric and oceanic climate.

In general, as seen in the figure below, there are five categories of disaster in the atmospheric climate affected by two climate drivers, namely extreme rainfall and extreme temperature. Extreme rainfall will contribute to the occurrence of climate hazards in the form of floods, landslides, and droughts. As for the climate drivers of the extreme temperature, climate hazards will be related to forest fires and lightning strikes. Lastly, the climate hazards in the oceanic climate type include strong wind, high tides, and sea level rise.

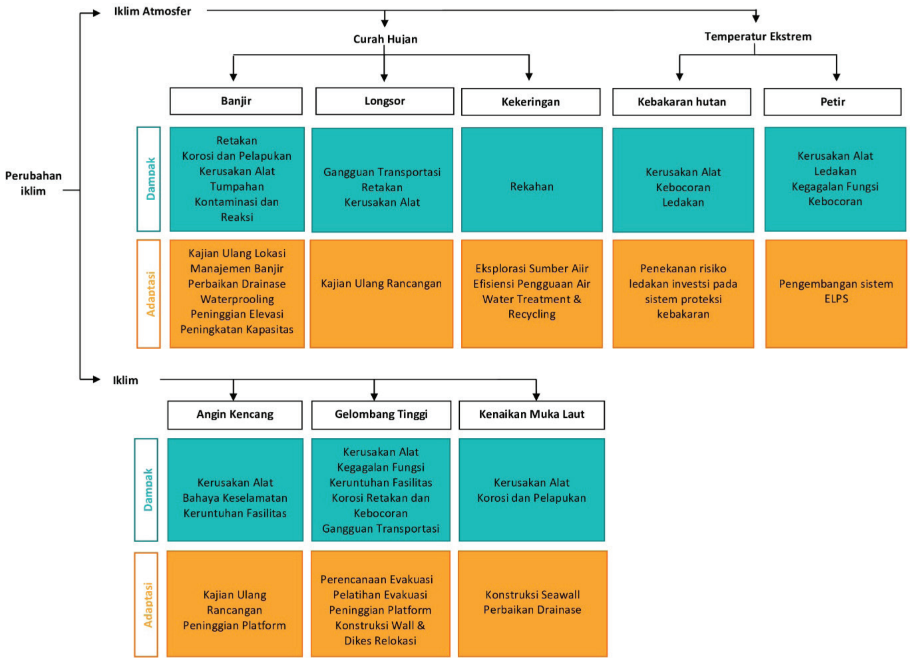


Figure 4. 8 The Example of Specific Impacts and Climate Change Adaptation Efforts in the Energy Sector
Source: Katopodis (2019)

Each climate hazard of both climate types contains a more specific explanation of its impacts on human safety, the environment, and equipment, such as tool malfunction, leakage, corrosion, safety hazards, etc. Effective adaptation actions and preparedness in dealing with climate change which are in line with criteria and types of disaster are highly required by the energy sector to anticipate and minimize potential impacts of climate change today and in the future. In the context of adapting to climate change in the energy sector, several adaptation actions can be taken, including technological and policy adjustment, improved workers' awareness, equipment and spatial design review and anticipatory infrastructure construction.

IV.3 Evaluation of Mitigation and Adaptation Actions

IV.3.1 Outlook on Climate Policy Direction

Based on the IPCC report (2023), it is evident that the concentration of GHG emissions continues to historically experience an increase. Today, climate investment has yet to reach the target required to limit increased temperature in accordance with the Paris Agreement (below 2°C). According to IPCC, with the emission trajectory of the stipulated policy, the temperature increases to 3.2°C, with a range of temperature increases within 2.2-3.5°C (*medium confidence*). This situation leads to a high increase in climate risks. In their report, the IPCC recommends reinforcing climate adaptation, other than because adaptation actions are still far less implemented than mitigation and because of the increased climate risks. The decline in temperature to the limit of 1.5°C and 2°C demands a quick, in-depth, and immediate GHG reduction.

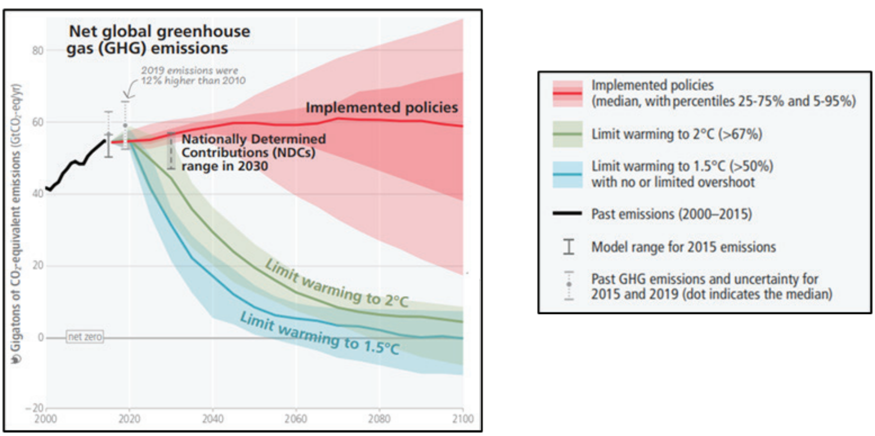


Figure 4. 9 Global GHG Emissions Projections
Source: IPCC (2023)

Based on the data by IEA EDGAR (2023), global GHG emission per capita slightly rose in 2022 and has displayed a significant increase since 1990. The six largest greenhouse gas (GHG) producing countries in 2022 are China, the United States, India, the European Union (EU27), Russia, and Brazil. Among these countries, China, the United States, and India underwent a GHG emission increase in 2022, while the other three countries experienced the opposite. EU27 experienced reduced GHG emissions in 2022, despite recovering in 2021. However, it remained below the number during the pre-COVID-19 pandemic.

Global GHG emissions are mostly resulted from fossil fuel combustion, particularly CO2. While several EU27 countries experienced reduced emissions, the opposite took place in the other countries, with Germany emerging as the largest GHG-producing country among them. Within the EU27, most sectors underwent reduced emissions, except for the transportation and power industry sectors. The building sector recorded the biggest decline, followed by the industry and the processing industry.

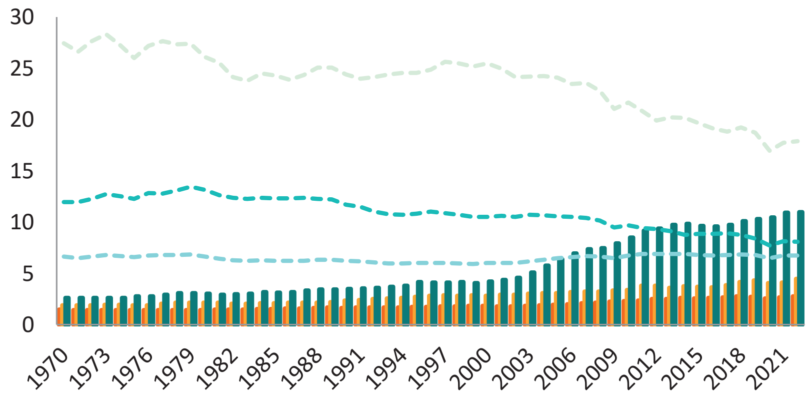


Figure 4. 10 GHG Emmisions per Capita (Mt CO2e/year)
Source: IEA EDGAR (2023)

IV.3.2 Climate Change and Climate Finance

According to the Climate Policy Initiative (2021), climate change funding today is still far behind the mean funding required to achieve 1.5°C, that is around US$ 4.5-5 trillion per year.

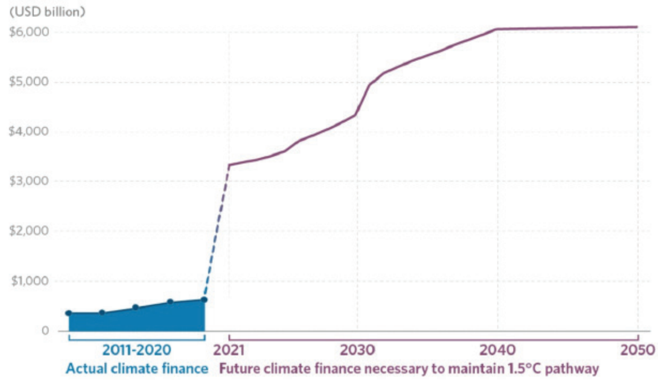


Figure 4. 11 Global Tracked Climate Finance Flows and The Average Estimated Annual Climate Invesment Need Through 2050
Source: Climate Policy Initiative (2021)

According to the Climate Change Association & Finance (2022), from 2019 until 2020, a climate fund of US$632 million was collected successfully, increasing by 10% from the previous two years. Despite an increase of 53% as compared to 2017-2018, funds for adaptation actions in 2019-2020 (with the amount of US$46 billion or 7.3% of the total) are still far from the equity target demanded by the Paris Agreement and from the needs of US$300 billion according to the Climate Policy Initiative by 2030. Therefore, most of the fundings (90%) remained to be used for mitigation, that is about US$571 billion in 2019-2020. International funds collected by the industrial countries for the Global South countries only reached US$83.3 billion in 2020, far below the target of US$100 billion per year set for 2020 during the COP15 in Copenhagen.

Furthermore, as reported by OECD (2022), the climate funding for emerging markets and developing economies (EMDEs) in 2020 only rose by 4% to US$83 billion, not yet achieving the financial support pledge. From the total mentioned, public climate funding (bilateral and multilateral) still dominated with a percentage of 82%. Private funding managed by the public climate funding declined to US$13 billion, while export credit for climate remained low. The funding for mitigation persisted in the majority (58%), despite experiencing a decline of US$ 2.8 billion. The funding for adaptation actions increased by US$ 8.3 billion, reaching 34% owing to several huge infrastructure projects. 72% of the public funding during the period of 2016-2020 constituted loans, 25% grants, while the equity remained limited.

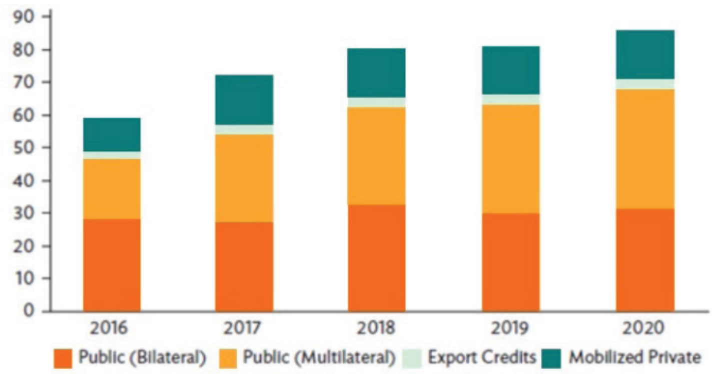


Figure 4. 12 Total Climate Finance Provided and Mobilised (US$ billion)
Source: OECD (2022)

The social and economic impacts of the climate change crises are inevitable as they trigger the frequent occurrence of disasters. As stated by BNPB (2023), the frequency of disasters related to climate at the global level has risen since 1961, particularly in hydrometeorological disasters. Within the first five months of 2023, BNPB recorded 1,675 disaster occurrences, with 99.1% of them originating from wet and dry hydrometeorological disasters. Urbanization and land conversion are identified as the root cause of major wet hydrometeorological disasters. Increased global temperature also impacted on the sea level rise, causing the increased frequency of coastal floods, particularly due to coastal ecosystem damage. In addition to wet hydrometeorological disasters, forest fires also increased, with large burned areas linked with high carbon emissions. Losses due to climate change in Indonesia by 2100 range from 2,5 to 7% of the GDP (WBG and ADB, 2021). Hence, adaptation actions are highly crucial.

Chapter V

CONCLUSION
AND RECOMMENDATION

Indonesia, as a developing country, has a vision to achieve developed nation status by 2045 or even earlier while still meeting its commitment to address climate change. Based on this vision, Indonesia needs to attain high economic growth underpinned by structural transformation, such as an increased contribution from the industrial and service sectors, policy and bureaucratic changes, and a transition from an energy and economic system to a green energy-economic system. This structural transformation requires significant changes across all levels of society, supported by stakeholders, and must be reinforced by strong government policies.

However, the national energy-economic system is a complex one influenced not only by interactions within the system itself but also by external factors. Geopolitical situations and global cooperation, technological breakthroughs, financial assistance from developed nations for energy transitions, and public preferences can change the landscape of Indonesia's energy-economic transformation in the future. Additionally, during this long-term structural transformation that Indonesia is undertaking, it will also face the impacts of climate change, which are already occurring and will worsen if global mitigation efforts proceed slowly.

Therefore, PEO 2023 recommends the following:

1. Stress Testing of the Long-Term Plan Against Different Future Scenarios.

   The complexity of the energy-economic system and the unpredictable nature of future developments can pose risks and challenges to planning. PEO 2023 provides three combinations of energy-economic scenarios and climate change scenarios that can be used to stress test long-term planning against different future possibilities. While the range of possible future outcomes is vast, the scenarios presented in PEO 2023 are only there out of many future scenarios that have been carefully crafted to explore challenging possibilities, in line with scenario development theory, so they can be used to stress test long-term planning.

   The goal of scenario analysis is to challenge mental models and biases in long-term planning. Additionally, factors that need evaluation, such as policy changes, shifts in market preferences, technological developments and breakthroughs, reputation pressures, and climate change impacts, have also been discussed in PEO

2023 to provide insights into factors that could pose risks or opportunities in the future.

2. Climate Adaptation Planning.

   Based on the latest report from the IPCC that has considered mitigation commitments and actions, global climate change is trending toward RCP 8.5. In the RCP 8.5 scenario, the world will face temperature increases of 3.2°-5.4°C by the year 2100. PEO 2023 Subsection IV.2.1 provides an overview of the situation in Indonesia if climate change trends towards the RCP 8.5 scenario. Based on this situation, climate adaptation actions need to be prepared by various stakeholders, especially in critical sectors that impact people's livelihoods and are affected by climate change. Examples of such sectors include the energy and food sectors.

   To illustrate this, in the Economic Renaissance (ER) scenario, the need for food, electricity consumption, and national intermittent power generation will significantly increase. In this context, the physical risks of climate change will increase the vulnerability of food and energy systems, necessitating adaptation measures. Furthermore, the regional conditions of physical climate change risks will vary, so it is essential to examine a regional risk map in Indonesia for proper adaptation planning.

   Specifically in the energy sector, adaptation actions need to be strengthened for energy production facilities and supply networks, the improvement and retrofitting of facilities/assets to withstand extreme weather, relocation considering vulnerability to extreme weather, and energy supply chain management to withstand extreme weather disruptions (e.g., enhancing source variability, decentralization, redundancy usage).

3. Strengthening the Resilience and Financing of National Energy Transition

   Geopolitical situations have increased awareness in many countries to safeguard national energy resilience. This is evident in the implementation of policies for reshoring energy supply chains and energy self-sufficiency in several countries, such as the Inflation Reduction Act (IRA) in the United States, RePowerEU and Fit for 55 in the European Union, or energy self-sufficiency policies in the United Kingdom. The focus of these countries, especially advanced nations, on their domestic energy supplies will pose challenges for energy provision and financing the energy transition in Indonesia. In the future, with the growing demand for green energy from various stakeholders, the challenges of energy transition financing will become even more significant. Therefore, Indonesia needs to strengthen its domestic competitive advantage and prioritize the sourcing of energy resources from within the country.

4. Emerging Technologies Development Planning

The primary key to the energy system transformation that supports economy is the technological mastery. Conventional technologies currently have high emission intensities, while green technologies still require further development to reduce costs or enhance their economic viability. To master cleaner energy and support economic growth, Indonesia needs to master the technology. Hence, green technology that will be utilized has a larger multiplier and is not limited to being implemented only in Indonesia.

It is crucial to improve technological, patent, and knowledge mastery in Indonesia, by paying attention to the emerging technologies required in the energy system transformation, including its major obstacles. For example, the issue of carbon capture and storage (CCS) technology is with the capture technology, which constitutes around 80% of the total CCS cost. Solving this problem can improve economic viability and promote the development of CCS technology, which has the potential to reduce emissions in power generation or hard-to-abate sectors in Indonesia. Another example is the utilization of ocean-related energy, such as ocean tidal or waves, in which Indonesia, as an archipelagic nation, has significant potential in maritime areas.

5. Development of a Holistic and Integrated Energy Transition Roadmap.

Some countries, such as China and the US, have holistic energy transition roadmaps. For example, in the US's energy transition roadmap, hydrogen will be integrated into the energy system to support the economy. To achieve this, the US has prepared a roadmap, regulations, and policies to reduce the cost of hydrogen by $10 per kilogram within ten years. Indonesia also needs a roadmap like this to map out all the potential, risks, and opportunities in the future energy transition, enabling the allocation of resources and support necessary to achieve the target of a green energy-economic transformation. To date, there is still no holistic and integrated roadmap for the energy-economic transformation.

While various national energy outlooks and development directions describe energy mixes and technologies for green energy systems, there is still no clarity on the steps the government will take to achieve the energy transition, including who will execute and oversee these steps.

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The Pertamina Energy Outlook 2023 study focuses on the national energy demand projection, using specific assumptions and scenarios in modelling national energy demand until 2060. Historical data used is sourced from official publications of relevant institutions. The development of assumptions and scenarios in the Pertamina Energy Outlook 2023 is conducted by the Pertamina Energy Institute (PEI) using scenario planning methods, which involve:

1. Focused Group Discussions (FGD) with various stakeholders, including:

a. Government Ministries: National Development Planning Agency (Bappenas), Ministry of Energy and Mineral Resources, Ministry of Industry, Ministry of Finance, Ministry of Manpower, and Ministry of Environment and Forestry;

b. Government Institutions: National Energy Council, National Research and Innovation Agency, Meteorological, Climatological, and Geophysical Agency, and Educational Fund Management Institution;

c. Banking Sector: Bank Mandiri and Bank BCA;

d. Academic Institutions: Universitas Gadjah Mada, Universitas Indonesia, Bandung Institute of Technology, and Padjajaran University..

2. Discussion with the representatives from the Pertamina Group holding/ subholding.

3. Macroeconomic surveys by various experts and international market intelligence references.
4. Quantitative modeling using Low Emission Analysis Platform (LEAP).
5. Discussion with Advisors

Quantitative scenario modeling within this study uses Low Emission Analysis Platform (LEAP) software, the same software used by ministries/institutions in the energy sector in Indonesia for national energy demand planning. The data processed in the modelling of PEO 2023 is up to the period of May 2023.

Detailed modeling results from 2023 PEO, as described in this chapter, can be obtained, along with suggestions, feedback, or further inquiries related to this study, by sending an email to energy-institute@pertamina.com with the email subject: Enquiry PEO 2023.

REFERENCES

Bisnis.com (2023). Gandeng PLN & PIM, Investor Jerman Mau Bangun Pabrik Hidrogen Hijau di Aceh, retrieved from https://ekonomi.bisnis.com/read/20230828/44/1688954/gandeng-pln-pim-investor-jerman-mau-bangun-pabrik-hidrogen-hijau-di-aceh

BloombergNEF. (2022). 2022 Sustainable Aviation Fuel Outlook. https://about.bnef.com/blog/2022-sustainable-aviation-fuel-outlook/.

Bloomberg NEF (2023). Hydrogen Levelized Cost Update, BNEF, retrieved from https://about.bnef.com/blog/2023-hydrogen-levelized-cost-update-green-beats-gray/

BloombergNEF. (2023). Levelized Cost of Electricity 1H 2023. https://www.bnef.com/flagships/lcoe

BloombergNEF. (2023). Oil & Gas 2023 Transition Scores Analysis.

BNPB. (3 Juni 2023). BNPB. Retrieved from https://www.bnpb.go.id/berita/perubahan-iklim-picu-peningkatan-kejadian-bencana.

Chongkittavorn, Kavi. (2023). "ASEAN Broadens its Geopolitical Profile", *Bangkok Post*.

Climate Change Association & Finance. (2022). *Global Synthesis Report on Climate Finance*. Climate Change Association & Finance.

Climate Policy Initiative. (2021). *Global Landscape of Climate Finance 2021*. Climate Policy Initiative.

CNBC Indonesia (2022). Pertamina NRE Kembangkan Proyek Hidrogen & Amonia Hijau, retrieved from https://www.cnbcindonesia.com/news/20221111151923-4-387145/pertamina-nre-kembangkan-proyek-hidrogen-amonia-hijau

Cohen, Jared, Wilson Shirley, dan Klara Svensson. (2023). *Resource Realism: The Geopolitics of Critical Mineral Supply Chains*. Goldman Sachs.

Councin on Foreign Relations. (2022). *OPEC in a Changing World*.

Crow, Alexis dan Samir Saran. (2021). "The Geopolitics of Energy Transition: A Guide for Policymakers, Executives, and Investors", *ORF Special Report* No. 174.

Dewan Energi Nasional. (2017). Rencana Umum Energi Nasional.

DOE (2023). DOE Announces Nearly $48 Million To Advance Clean Hydrogen Technologies, retrieved from https://www.energy.gov/articles/doe-announces-nearly-48-million-advance-clean-hydrogen-technologies

Donnan, Shawn dan Enda Curran. (2023). *The Global Economy Enters an Era of Upheaval.* Bloomberg.

Draft RPJPN 2025-2045. (n.d.).

Economist Intelligence Unit (n.d.). *Real GDP (LCU).* Retrieved from https://viewpoint.eiu.com/data/results?searchId=3e2e150b-621f-4647-b8f4-57f169f5633e

ERIA (2022). Summary of ERIA Research Project Report 2022 no. 04 (2022). Demand and Supply Potential of Hydrogen Energy in East Asia – Phase 3, retrieved from https://www.eria.org/publications/demand-and-supply-potential-of-hydrogen-energy-in-east-asia-phase-3/

Gaikindo. (2023). Penjualan Mobil Listrik Semester I/2023 Tumbuh 557 Persen. https://otomotif.bisnis.com/read/20230718/46/1676015/penjualan-mobil-listrik-semester-i2023-tumbuh-557-persen.

Glasser, Robert, Anastasia Kapetas, Will Leben, dan Cathy Johnstone. (2022). *The Geopolitics of Climate and Security in the Indo-Pacific.* Australian Strategic Policy Institute.

HB Aditiya, M Aziz. (2021). Prospect of hydrogen energy in Asia-Pacific; A perspective review on techno-socio-economy, retrieved from https://www.sciencedirect.com/science/article/abs/pii/S0360319921032444

Hadi, T.W. (2023). *Modul-2 Pelatihan Integrasi Adaptasi Perubahan Iklim ke Dalam Rencana Tata Ruang, Kajian Bahaya Hidrometeorologis.* Bandung: Pusat Perubahan Iklim ITB.

Hock, R., G. Rasul, C. Adler, B. Cáceres, S. Gruber, Y. Hirabayashi, M. Jackson, A. Kääb, S. Kang, S. Kutuzov, Al. Milner, U. Molau, S. Morin, B. Orlove, dan H. Steltzer. (2019). "High Mountain Areas" dalam *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 131–202. https://doi.org/10.1017/9781009157964.004

Hydrogen Council (2023). Hydrogen Insights 2023, retrieved from, https://hydrogencouncil.com/en/hydrogen-insights-2023/

HyResource (2022). Hydrogen Energy Supply Chain – Pilot Project, retrieved from https://research.csiro.au/hyresource/hydrogen-energy-supply-chain-pilot-project/

International Air Transportat Association. (2022). Net zero 2050: sustainable aviation fuels. https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/

International Energy Agency. (2020). *Energy Technology Perspectives 2020*: Special Report on Carbon Capture Utilisation and Storage. Paris

International Energy Agency. (2021). Renewables 2021 Biofuels. https://www.iea.org/reports/renewables-2021/biofuels?mode=transport&region=World&publication=2021&flow=Consumption&product=Ethanol.

International Energy Agency. (2023). CO2 Emissions in 2022. https://www.iea.org/reports/co2-emissions-in-2022.

IEA EDGAR. (2023). *GHG Emissions of All World Countries: 2023 Report*. EU.

Institute for Essential Services Reform. (2023). Indonesia Electric Vehicle Outlook 2023. https://iesr.or.id/pustaka/indonesia-electric-vehicle-outlook-ievo-2023.

IPCC. (2023). *Summary for Policymakers. In: Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

IRENA (2021). Geopolitics of the Energy Transformation. Technology leadership opportunities in green hydrogen value chains. https://www.irena.org/Digital-Report/Geopolitics-of-the-Energy-Transformation#page-3

IRENA (2021). Green hydrogen policies and technology costs, retrieved from https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Nov/IRENA_Green_Hydrogen_breakthrough_2021.pdf?la=en&hash=40FA5B8AD7AB1666EECBDE30EF458C45EE5A0AA6

Jon Berry, KPMG. (2023). *Geopolitical Implications of the OPEC+ Oil Production Cut.*

Katopodis, T. dan T. Sfetsos. (2019). "A Review of Climate Change Impacts to Oil Sector Critical Services and Suggested Recommendations for Industry Uptake", *Infrastructures* 4, No. 4: 74. *https://doi.org/10.3390/infrastructures4040074*

Kementerian ESDM. (2023). Laporan Kinerja Tahun Anggaran 2022 Direktorat Jenderal Ketenagalistrikan.

Kementerian ESDM. (2020). Penyediaan Infrastruktur Pengisian Listrik dan Tarif Tenaga Listrik untuk Kendaraan Bermotor Listrik Berbasis Baterai. https://gatrik.esdm.go.id/assets/uploads/download_index/files/683a2-bahan-presentasi-pak-hendra-1-.pdf.

Kementerian ESDM. (2020). Rencana Strategis Kementerian ESDM 2020-2024.

Maihold, Günther. (2022). *A New Geopolitics of Supply Chains.* Stiftung Wissenschaft und Politik, German Institute for International and Security Affairs.

Misna, Andriah Feby. (21 Maret 2023). *Potensi Pemanfaatan Nuklir dalam Bauran Energi Nasional.* KESDM.

Kementerian Energi dan Sumber Daya Mineral. (2023). *Capaian Kinerja Sektor ESDM Tahun 2022 & Target Tahun 2023.* Jakarta.

Kementerian Energi dan Sumber Daya Mineral. (2023). *Handbook of Energy & Economic Statistics of Indonesia*. Jakarta.

Kementerian Energi dan Sumber Daya Mineral. (2023). Kementerian ESDM Dukung Pengembangan Hidrogen Hijau, retrieved from https://ebtke.esdm.go.id/post/2023/08/30/3591/kementerian.esdm.dukung.pengembangan.hidrogen.hijau

Kementerian Energi dan Sumber Daya Mineral. (2023). *16 Proyek CCS/CCUS Ditargetkan Beroperasi Sebelum 2030. https://www.esdm.go.id/id/media-center/arsip-berita/16-proyek-ccs-ccus-ditargetkan-beroperasi-sebelum-2030.*

Kementerian Energi dan Sumber Daya Mineral. (2023). *Menteri ESDM Luncurkan Perdagangan Karbon Subsektor Pembangkit Listrik. https://www.esdm.go.id/id/media-center/arsip-berita/menteri-esdm-luncurkan-perdagangan-karbon-subsektor-pembangkit-listrik-.*

Kementerian Energi dan Sumber Daya Mineral. (2023). *Program Bahan Bakar Nabati B35 Siap Implementasi Mulai 1 Februari 2023. https://ebetke.esdm.go.id/post/2023/01/09/3395/program.bahan.bakar.nabati.b35.siap.implementasi.mulai.1.februari.2023.*

Knowledge for Policy (2023). *Shift in the Geopolitical Landscape.*

Kuykendall, T. (4 Mei 2022). *S&P Global Market Intelligence.* Retrieved from S&P Global Market Intelligence: https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/they-ve-absolutely-exploded-coal-investors-win-triple-digit-us-stock-gains-70051407.

McKinsey Energy Insight Global Perspective (2022), retrieved from https://www.mckinsey.com/industries/oil-and-gas/our-insights/global-energy-perspective-2022

Meehl, G.A., F. Zwiers, J. Evans, T. Knutson, L. Mearns, dan P. Whetton. (2000). "Trends in Extreme Weather and Climate Events: Issues Related to Modeling Extremes in Projections of Future Climate Change", *Bulletin of America Meteorology Society*, 81, 427–436, *https://doi.org/10.1175/1520-0477(2000)081<0427:TIEWAC>2.3.CO;2* .

M. Ilyas dan F. Aydogan. "Steam Generator Performance Improvements for Integral Small Modular Reactors", *Nuclear Engineering and Technology*, Vol. 49, hlm. 1669-1679, 2017.

Natalegawa, Marty M. (2022). *Geopolitik dan Perekonomian Indonesia: Dampak dan Respons Kebijakan.* Bank Indonesia Institute.

Neom.com (2023). Neom green hydrogen investment, retrieved from https://www.neom.com/en-us/newsroom/neom-green-hydrogen-investment

Nian, V. (2017). "The Prospects of Small Modular Reactors in

Southeast Asia", *Progress in Nuclear Energy*, Vol. 98, hlm. 131-142.

OECD. (2022). *Climate Finance Provided and Mobilised by Developed Countries in 2016-2020: Insights from Disaggregated Analysis, Climate Finance and the USD 100 Billion Goal*. Paris: OECD Publishing.

Office of Energy Efficiency & Renewable Energy (2022). Financial Incentives for Hydrogen and Fuel Cell Projects, retrieved from https://www.energy.gov/eere/fuelcells/financial-incentives-hydrogen-and-fuel-cell-projects

Peraturan Menteri ESDM. (2020). Penyediaan Infrastruktur Pengisian Listrik Untuk Kendaraan Bermotor Listrik Berbasis Baterai (Peraturan Menteri ESDM Nomor 13 Tahun 2020).

Peraturan Menteri ESDM. (2023). Penyediaan Infrastruktur Pengisian Listrik Untuk Kendaraan Bermotor Listrik Berbasis Baterai (Peraturan Menteri ESDM Nomor 1 Tahun 2023).

Peraturan Presiden Republik Indonesia. (2019). Percepatan Program Kendaraan Bermotor Listrik Berbasis Baterai (Battery Electric Vehicle) untuk Transportasi Jalan (Peraturan Presiden Nomor 55 Tahun 2019).

Peraturan Presiden Republik Indonesia. (2023). Percepatan Swasembada Gula Nasional dan Penyediaan Bioetanool Sebagai Bahan Bakar Nabati (Biofuel).

Percopo, Bob. (2022). *Geopolitics and Climate Change: Economic Implications*. Columbia SPS.

PRIS. (2023). IAEA. Retrieved from https://pris.iaea.org/pris/home.aspx

PT PLN (Persero). (2023). Annual Report 2022.

PT PLN (Persero). (2023). Mudahkan Pengguna Kendaraan Listrik Selama Mudik, PLN Operasikan 616 SPKLU di 237 Lokasi di Indonesia. https://web.pln.co.id/media/siaran-pers/2023/04/mudahkan-pengguna-kendaraan-listrik-selama-mudik-pln-operasikan-616-spklu-di-237-lokasi-di-indonesia.

PWC. (2019). PWC. Retrieved from https://www.pwc.com/us/en/industries/energy-utilities-resources/library/oil-and-gas-companies-attract-investors.html.

Reuters. (23 Maret 2022). *Reuters*. Retrieved from https://www.reuters.com/business/sustainable-business/exclusive-dutch-bank-ing-ends-financing-new-oil-gas-projects-2022-03-23/.

Reuters. (10 Februari 2023). *Reuters*. Retrieved from https://www.reuters.com/business/sustainable-business/investors-call-five-european-banks-end-new-oil-gas-finance-2023-02-10/.

REN21. (2023). Renewable in Energy Demand Agriculture in Focus. https://www.ren21.net/gsr-2023/modules/energy_demand/04_agriculture_in_focus/02_policy/.

Ross, A. (15 September 2023). *Financial Times*. Retrieved from https://www-ft-com.ezp.lib.cam.ac.uk/content/1c3a8e9c-a10c-46ce-9903-084e07056d40.

S&P Global (2023). *Top Geopolitical Risk 2023*.

The Economist. (12 Februari 2022). "Finance & Economics". Retrieved from *The Economics*: https://www.economist.com/finance-and-economics/who-buys-the-dirty-energy-assets-public-companies-no-longer-want/21807594.

The Hague Centre for Strategic Studies. (2017). *The Geopolitical Impact of Climate Mitigation Policies*.

Townend, Ruth dan Anna Åberg. (2023). *What is COP28 and Why is it Important?* Chathamhouse.org.

Valle, S. (13 September 2023). *Reuters*. Retrieved from *https://www.reuters.com/business/energy/oil-investors-open-dividend-cut-boost-clean-energy-spending-deloitte-2023-09-12/*.

Vujic, J., M.R. Bergmann, R. Skoda, dan M. Miletic. (2012). "Small Modular Reactors: Simpler, Safer, Cheaper?", *Energy*, Vol. 45, hlm. 288-295.

Warstek Media. (n.a). *Warstek*. Retrieved from https://warstek.com/smr/.

WBG dan ADB. (2021). *Climate Risk Country Profile: Indonesia*. WBG and ADB.

Wester, P. *et al*. (2019). *The Hindu Kush Himalaya Assessment: Mountains, Climate Change, Sustainability and People.* Springer Cham. *https://doi.org/10.1007/978-3-319-92288-1*

World Bank Group. (2023). *Falling Long-Term Growth Prospects*. Washington D.C: The World Bank.

World Bank Group. (2023). *World Bank East Asia and The Pacific Economic*, Update April 2023. Washington, DC: The World Bank.

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