

Decarbonization Strategy Evaluation at Pertamina

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AS.425.800.81.SP23

Research Design for Capstone Projects
in Energy and Environmental Sciences

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May, 13, 2022

Abstract

As a state-owned energy company, Pertamina has an obligation to secure the nation's energy independence while at the same time supporting Indonesia's Net Zero Emission (NZE) Target by 2060 or sooner. To achieve this goal, Pertamina has crafted the Decarbonization of Business Activities and New Business Building roadmap. Since the NZE roadmap is designed using the top-down approach to comply with the national NZE target in 2060, the decarbonization strategy has yet to be prioritized and evaluated in detail whether it will contribute effectively to the target.

The researcher developed six main steps as the methodology, mainly used to analyze the strategy from various points of view in answering the research problem. First, mapping and classifying unique emission reduction efforts from each business unit into defined strategic initiatives were conducted. Furthermore, to see the priority initiatives in each business unit, every projected emission initiative was calculated in percentage relative to the total emission reduction projection. Moreover, the researcher calculated overall emission reduction contribution to see which type of activity and business unit has the biggest contribution to company-wide. To see and analyze how much the emission reduction target by the program can cover the emission reduction target by the NZE roadmap, the researcher plotted the emission reduction trend for the upstream business unit in the short and medium term. In addition, the researcher plotted the emission intensity target in the Business As Usual (BAU) scenario and NZE Roadmap Target Scenario. Finally, the researcher used plotted emission intensity targets to benchmark various world's significant oil and gas producers and Oil and Gas Climate Initiative (OGCI).

As a result, the researcher found that energy efficiency initiatives will be the backbone of decarbonization activities during the short and mid-term periods, followed by loss reduction and

green power generation initiatives. However, in the upstream business unit, which was projected to be the biggest contributor, the declared initiatives have only accounted for about 58% of the emission reduction target. Thus, Pertamina should reevaluate its short and mid-term strategies. Otherwise, the accomplishment of the NZE target will be jeopardized.

Executive Summary

Indonesia, the fourth most populous country in the world, is considered one of the biggest energy consumer countries in the world and ranked nine for the most significant fuel combustion CO₂ emitter. During 2021 UNFCCC, Indonesia has set an ambitious target of Net Zero Green House Gases (GHG) Emissions in 2060. Pertamina, a state-owned energy company, aspires to support this target by declaring Scope 1 & 2 Net Zero Emission by 2060 or sooner. To achieve this goal, Pertamina has developed a roadmap of asset decarbonization and green business building.

The net-zero emission roadmap is designed using the top-down approach to comply with the national Net Zero Emission (NZE) target in 2060. The decarbonization strategy has yet to be prioritized and evaluated in detail whether it will contribute effectively to the target. This research evaluates the current strategy of decarbonizing business activities at Pertamina and how significantly the decarbonization activities reduce emissions. The researcher developed six main steps as the methodology, mainly used to analyze the strategy from various points of view in answering the research problem.

This research demonstrated the application of the researcher's knowledge in various Energy Policy & Climate program courses, such as Energy Technology, Climate Change, and Energy Policy Application. Besides, some analyses are developed from the researcher's experience in various energy companies for over 13 years. This research explored the detailed area Pertamina should focus on in chasing its Net Zero Emission aspiration while showing potential future research to support that goal. The result of this research should be used as a clearer path for Pertamina in realigning its NZE roadmap in the future.

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Introduction

Net Zero Pledges and Target for Emission Reductions

According to the Paris Agreement, all parties, which consist of United Nations (UN) members, UN General Assembly Observer State of Palestine, UN non-member states Niue and the Cook Islands, and the European Union, has an obligation to submit their Nationally Determined Contribution (NDCs) in emission reduction efforts to the United Nations Framework Conventions on Climate Change (UNFCCC). Every five years, members must update their NDC progressively, showing the biggest possible emission reduction efforts. Until April 2021, more than 40% of global CO₂ emissions are covered by the new or updated NDC submitted by 80 countries (International Energy Agency, 2021).

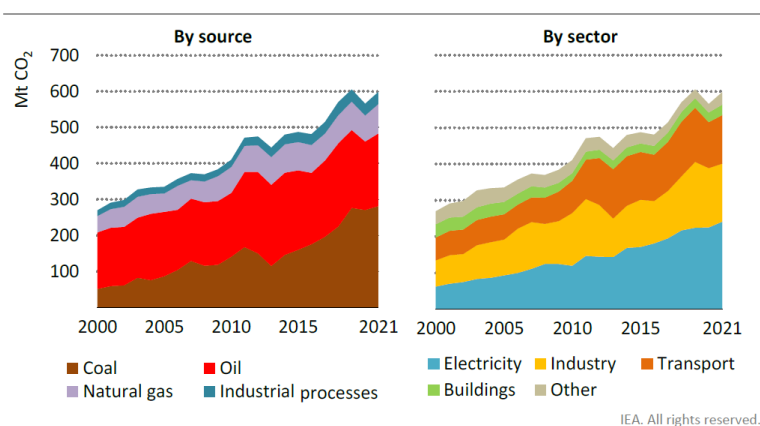
Several strategies submitted to the UNFCCC by the parties include the net zero pledge. It means that some members commit to achieving a condition where they can balance the greenhouse gases' anthropogenic emissions to the atmosphere over a specific period with the anthropogenic removals (Matthews, 2022). However, only a few members commit to the net zero pledge with specific routes and policies for implementation (International Energy Agency, 2021).

Indonesia Net Zero Emission Target in 2060

Ranked number four as the world's most populous country, Indonesia has become one of the world's fastest-growing economies. This country has only behind Korea, Singapore, and China in the fastest growth per capita GDP rate since the 1970s. As the biggest archipelago country with more than 17,000 islands and various distinctive landscapes, it is ranked twelfth in Energy-Consuming and, simultaneously become the ninth largest fuel combustion CO₂ emitter (International Energy Agency, 2022).

Figure 1

Indonesia's CO₂ emissions from Energy Sector, from 2000-2021



Note : Emission from energy sector dominated by coal, oil, and natural gas. From *An Energy Sector Roadmap to Net Zero Emissions in Indonesia* (p. 36), by International Energy Agency, 2022.

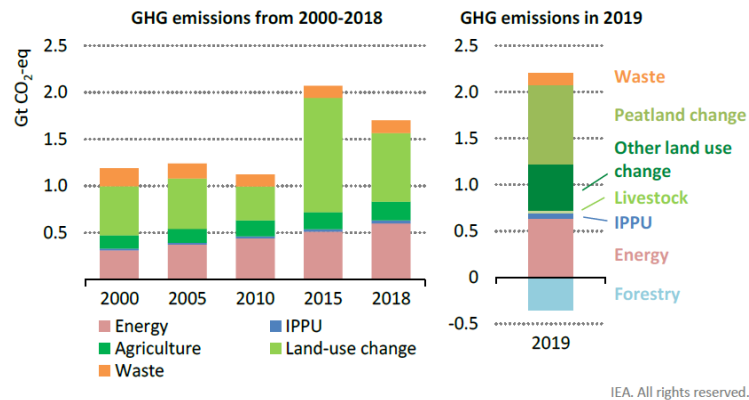
Coal, oil, and natural gas are the primary type of fossil fuel sources in Indonesia. As seen in Figure 1, coal is used mainly for electricity sources, oil products are used for transportation, and natural gas is mainly used for industry. Those sources dominate the CO₂ emissions in the energy sector in Indonesia, with almost half being contributed by coal, about one-third from oil, and around 15% and 5% from natural gas and industrial processes, respectively. As described in Figure 2, the energy sector emission increased from 2000 until 2019 and was responsible for about one-third of Indonesia's total net emissions in 2019 (International Energy Agency, 2022).

Indonesia has set an ambitious target of Net Zero Green House Gases (GHG) Emissions in 2060. This target is based on its Long-Term Low Emissions Strategy (LTS) that was submitted to the UNFCC 2021 as an updated NDCs. Indonesia needs immediate, comprehensive, and sustainable actions to achieve this target. According to IEA's Announced Pledges Scenario (APS), Indonesia's CO₂ emissions from the energy sector in 2030 will be 20% higher than the 2021 level and will experience a peak period before it will decline to 20% lower in 2040 and remain just over

100 Mt in 2060. In 2060, energy consumption will be provided half by electricity and one-fifth by low emissions fuel (International Energy Agency, 2022).

Figure 2

Total greenhouse gas emissions by sector, from 2000-2019



Note : Emission from energy sector increased from 2000-2019. From *An Energy Sector Roadmap to Net Zero Emissions in Indonesia* (p. 39), by International Energy Agency, 2022.

Pertamina's Commitment to Support Indonesia NZE Target

Pertamina has a long history in Indonesia since 1950 as a company appointed by the government to secure the nation's energy independence. It started with the name of PT Eksploitasi Tambang Minyak Sumatera Utara, responsible for managing the oil field in Sumatera. Through six decades, Pertamina has experienced many changes and transformations while providing energy as a basic need and critical commodity in Indonesia. The latest fundamental transformation happened on June 12th, 2020, when the Ministry of State-Owned Enterprises appointed Pertamina as a Holding Company in energy sectors that consist of six business units: Upstream, Gas, Refinery & Petrochemical (R&P), Power and New & Renewable Energy (PNRE), Commercial & Trading

(C&T), and Integrated Marine Logistics (IML). This transformation makes Pertamina's position in Indonesia's Energy Sector more strategic and critical (PT Pertamina, n.d.).

As a state-owned energy company, Pertamina aspires to support Indonesia's Net Zero Emission Target in 2060. Pertamina has declared the aspiration toward Scope 1 & 2 Net Zero Emission by 2060 or sooner. Pertamina has developed a roadmap of asset decarbonization and green business building to achieve this goal. As seen in Figure 3, there are strategic initiatives that support Decarbonization of Business Pillar and New Business Building pillar. Pertamina is also establishing some enablers factors, such as Sustainability organization, capabilities, and stakeholder engagement. The roadmap is projected to create 25-30 Mn Tonnes CO2 Abatement (Scope 1 & 2) in 2060 which is reflected to contribute about 2% of Indonesia's Net Zero Aspirations (Muraza, 2023).

Figure 3

Pertamina’s Strategic Initiatives and Enablers to achieve Net Zero Emission by 2060



Note : Declared initiatives in achieving scope 1 & 2 : Net Zero Emissions by 2060. From *Pertamina Decarbonization Roadmap* (p. 4), by Oki Muraza, 2023.

Research Problem, Question, & Hypothesis

The NZE roadmap is designed using the top-down approach to comply with the national NZE target in 2060. The decarbonization strategy has yet to be prioritized and evaluated in detail whether it will contribute effectively to the target. This research evaluates the current strategy of decarbonizing business activities at Pertamina that have been declared: Energy Efficiency, Green Power Generation, Loss Reduction, Fleet Electrification, Static Equipment Electrification, Carbon Capture and Storage, and Low/Zero Carbon fuel for fleets.

The research question is: How will decarbonizing business activities effectively contribute to the net-zero emissions target in Pertamina? Effectively means how significant the decarbonization activities reduce the emission. The hypothesis is energy efficiency programs will be the major contributor to Pertamina's decarbonization of business activities. A deeper analysis will be conducted to evaluate each strategy and compare it to the industry practice of each program. Due to data limitations, this research focused on the short-term (2022-2025) and mid-term (2026-2030) periods, even though the general long-term (2031-2060) strategy was still discussed at a glance.

Literature Review

The researcher did a literature review using primary references from inside Pertamina and well-known companies in the oil and gas sector, such as Conoco Phillips, Exxon Mobil, Chevron, Saudi Aramco, and Petrobras. Besides, some pieces of literature are taken from organizations/agencies/bodies that have specialization in the energy and climate change sector, such as the International Energy Agency (IEA), the Intergovernmental Panel on Climate Change

(IPCC), The World Bank Group (WBG), and U.S. Department of Energy (DOE). In addition, several academic/scientific resources are also used throughout the research.

NZE is a condition when the greenhouse gases' anthropogenic removals can balance the greenhouse gases' anthropogenic emissions to the atmosphere over a specific period (Matthews, 2022). The NZE target is formed as an effort to achieve one of the targets of the Paris Agreement. Paris Agreement was adopted in December 2015 in Paris at the 21st session of the Conference Of the Parties (COP) to the UNFCCC. One of the Paris Agreement's goals is to keep the global average temperature increase well below two degrees Celsius and maintain efforts to keep the rise to one and a half degrees Celsius above the pre-industrial level. Some countries have committed to the NZE target based on updated NDCs submitted to the IPCC. However, most do not have a specific, firm roadmap and detailed policies to support the target (International Energy Agency, 2021).

The research problem mainly came from reviewing some literature issued by Pertamina about the roadmap of Pertamina's NZE aspiration in 2060 or sooner. As a state-owned energy company, Pertamina has an obligation to secure energy independence while supporting Indonesia's government commitment to achieving the NZE target in 2060 (Muraza, 2023). This top-down approach has some limitations since Pertamina as an enterprise currently runs its business heavily in upstream and refinery & petrochemical business unit. The company's NZE roadmap document states that fossil fuel-based business will dominate Pertamina revenue-mix from 2022-2060. Despite the fact that the green business contribution will increase from time to time, the fossil-fuel base business will dominate Pertamina's revenue mix from 95% in 2022 to 50% - 55% in 2060 (Pertamina, 2022). Thus, the success of the NZE roadmap will heavily depend on how to manage the decarbonization strategy in the business unit that runs fossil-fuel-based businesses, such as the Upstream and R&P business unit. This fact is also reflected in the Pertamina Scope 1 & 2 Green

House Gas (GHG) emissions projection that shows more than threefold of GHG emission in Pertamina is contributed by upstream and R&P business units (Pertamina, 2022). As defined by IPCC, Scope 1 is defined as direct GHG emissions that come from the sources owned and controlled by the entity that reports the emission. Scope 2 is defined as GHG emissions produced by other entities that produce electricity, heat, or steam that are not owned or controlled but sell the products to the entity (Alwood et.al., 2014).

Furthermore, the hypothesis was built using the claim that energy efficiency initiatives are the main levers in reducing energy demand and emissions up to 2030 (International Energy Agency, 2021). Energy efficiency also will be the short-term pathway along with renewables in the electricity sector and electrification of transport by 2030 (International Energy Agency, 2022). In collecting the primary data, the researcher used some broad literature from Pertamina group, which explains the specific emission reduction initiatives in every business unit. This information was then crafted and analyzed to classify the type of strategic initiatives and the amount of emission abatement caused by the initiative. The idea to deep dive into the upstream business unit decarbonization activities was also come from the information that projected growth emission in Pertamina in the short and medium term will be driven by upstream production growth and downstream sales growth (Pertamina, 2022).

The detailed analysis within the upstream industry, specifically for energy efficiency initiatives, came from some well know research. Energy efficiency initiatives such as Compressor Capacity Optimization, Turbine Load Optimization, and Diesel Gas conversion are well known as one of the upstream oil and gas industry's (upstream business) most cost-effective energy efficiency practices because dynamic production rates result in the under-utilization of some equipment, such as pumps and compressors. Significant energy savings can be achieved through

well-known optimization techniques like appropriate sizing, sequencing, or the optimization of different gas flow rates (Kolwey, 2020). Moreover, about half of the refinery emissions are caused by chemical processes, with a higher concentration in small processes of heating sources (International Energy Agency, 2022). This premise inspired the researcher to analyze the practice of energy efficiency in the R&P business unit, which also has significant emissions contribution company-wide.

The role of loss reduction initiatives such as flaring and venting reduction in oil and gas sectors is critical in the short and mid-term. The effort to end routine gas flaring is significant in meeting net-zero targets while ensuring they can deliver their products in the cleaner manner possible (IBRD-The World Bank Group, 2023). Various approach in flaring and venting reduction within the Pertamina group was assessed to see if the target launched by Pertamina specific in loss reduction initiatives aligns with the practice in the energy industry.

Carbon Capture, Utilization, & Storage (CCUS) technology development also has significant roles in the NZE roadmap worldwide. To increase the pace of the transition to NZE, the portion of CCUS has to increase within the decarbonization strategy. In the sustainable development scenario, the portion of CCUS in cumulative reduction must increase from 15% to 50% to move the NZE target from 2070 to 2050 (International Energy Agency, 2020). The researcher uses this information to analyze the CCUS implementation plan within Pertamina group, both in the fossil-fuel businesses, such as Upstream and R&P, and in the green business unit, such as PNRE.

The technology development in the marine industry is also discussed in giving potential solutions to the emission reduction gap. For the same amount of power, LNG emits less quarter amount of CO₂ compared to conventional marine fuels (Pavlenko et al., 2021). Besides, alternative

fuels such as biofuels should be considered by the Integrated Marine Logistic business unit since this type of low-carbon fuel can be used in existing vessels (Connelly & Idini, 2022). The sewing system that uses kite technology which can utilize wind power to reduce its fuel consumption and emission (Tamim, 2023), is also considered to be an excellent short and mid-term solution.

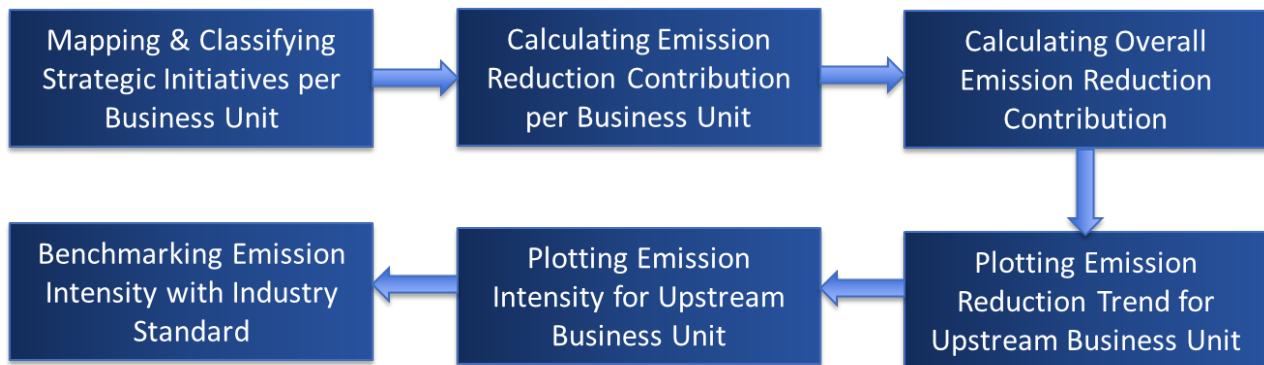
The researcher decided to use the carbon intensity standard to do the benchmarking with industry standards since the most efficient way to reduce net emission is to focus on the overall carbon intensity of the company's operations and activities rather than only focusing on absolute emissions on individual hydrocarbon streams (Baker et al., 2022b). Even though the intensity-based targets cannot guarantee absolute emission reductions, most oil and gas companies use the intensity-based formula in creating decarbonization targets (Arnold & Toledano, 2023). Overall, the literature review from various references has been the foundation for this research, where the research question and hypothesis are built from and finally discussed and answered throughout this document.

Methodology

As seen in Figure 4, this research used six main steps to answer the research question. Each step was performed to elaborate and analyze the detailed initiative and strategy of the Net Zero Emission Roadmap launched by Pertamina in October 2022, specifically for short and medium-term targets. On the roadmap document, Pertamina listed the detailed strategies for each business unit separately and did not give any comprehensive image of how effectively those initiatives will contribute to the NZE target. Therefore, this research comprehensively reviews those strategies related to the NZE target.

Figure 4

Six main steps used as methodology in this research



Note : Methodology was developed by the researcher to answer research question and based on the data availability

Mapping and Classification of Strategic Initiatives per Business Unit

Along with its six business units: Upstream, Gas, Refinery & Petrochemical, Power and New & Renewable Energy, Commercial & Trading, and Integrated Marine Logistics, Pertamina runs its energy business from upstream to downstream as an integrated energy company. Each business unit has its specific type of operational activity, resulting in each business unit having different activities that possibly create emissions. Each business unit will significantly contribute to Pertamina's Net Zero journey (Pertamina, 2022).

Pertamina has established its strategic initiatives to pursue the aspiration of Net Zero Emission by 2060. Two pillars of strategic initiatives have been defined at the holding level; Decarbonization of business activities and New (Green) business building. As seen above in Figure 3, each pillar has several strategic initiatives for reducing emissions. Table 1 shows that those strategic initiatives will be used as the primary classification.

Table 1*Primary Classification of Strategic Initiatives*

Initiative Classification	Pillar Classification
Energy Efficiency	Decarbonization of Business Activities
Green Power Generation	Decarbonization of Business Activities
Loss Reduction (e.g., flare, methane)	Decarbonization of Business Activities
Fleet Electrification	Decarbonization of Business Activities
Static Equipment Electrification	Decarbonization of Business Activities
Carbon Capture and Storage (Own use)	Decarbonization of Business Activities
Low/zero carbon fuel for fleets	Decarbonization of Business Activities
Renewables	New (Green) Business Building
EV Charging and Swapping	New (Green) Business Building
Blue/Green Hydrogen (manufacturing, transport)	New (Green) Business Building
Nature-based solutions	New (Green) Business Building
Battery and EV	New (Green) Business Building
Biofuels	New (Green) Business Building
Integrated CCS/CCUS Service (domestic / regional carbon sink)	New (Green) Business Building
Carbon Market Business	New (Green) Business Building

Note : Primary classification was reproduced from “*Pertamina Decarbonization Roadmap* (p. 4), by Oki Muraza, 2023.

Every business unit establishes its detailed activities to reduce emissions. The efforts are divided into three phases, which are the near-term focus (2022-2025), mid-term focus (2026-2030), and long-term focus (2031-2060). Although every activity effort is unique and depends on each typical operation activity for each business unit, those activities can be classified into the type of strategic initiative. Thus, in this phase, there was a mapping and classification for each emission reduction effort for each business unit based on Table 1.

During mapping and classification, researcher used various definitions that is synthesized from various well-known resources such as U.S. Department of Energy (DOE), U.S. Environmental Protection Agency (EPA), Exxon Mobil and Petrofac, World Bank, United Nations

Development Program (UNDP), Pertamina, and common practice in energy industry. Those definitions can be seen in Table 2.

Table 2

Definition used for classifying various detail initiatives in each business unit

Initiative Classification	Definition	Sources
Energy Efficiency	the use of less energy to perform the same task or produce the same result.	U.S. DOE
Green Power Generation	electricity produced from solar, wind, geothermal, biogas, eligible biomass, and low-impact small hydroelectric sources.	U.S. EPA
Loss Reduction (e.g., flare, methane)	reduce/minimize/utilize flaring amount and methane leak during operations	Common Practice
Fleet Electrification	the changing of fleet vehicles that use Internal Combustion Engine (ICE) to Electric Vehicle (EV)	Common Practice
Static Equipment Electrification	The electrification of static equipment	
Carbon Capture and Storage (Own use)	process that captures carbon dioxide emissions from sources like coal-fired power plants and either reuses or stores it so it will not enter the atmosphere.	U.S. DOE
Low/zero carbon fuel for fleets	changing/using fleet that use low carbon fuels such as hydrogen, biomethane, renewable diesel, sustainable diesel, etc	U.S. DOE & Clear Flame
Renewables	energy produced from sources like the sun, wind, biomass, geothermal, & water that are naturally replenished and do not run out	U.S. DOE
EV Charging and Swapping	providing charging station or swapping battery station for Electric Vehicle	Common Practice
Blue/Green Hydrogen (manufacturing, transport)	hydrogen produced from natural gas and supported by carbon capture and storage. Hydrogen produced from splitting water by electrolysis process that is powered from renewable energy sources	Exxon Mobil and Petrofac
Nature-based solutions	Actions to protect, sustainably manage, or restore natural ecosystems, that address societal challenges such as climate change, human health, food and water security, and disaster risk reduction effectively and adaptively, simultaneously providing human well-being and biodiversity benefits	World Bank
Battery and EV	Produce Electric Vehicle (i.e. : Electric Two Wheelers - ETW) and Battery for EV	Common Practice
Biofuels	Biofuels are liquid fuels produced from renewable biological sources, including plants and algae	U.S. DOE
Integrated CCS/CCUS Service (domestic / regional carbon sink)	Develop and scale CCS to support emission abatement including integrate end-to-end CCUS business	Pertamina
Carbon Market Business	Develop business of carbon markets, which are trading systems where carbon credits are sold and bought. One tradable carbon credit equals one tonne of carbon dioxide or the equivalent amount of a different greenhouse gas reduced, sequestered or avoided.	UNDP

Note : Definition is synthesized from various resources as a guidance in classifying process

Calculating Emission Reduction Contribution per Business Unit

After mapping and classifying the efforts in each business unit, every projected emission initiative was calculated in percentage relative to the total emission reduction projection in the business unit. The available emission reduction data is in annual amount abated (Million tonnes CO₂ equivalent / CO₂e). Since there is no specific data about total emission reduction projection in every phase, the assumption is that total projection emission reduction comes from the total

annual amount abated for every initiative. This percentage was analyzed to see the priority initiatives in each business unit.

Calculating Overall Emission Reduction Contribution

Emission reduction from the strategic initiative was calculated in percentages related to total emission reduction combined from all business units to evaluate the effectiveness of the decarbonization initiatives as a whole integrated energy company. In the roadmap launched by the company, the absolute emission will increase until 2030 due to production growth. It will decrease from 2030 until 2060 due to a decrease in upstream production and downstream sales of gasoline and diesel. Due to data limitation, the researcher calculated the total emission projection based on the total number of projected annual amounts abated caused by all initiatives.

This phase aims to show the type of the main contributor to the emission reduction as a whole integrated company. There were two outputs in this phase. The first one was the type of activity that became the main contributor. The second one was which business unit that would be the main contributor. The results in this phase were used in later analysis.

Plotting Emission Reduction Trend for Upstream Business Unit (2022 – 2030)

After knowing the main contributor to the emission reduction, which were the upstream business unit for the short and mid-term period (2022-2030) and Refinery & Petrochemical (R&P) for the long-term period (2030-2060), the next step was to plot the emission reduction trend for upstream business unit for the short and mid-term period (2022-2030). Due to data limitations, this research did not cover the emission reduction trend in the R&P business unit for a long-term period. Besides, the emission reduction roadmap for the long-term period will mostly depend on the development of CCS/CCUS technology or another green technology. Thus, this research

focused on the short and mid-term, which is relatively more measurable. This phase is aimed to see and analyze how much the emission reduction target by the program can cover the emission reduction target by the NZE roadmap.

Plotting Emission Intensity for Upstream Business Unit (2022 – 2030)

As an effort to review more comprehensively, this research also elaborated and emphasized the projected carbon intensity reduction of the decarbonization roadmap and made a benchmark to the significant oil and gas producers and Oil & Gas Climate Initiative (OGCI) target. Although Pertamina calculated the emission reduction target as absolute CO₂e emission reduction, the researcher decided to compare it in the form of carbon intensity, which calculates the emission released in every barrel of oil equivalent production of oil and gas.

Based on the document of Pertamina NZE Roadmap 2022-2060, there is no clear target for emission intensity reduction. On the other hand, to reduce its net emission, the most efficient way is to focus on the overall carbon intensity of the company's operations and activities rather than only focusing on absolute emissions on individual hydrocarbon streams (Baker et al., 2022b). Even though the intensity-based targets cannot guarantee absolute emission reductions, most oil and gas companies use the intensity-based formula in creating decarbonization targets (Arnold & Toledano, 2023). Therefore, the researcher used an intensity-based target to benchmark with industry standards. Two reviewed variables were Emission Intensity in a Business As Usual (BAU) scenario and Emission Intensity in an NZE roadmap scenario (Target). Emission Intensity was calculated by dividing the absolute emission (both in BAU and NZE scenario) with oil and gas total production in Barrel Oil Equivalent (BOE).

Benchmarking Emission Intensity with Industry Standard

After plotting the emission intensity, the researcher compared the carbon intensity reduction rate to other oil and gas producers implementing Scope 1 and 2 Net Zero Emission Target: Conoco Phillips, Exxon Mobil, Chevron, Saudi Aramco, and Petrobras. Every company typically has a specific emission intensity reduction target for a specific period. In this phase, the researcher calculated the annual carbon intensity by dividing the emission intensity reduction target by the year period. For example, Conoco Philips aims to reduce GHG intensity 40-50% in 2030 relative to the 2016 baseline. Thus, the annual emission intensity reduction is calculated by dividing 40-50% target by 15 years (year period), resulting in a 2.9% - 3.5% annual emission intensity reduction target. This method was also applied to OGI target, which wants to reduce the carbon intensity from 23 to 17 kg CO₂e per boe by 2025 compared to 2017. It gave the result of 3.26% annual emission reduction target.

Result

Mapping and Classification of Strategic Initiatives per Business Unit

Table 3

Classification result of detail emission reduction efforts in Upstream Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives
Upstream	Decarbonization	Green Power Generation	Solar PV in all zones
Upstream	Decarbonization	Energy Efficiency	Turbine & Comp Opt, Flare Gas Recovery System
Upstream	Decarbonization	Energy Efficiency	Compressor Capacity - Turbine Load Opt - Diesel to Gas
Upstream	Decarbonization	Carbon Capt & Storage (Own Use)	CCUS Pilots in Gundih, Sukowati, and Ramba
Upstream	Decarbonization	Loss Reduction	Reduce Flaring
Upstream	Decarbonization	Energy Efficiency	Accelerate Decommissioning
Upstream	Decarbonization	Green Power Generation	Solar/Grid Electrification
Upstream	Green Business Building	Integrated CCS/CCUS Service	Develop and scale CCS across Pertamina
Upstream	Decarbonization	Green Power Generation	Electrify Equipment

Table 4

Classification result of detail emission reduction efforts in Refinery and Petrochemical Business Unit

Unit

Business Unit	Strategic Initiatives	Types	Initiatives
R&P	Decarbonization	Green Power Generation	Campaign on Solar PV & Connect to PLN Grid
R&P	Decarbonization	Energy Efficiency	Energy Efficiency & Flare Reduction (Switching to Gas Fu
R&P	Decarbonization	Loss Reduction	Energy Efficiency, Flaring/Venting levers
R&P	Decarbonization	Green Power Generation	Electrify Equipment and Switch to Green Electricity
R&P	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS Technology (blue hydrogen technology and CO2 venting)
R&P	Decarbonization	Green Power Generation	Electrify Equipment (build on-site renewables & battery levers)
R&P	Green Business Building	Biofuels	Scale up CPO based HVO capacity when the economics is viable and build HEFA capacity post 2040 when SAF blending picks up both domestic and globally; explore potential market for bio-naphtha

Table 5

Classification result of detail emission reduction efforts in Commercial & Trading Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives
C&T	Decarbonization	Green Power Generation	Low Carbon Power Initiatives (Solar PV for SPBUs and offices and switch fuel trucks to gas fuel)
C&T	Decarbonization	Energy Efficiency	Implement Energy Efficiency on aircraft refueling
C&T	Decarbonization	Fleet Electrification	Conversion of Fleet to battery electric trucks
C&T	Decarbonization	Low/Zero Carbon Fuel For Fleets	Conversion of Large HDT to low-carbon HDT (e.g.CNG,H2)
C&T	Green Business Building	EV Charging & Swapping	Build Up Charging Stations (up to 15,000 stations)
C&T	Green Business Building	Biofuels	Scale up biofuel blending infrastructure
C&T	Green Business Building	Blue/Green Hydrogen	Set up Infrastructure for Liquid H2 refueling station for road transport when demand picks up post 2045

Table 6

Classification result of detail emission reduction efforts in Gas Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives
Gas	Decarbonization	Green Power Generation	Install Solar PV for internal operations in Pertagas, SAKA
Gas	Decarbonization	Energy Efficiency	Implement Energy Efficiency
Gas	Decarbonization	Green Power Generation	Switch to green electricity for transmission assets
Gas	Decarbonization	Carbon Capt & Storage (Own Use)	Point source CCS on machine drive units on gas pipeline
Gas	Decarbonization	Electrification	Electrification of Gas Turbines (switch to electric motors)
Gas	Decarbonization	Green Power Generation	Switch own generation to green electricity
Gas	Green Business Building	Integrated CCS/CCUS Service	Scale up Infrastructure for CO2 transport

Table 7

Classification result of detail emission reduction efforts in Integrated Marine Logistic Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives
IML	Decarbonization	Energy Efficiency	Implement ships speed management and route optimization
IML	Decarbonization	Low/Zero Carbon Fuel For Fleets	Renew 200 ships into dual-fuel engines to improve fuel efficiency
IML	Green Business Building	Hydrogen	Purchase Tankers for Ammonia Transport to Japan and Korea for 0.15 MTPA H2E Cargo Vol
IML	Green Business Building	Integrated CCS/CCUS Service	Set up Fleets for liquid CO2 domestic shipping and seek for potential vol. from Asia region as Indonesia becoming carbon sink

Table 8

Classification result of detail emission reduction efforts in Power and New & Renewable Energy

Business Unit	Strategic Initiatives	Types	Initiatives
P&RE	Decarbonization	Green Power Generation	Implement Low Carbon Power Lever (e.g., Install binary power plant in Lahendong)
P&RE	Decarbonization	Green Power Generation	Install Green Electricity for owned use (e.g. WPS Cikaro and PLTBg Sei Mangkei)
P&RE	Decarbonization	Energy Efficiency	Energy Efficiency levers on CCGT plants
P&RE	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS for Geothermal Assets
P&RE	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS for CCGT
P&RE	Green Business Building	Renewables	Pilot and Scale up in Solar/Hydro and Geothermal, build up to 40 GW solar, 8 GW hydro, 1 GW Wind, and 5 GW Geothermal
P&RE	Green Business Building	Battery and EV	Ni Sulfate export market, battery production & E2W
P&RE	Green Business Building	Hydrogen	Launch Pilot and scale up H2 and NH3 export volume
P&RE	Green Business Building	Carbon Market Business	Establish Carbon Co, expand more types NBS projects

Calculating Annual Emission Reduction Contribution per Business Unit

Table 9

Annual Emission Abatement (in MM tons CO2e & percentage) in Upstream Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO2e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
Upstream	Decarbonization	Green Power Generation	Solar PV in all zones	0.03			3%	0%	0%
Upstream	Decarbonization	Energy Efficiency	Turbine & Comp Opt, Flare Gas Recovery System	0.6			53%	0%	0%
Upstream	Decarbonization	Energy Efficiency	Compressor Capacity - Turbine Load Opt - Diesel to Gas	0.5	0.6		44%	9%	0%
Upstream	Decarbonization	Carbon Capt & Storage (Own Use)	CCUS Pilots in Gundih, Sukowati, and Ramba		1		0%	15%	0%
Upstream	Decarbonization	Loss Reduction	Reduce Flaring		2	0.7	0%	31%	19%
Upstream	Decarbonization	Energy Efficiency	Accelerate Decommissioning		1.6		0%	25%	0%
Upstream	Decarbonization	Green Power Generation	Solar/Grid Electrification		1.3		0%	20%	0%
Upstream	Green Business Building	Integrated CCS/CCUS Service	Develop and scale CCS across Pertamina				0%	0%	0%
Upstream	Decarbonization	Green Power Generation	Electrify Equipment			3	0%	0%	81%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Table 10

Annual Emission Abatement (in MM tons CO₂e & percentage) in Refinery & Petrochemical Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO ₂ e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
R&P	Decarbonization	Green Power Generation	Campaign on Solar PV & Connect to PLN Grid	0.3	0.2		60%	11%	0%
R&P	Decarbonization	Energy Efficiency	Energy Efficiency & Flare Reduction (Switching to Gas Fu	0.2	0.15		40%	8%	0%
R&P	Decarbonization	Loss Reduction	Energy Efficiency, Flaring/Venting levers		1.1		0%	59%	0%
R&P	Decarbonization	Green Power Generation	Electrify Equipment and Switch to Green Electricity		0.4		0%	22%	0%
R&P	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS Technology (blue hydrogen technology and CO ₂ venting)			10	0%	0%	77%
R&P	Decarbonization	Green Power Generation	Electrify Equipment (build on-site renewables & battery levers)			3	0%	0%	23%
R&P	Green Business Building	Biofuels	Scale up CPO based HVO capacity when the economics is viable and build HEFA capacity post 2040 when SAF blending picks up both domestic and globally; explore potential market for bio-naphtha				0%	0%	0%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Table 11

Annual Emission Abatement (in MM tons CO₂e & percentage) in Commercial and Trading Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO ₂ e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
C&T	Decarbonization	Green Power Generation	Low Carbon Power Initiatives (Solar PV for SPBUs and offices and switch fuel trucks to gas fuel)	0.004	0.004		89%	89%	0%
C&T	Decarbonization	Energy Efficiency	Implement Energy Efficiency on aircraft refueling	0.0005	0.0005		11%	11%	0%
C&T	Decarbonization	Fleet Electrification	Conversion of Fleet to battery electric trucks			0.1	0%	0%	77%
C&T	Decarbonization	Low/Zero Carbon Fuel For Fleets	Conversion of Large HDT to low-carbon HDT (e.g.CNG,H ₂)			0.03	0%	0%	23%
C&T	Green Business Building	EV Charging & Swapping	Build Up Charging Stations (up to 15,000 stations)				0%	0%	0%
C&T	Green Business Building	Biofuels	Scale up biofuel blending infrastructure				0%	0%	0%
C&T	Green Business Building	Blue/Green Hydrogen	Set up Infrastructure for Liquid H ₂ refueling station for road transport when demand picks up post 2045				0%	0%	0%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Table 12

Annual Emission Abatement (in MM tons CO₂e & percentage) in Gas Business Unit

Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO ₂ e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
Gas	Decarbonization	Green Power Generation	Install Solar PV for internal operations in Pertamina, SAKA	0.0008			53%	0%	0%
Gas	Decarbonization	Energy Efficiency	Implement Energy Efficiency	0.0007	0.02		47%	87%	0%
Gas	Decarbonization	Green Power Generation	Switch to green electricity for transmission assets		0.003		0%	13%	0%
Gas	Decarbonization	Carbon Capt & Storage (Own Use)	Point source CCS on machine drive units on gas pipelines			0.2	0%	0%	41%
Gas	Decarbonization	Electrification	Electrification of Gas Turbines (switch to electric motors)			0.18	0%	0%	37%
Gas	Decarbonization	Green Power Generation	Switch own generation to green electricity			0.11	0%	0%	22%
Gas	Green Business Building	Integrated CCS/CCUS Service	Scale up Infrastructure for CO ₂ transport				0%	0%	0%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Table 13*Annual Emission Abatement (in MM tons CO₂e & percentage) in Integrated Marine Logistic*

Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO ₂ e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
IML	Decarbonization	Energy Efficiency	Implement ships speed management and route optimization	0.02	0.02		100%	100%	0%
IML	Decarbonization	Low/Zero Carbon Fuel For Fleets	Renew 200 ships into dual-fuel engines to improve fuel efficiency				0%	0%	0%
IML	Green Business Building	Hydrogen	Purchase Tankers for Ammonia Transport to Japan and Korea for 0.15 MTPA H ₂ E Cargo Vol				0%	0%	0%
IML	Green Business Building	Integrated CCS/CCUS Service	Set up Fleets for liquid CO ₂ domestic shipping and seek for potential vol. from Asia region as Indonesia becoming carbon sink				0%	0%	0%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Table 14

Annual Emission Abatement (in MM tons CO₂e & percentage) in Power and New & Renewable Energy (PNRE) Business Unit

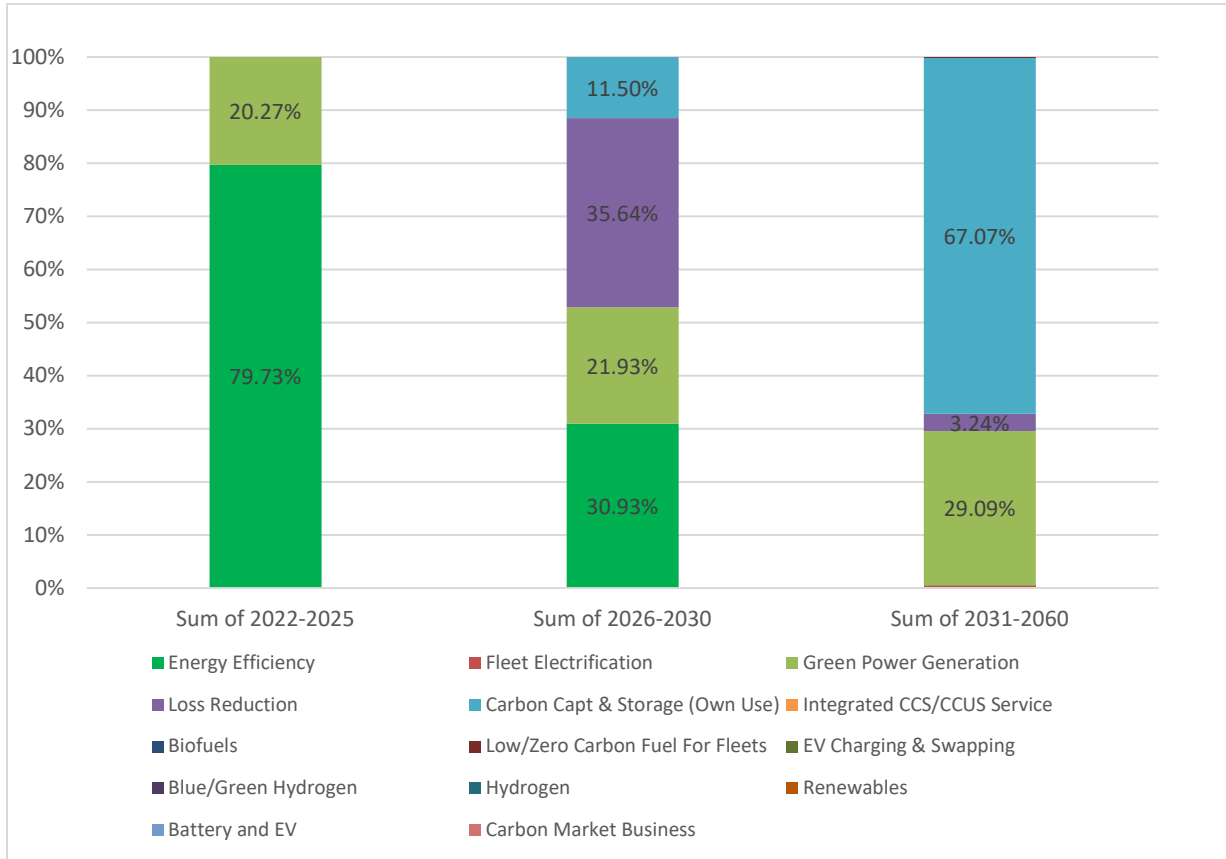
Business Unit	Strategic Initiatives	Types	Initiatives	Annual Emission Abated (tons CO ₂ e)			Annual Emission Abated (%)		
				2022-2025	2026-2030	2031-2060	2022-2025	2026-2030	2031-2060
P&RE	Decarbonization	Green Power Generation	Implement Low Carbon Power Lever (e.g., Install binary power plant in Lahendong)	0.0005			45%	0%	0%
P&RE	Decarbonization	Green Power Generation	Install Green Electricity for owned use (e.g. WPS Cikaro and PLTBg Sei Mangkei)	0.0006			55%	0%	0%
P&RE	Decarbonization	Energy Efficiency	Energy Efficiency levers on CCGT plants		0.3		0%	100%	0%
P&RE	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS for Geothermal Assets			0.3	0%	0%	7%
P&RE	Decarbonization	Carbon Capt & Storage (Own Use)	Implement CCUS for CCGT			4	0%	0%	93%
P&RE	Green Business Building	Renewables	Pilot and Scale up in Solar/Hydro and Geothermal, build up to 40 GW solar, 8 GW hydro, 1 GW Wind, and 5 GW Geothermal				0%	0%	0%
P&RE	Green Business Building	Battery and EV	Ni Sulfate export market, battery production & E2W				0%	0%	0%
P&RE	Green Business Building	Hydrogen	Launch Pilot and scale up H ₂ and NH ₃ export volume				0%	0%	0%
P&RE	Green Business Building	Carbon Market Business	Establish Carbon Co, expand more types NBS projects				0%	0%	0%

Note : Percentage contribution per detail initiative is calculated relative to overall contribution

Calculating Overall Annual Emission Reduction Contribution

Figure 5

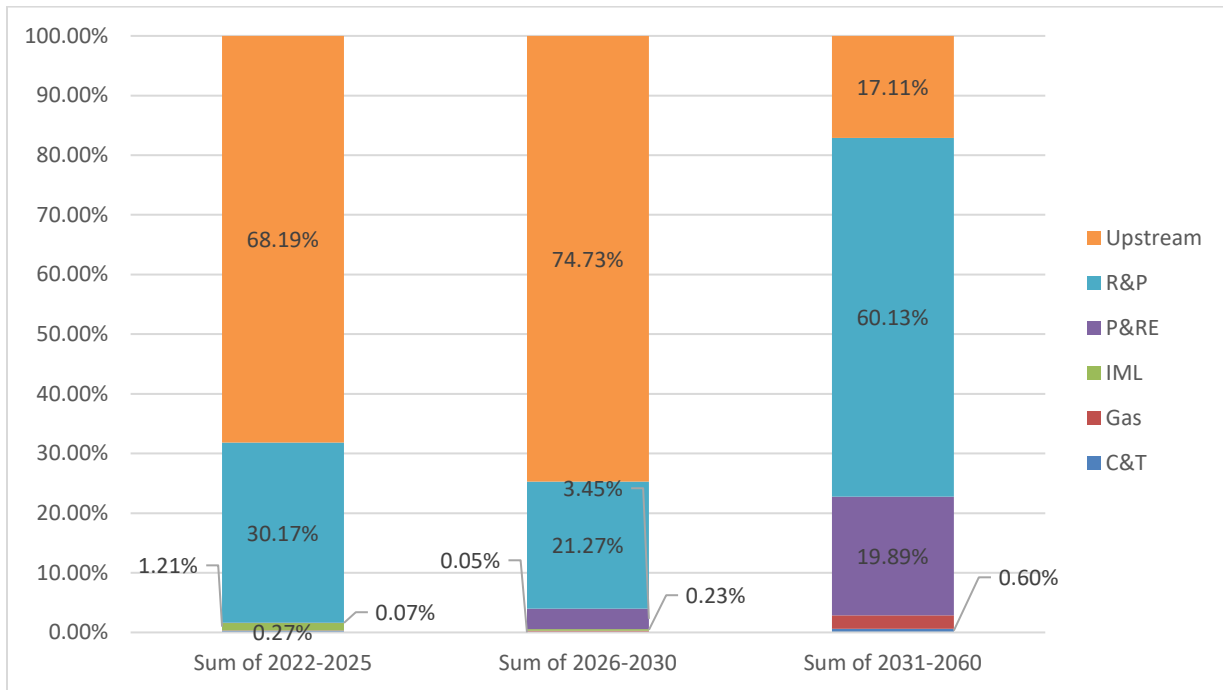
Overall Annual Emission Reduction Contribution by Initiative



Note : Percentage contribution per initiative is calculated relative to combine overall contribution from all business unit

Figure 6

Overall Annual Emission Reduction Contribution by Business Unit

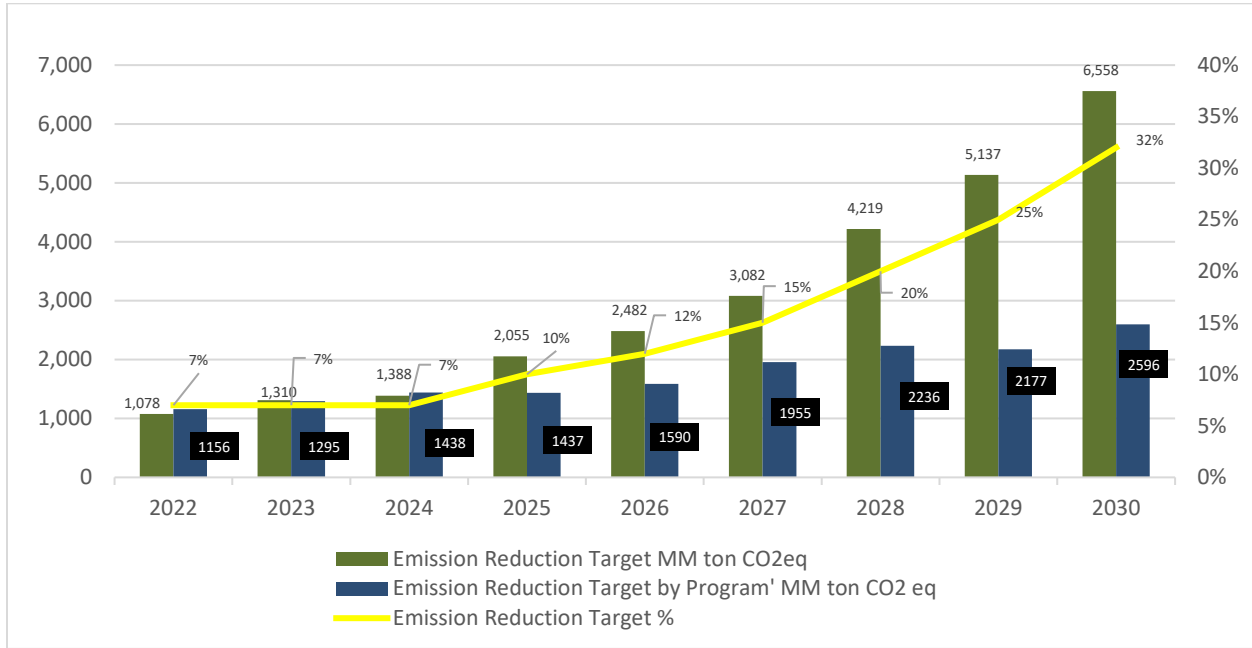


Note : Percentage contribution per business unit is calculated relative to combine overall contribution from all business unit's initiative

Plotting Emission Reduction Trend for Upstream Business Unit (2022 – 2030)

Figure 7

Emission Reduction Target Projection Profile (2022 – 2030) for Upstream Business Unit

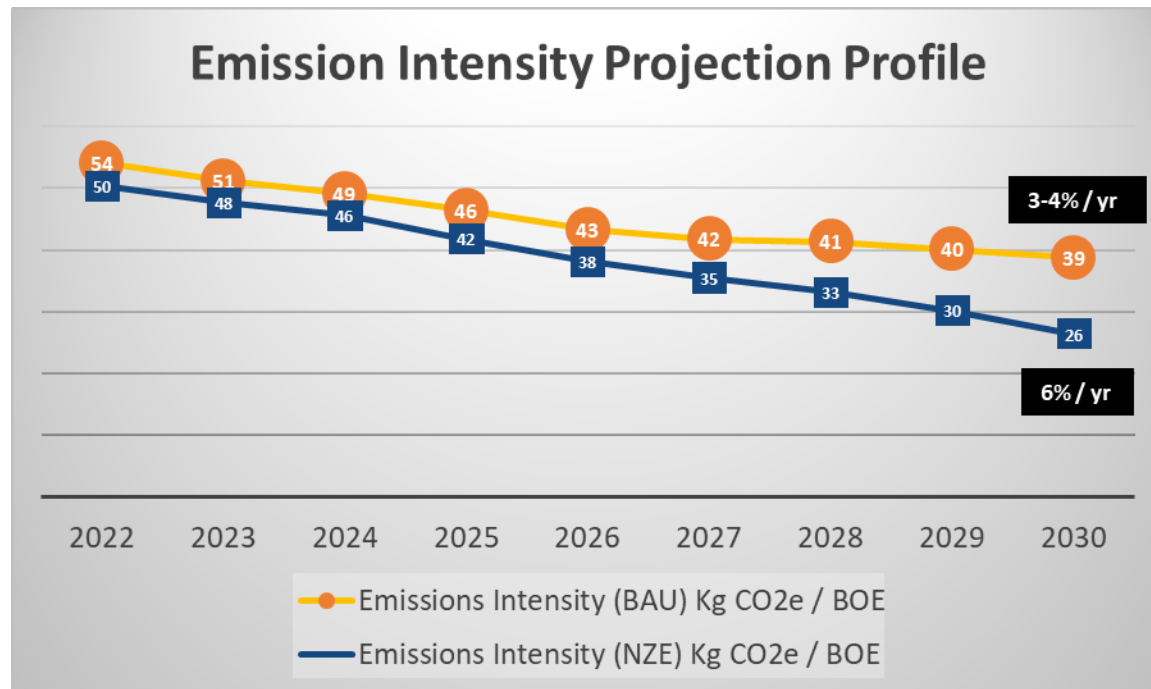


Note : Emission Reduction Target (green bar) shows the target based on NZE Roadmap, while Emission Reduction Target by Program (blue bar) shows the target as a result of declared initiatives

Plotting Emission Intensity for Upstream Business Unit (2022 – 2030)

Figure 8

Emission Intensity Projection Profile (2022-2030) for Upstream Business Unit



Note : Emission Reduction Target (orange line) shows the target based on Business As Usual, while Emission Reduction Target by Program (blue line) shows the target based on NZE Roadmap

Analysis & Discussion

Emission Reduction Contributor in Each Business Unit

Short-Term (2022-2025)

As shown in Table 9, Energy efficiency initiatives like Compressor Capacity Optimization, Turbine Load Optimization, and Diesel to Gas conversion dominate the upstream business unit's short-term emission reduction effort by up to 97%. These initiatives are typically recognized as one of the upstream oil and gas industry's (upstream business) most cost-effective energy efficiency practices because dynamic production rates result in the under-utilization of some

equipment, such as pumps and compressors. Significant energy savings can be achieved through well-known optimization techniques like appropriate sizing, sequencing, or the optimization of different gas flow rates (Kolwey, 2020). This information demonstrates that Pertamina's short-term plans for its upstream business unit are consistent with industry standards.

Energy efficiency initiatives are a significant short-term contributor in other business units as well, even though they aren't always at the top of the list. For example, in the refinery and petrochemical (R&P) business unit, 40% of emission reduction will come from energy efficiency measures like switching to gas and improving heat exchangers, while the remaining 60% will come from green power generation (see Table 10). The initiatives for green power generation include installing Solar PV and connecting the refinery/petrochemical plant to PLN (power company) grid. In addition, about half of refinery emissions are caused by chemical processes, with a higher concentration in small processes of heating sources (IEA, 2022). The initiatives in energy efficiency and green power generation for short term in R&P are therefore very consistent with the IEA's claim, which were very relate with the major emission contribution in chemical and heating process.

In addition to the R&P business unit, gas business unit was also implementing a strategy similar to that of R&P, with 53% of its focus being on the production of green power and the remaining 47% on energy efficiency (see Table 12). The Solar PV installation contributed to green power generation and continued with energy-saving initiatives like reducing fuel consumption during operation and maintenance tasks. Those initiatives were in line with the basic operation of the gas business unit, which mostly uses high energy in transporting and distributing gas products.

In Power & New and Renewable Energy (PNRE) business unit, as shown in Table 14, green power generation initiatives were projected to contribute to all short-term emissions

reduction. The detailed initiatives included installing a binary power plant as a carbon power lever and installing green electricity for its own use. Since the Combined Cycle Gas Turbine (CCGT) Power Plant operations are relatively new (commissioned in December 2021), having no significant energy efficiency initiatives makes sense for this new business unit. The major overhaul interval for modern gas turbines is about 25,000 to 50,000 hours (Darrow et al., 2015), which means that it needs three to six years to do a major overhaul and create an adjustment for efficiency that will not happen in the short-term period.

In addition, Integrated Marine Logistics (IML) business unit only had one contributor for short-term emission reduction: energy efficiency in the form of implement ships speed management and route optimization (see Table 13). The two main ways to decrease emissions by reducing fuel consumption without modifying the ships are shortening routes (without considering weather conditions) and reducing speeds (Ma et al., 2021b). Therefore, IML initiatives for short-term are in-line with industry practices which do not need high capital investment and can be implemented as soon as possible.

Medium-Term (2026-2030)

In the upstream business unit, efforts in energy efficiency, such as turbine and compressor optimization and decommissioning acceleration, were projected to still dominate the medium-term emission reduction initiatives for about 34% of all emissions abated. The other effort in green power generation, such as grid electrification, was also projected to contribute about 20%. In addition, the flaring reduction effort as a loss reduction initiative was projected to give a significant contribution also for about 31%. In the business as usual (BAU) scenario, the upstream business unit will experience a considerable scope 1 & 2 GHG emissions, from 16.3 million CO₂e in 2022 to 21.1 million CO₂e in 2030 per year. It aligns with the upstream business unit's production

projection, which is would experience significant incremental for about 94% for crude oil and 17% for gas (Pertamina, 2022). Thus, the focus on reducing flaring amount is good and aligns with the incremental production projection profile.

Besides, the different type of initiative in Carbon Capture & Storage (for own use) was predicted to grow and give a good portion of reduction contribution for about 15%. This contribution will be supported by the commercialization of the CCUS pilot project in Gundih, Sukowati, and Ramba to decrease up to 1 Million tons of CO₂e per year. However, the contribution of CCUS in reducing global energy sector CO₂ emissions was projected to be only about four percent of all CO₂ emissions for the short-term period until 2030. Although the contribution of CCUS will grow, the cumulative emission reductions from CCUS will only contribute about 12% until 2050 (International Energy Agency, 2020). This projection should be a clear warning for Pertamina to reevaluate its strategy for CCUS implementation.

In the Refinery & Petrochemical business unit, the effort in flaring or venting reduction as a loss reduction initiative was predicted to dominate the emission reduction by about 59%. This significant portion of the target that outweigh the part of green power generation (33%) and energy efficiency (8%) must also be reviewed. Despite the gas flaring is considered to be more easily mitigated, the gas flaring contribution to total refinery emissions is relatively low, only about two percent (Wakil, 2023). Therefore, Pertamina should comprehensively review this strategy and whether it will be achievable.

In the PNRE business unit, the contributor for emission reduction was projected to be part of energy efficiency in CCGT plants. As the CCGT power plant will be more than four years old in the mid-term period, the initiative in the energy efficiency of CCGT plants is very applicable since, in this period, the gas turbine in the plants need to experience a major overhaul. In addition,

there is no finding or discussion for the other business units, since those business units are using the typical strategies like previous period and have only very small contribution to the total emission reduction in the mid-term.

As a conclusion for short and mid-term strategy evaluation, Pertamina is in the right direction specific for the type of strategy used compared to various studies and research related to decarbonization initiatives. However, some clear warnings should be addressed by Pertamina, specific to gas flaring reduction high expectation in R&P business unit and CCUS high expectation in the upstream business unit.

Long-Term (2031-2060)

During this period, about 60 percent of the overall emission reduction in Pertamina will be contributed by the R&P business unit by implementing CCUS Technology (blue hydrogen technology and CO₂ venting) for about 77% and green power generation by building on-site renewables & battery (responsible for about 23% of emission reduction). Despite the fact that the CCUS contribution will grow over time, the CCUS will only have cumulative reduction in CO₂ emission in the energy sector of about 15% (IEA, 2020). Understandably, the contribution of CCUS in the R&P business's emission reduction will depend on the development of CCUS technology. However, similar to the previous analysis, this figure should be a warning for Pertamina in deciding the backup plan since the expectation for CCUS contribution is very high.

PNRE business unit will be the 2nd major contributor to reduction emissions in this period for almost 20%. All of these contributions will come from implementing CCUS for CCGT and Geothermal Assets. Despite PNRE will not be the biggest emitter during this period, the scope 1 & 2 emissions from this business unit will grow since PNRE aims to be one of the biggest renewable players in Indonesia, with the geothermal business will be the backbone of this strategy

with 1.8 GW target operation in 2030 (Pertamina Power Indonesia, 2022). Thus, implementing CCUS for Geothermal Assets and CCGT will align with the company's future strategy. In addition, the 20% contribution from the PNRE business unit in CCUS form still makes sense, even though it is still above IEA's claim that state CCUS contribution in the Energy sector will be around 15% in the long term.

The upstream business unit will still contribute around 17% of emission reduction. It will continue the previous strategy in green power generation by electrifying equipment by replacing gas turbines with electric motors and switching energy sources to renewables such as solar, where applicable. The reduction role of the upstream business unit in decarbonization is in line with the projection that scopes 1 & 2 GHG emissions in 2030-2060 will reduce due to a decline in upstream production in the operated asset for up to 80% (Pertamina, 2022).

In summary, the CCUS implementation will dominate the emission reduction effort in R&P and PNRE long-term. Despite the success of CCUS will very depend on the technology development, the expectation for CCUS's role in Pertamina's decarbonization is considerably high compared to various references. Thus, the extra effort in research, development, and cooperation with leading players specific to CCUS technology should be conducted promptly.

Energy Efficiency and Loss Reduction as Overall Emission Reduction Biggest Contributors

As seen in Figure 5, the energy efficiency initiatives in all business units will dominate the annual emission reduction contribution in the short term for almost 80% of the overall reduction. These initiatives will continue to contribute significantly in the mid-term for about 31%, even though loss reduction initiatives will have a slightly more significant portion in this period for

about 35%. Energy efficiency initiatives are the main levers in reducing energy demand and emission up to 2030 (International Energy Agency, 2021). Thus, this scenario is aligned with the Net Zero Emission Roadmap projected by IEA.

Furthermore, it is seen that energy efficiency initiatives will not contribute for the long-term period (2031-2060). It is in line with the projection in the Net Zero Emission scenario that the role of energy efficiency will fall after 2030 due to the incremental part of other mitigation measures (International Energy Agency, 2021).

Loss reduction initiatives such as flaring reduction have a significant role in overall emission reduction for about 35% in the mid-term period (2026-2030). Most of the contribution comes from upstream and R&P business units. As discussed earlier, the rise of the upstream's oil and gas production and incremental crude run capacity from the refinery business unit is responsible for increasing the loss reduction initiatives in the mid-term period. Despite flaring and venting's contribution to the total emission for onshore and offshore production being 19.3% and 25.4% (Wakil, 2023), the United States (U.S.) has only decreased its flaring intensity by about 14% during 2021-2022 (IBRD-The World Bank Group, 2023). In addition, the flare reduction rate from Global Gas Flaring Reduction Partnership (GGFR) is expected for about 6-7% a year. GGFR is a multi-donor trust fund made up of governments, multilateral organizations, and oil companies that agree to end routine gas flaring at oil production sites around the world (Global Gas Flaring Reduction Partnership (GGFR) Homepage, n.d.) GGFR launched Zero-Routine Flaring (ZRF) initiatives in 2015 that targeted zero-routine flaring in 2030. Based on the benchmark to the GGFR target and the actual decrease of U.S. offshore and onshore flare intensity, Pertamina should review its annual emission reduction target from flaring for about 35% further to determine whether it is achievable or not.

Emission Reduction Trend Comparison for Upstream Business Unit

As seen in Figure 6, the upstream business unit will dominate the emission reduction initiatives for 68% in the short term and 74% in the medium term before being outweighed by the R&P business unit in the long term. Therefore, the strategy and target of the upstream business unit in the short-term and mid-term will be very critical to the success of Pertamina in achieving Net-Zero Aspiration in 2060. After discussing the detailed initiatives in the previous section, the researcher analyzed the trend comparison of the emission reduction rate for the upstream business unit. Pertamina has created an annual emission reduction target based on Net Zero Emission Roadmap in 2060. With this scenario, Pertamina aims to reduce its emission by 32% in 2030. In line with this target, the upstream business unit establishes an annual emission reduction target in percentage before 2030 (yellow line) in Figure 7. The absolute annual emission reduction targets (in MM ton CO₂ equivalent, green bar) were calculated by multiplying the percentage with the projected emission in each year. In addition, the projected annual emission reduction targets (blue bar) reflect the reduction target due to planned initiatives, both for decarbonization and green business-building initiatives.

From Figure 7, the green bar shows the annual emission reduction target, with the total emission reduction target from 2022 until 2030 being 27,309 MM ton CO₂e. In addition, the annual emission reduction target in 2030 will be 6,558 MMton CO₂e, or five-fold than the target in 2022. The huge incremental annual emission reduction target is strongly related to the emission growth from 2022 – 2030 due to incremental upstream production and downstream sales growth (Pertamina, 2022). The yellow line, which represents the percentage of the emission reduction target, starts at 7% in 2022, continues with the same percentage until 2024, and increases gradually to 32% in 2030. The annual reduction percentage from 2022-2030 is about 15% on average. As a

benchmark, Total Energies, one of the world's biggest oil and gas producers, aims to reduce GHG emissions (scope 1 + 2) by 40% in 2030 compared to the 2015 level on its operated activities (Total Energies, 2021). With the flat annual reduction assumption for 15 years, it means that Total Energies only has to cut its emission by 2-3% per year. However, this trend can't be directly compared since every upstream company has its own long-term production profile and strategy. The other way to benchmark the trend is to calculate the emission intensity, which can be calculated by dividing total absolute emission by the total oil and gas produced. The emission intensity comparison will be analyzed in the following section.

On the other hand, the emission reduction target by the programs (blue bar) calculated using the decarbonization initiatives discussed in the previous section are projected to have fewer reductions in most of the years compared to the NZE reduction target. As seen in Figure 7, the emission reduction amount by the program that can outweigh the target is only in 2022 and 2024. Consequently, the total reduction target by the programs from 2022-2030 is 15,880 MM ton CO₂e, or 11,429 MM ton CO₂e lower than the NZE scenario target, which means that cumulative emission reduction from decarbonization initiatives only cover about 58% of the NZE target. From this figure, it is clearly shown that current decarbonization initiatives that has been declared are not enough and Pertamina needs an additional amount of reduction to close the gap and comply with the target.

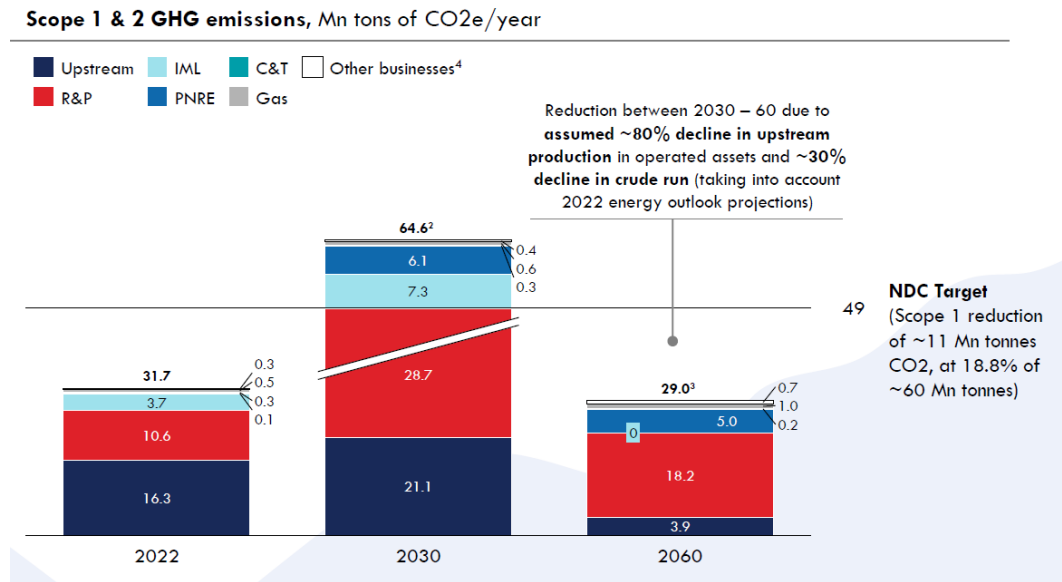
There are some way-out to overcome this gap. The first one is to do carbon trading to offset the emission. As seen in Figure 7, the additional reductions needed fluctuate in the short term. The gap will start in 2025 for 30% and gradually increase to 60% by 2030. Looking at the incremental amount gap, having a significant portion of offset amount in the company's reduction emission strategy is becoming questionable. On the other hand, there is no absolute standard of how much

percentage of emission that company can offset using a carbon trading mechanism compared to its own initiatives. Every company may have its own understanding of how much voluntary carbon credits can take part in its Net Zero Emission programs (Blaufelder et al., 2020). There are some skepticisms about using carbon credits in the decarbonization strategy. The big question is the doubt for the company to make further efforts in emission reduction if they have the other option using offset programs in achieving their net zero emission target. One of the solutions to this problem is a consensus between companies to create principles that will be clear guidance for them to utilize offsetting programs as part of their NZE journey (Blaufelder et al., 2021). Therefore, carbon trading can be one of the best solutions, specifically in 2023 when the additional reduction needed is relatively low (1.16%). At the same time, Pertamina should develop and establish clear guidance for using carbon credits responsibly that will be used as a clear pathway in deciding the portion of carbon credits from 2025 onwards. Oil and gas companies rely heavily on offsets to comply their net-zero targets as a result of their unavoidable future emissions in the coming years (Arnold & Toledano, 2023).

Beside carbon trading, another way out is to make additional emission reductions from another major polluter. As seen in Figure 9, total emission from the IML business unit was relatively significant, with 12% in 2022 and 11% in 2030. However, as described in Figure 6, the projected annual contributions of IML in the emission reduction initiatives were very small, only 1.21% in the short term (2022-2025) and 0.23% in the mid-term (2026-2030). Thus, the additional initiatives specific to the IML business unit needs to be addressed as soon as possible. It can reduce the gap in other business unit, such as upstream business unit.

Figure 9

Pertamina’s Scope 1 & 2 GHG Emissions Projection for All Business Unit



Note : Emission Projection based on Business As Usual (BAU) Scenario. From *Pertamina NZE Roadmap 2022-2060* (p. 6), by Pertamina, 2022.

As discussed earlier, IML will focus on energy efficiency, particularly in implementing speed management and route optimization for the short and mid-term. However, another initiative in using alternative cleaner fuel is not detailed discussed in the roadmap. During Pertamina Energy Webinar, Mr. Wisnu from IML shared that besides energy efficiency, the focus of IML in the short and medium term will be converting the fuel of the vessel into LNG (Pertamina International Shipping, 2022). This strategy is most likely driven by the idea that for the same amount of power, LNG emits less quarter amount of CO₂ compared to conventional marine fuels (Pavlenko et al., 2021). Besides, alternative fuels such as biofuels should be considered by IML since this type of low-carbon fuel can be used in existing vessels (Connelly & Idini, 2022). In addition, IEA projected that biofuel will contribute half of the low-emission fuel in 2030 for international

shipping. Thus, IML should enhanced its focus not only on energy efficiency, but also on the possibility in using biofuel and LNG during short and medium term.

The technology development in shipping industry should be closely followed by IML as well. In December 2022, Airseas, French start-up company that concentrate in developing renewable energy shipping propulsion system, successfully installed seawing system in the vessels owned by Kawasaki Kisen Khaisa, Ltd. This seawing system is using kite technology that combined with automated flight control used by aerospace industry, resulting in the ship can utilize wind power to reduce its fuel consumption and the emission as well. The company claimed that this technology can reduce fuel consumption by 20% in average and can be installed in almost all type of vessels (Tamim, 2023). Therefore, this technology can be a good solution for short and mid-term for IML.

Furthermore, as shown in Table 9, 10, 11, 12, 13, and 14, some listed green business initiatives do not contribute to the emission reduction percentage. It can be caused by the data limitation, difficulty to quantify the contribution in the early stage of implementation, or less priority compared to current decarbonization initiative. As a result, the potential emission reduction caused by green business initiatives should be a subject for further research, specifically to see their contribution in filling the gap in the short-term and medium-term.

Emission Intensity Trend

After discussing the possible way to fill the gap between target and reduction initiatives in the previous section, the next critical point is analyzing whether the emission reduction target for the upstream business unit still reflects the standard practice in the upstream industry. As discussed before, comparing the trend of absolute emission reduction can lead to a bias since every company

has its own production profile and strategy. Therefore, as explained in methodology, researcher used emission intensity reduction data to do the fair comparison with major oil and gas producers and OGCI target as well.

Based on its net emission reduction target, the upstream business unit has created a pathway to reduce its emission intensity. However, this parameter is not becoming a specific target and is not stated in the NZE roadmaps document. As shown in Figure 8, based on its Business As Usual (BAU) scenario (orange line), the projected annual emission intensity will be decreased from 54.1 kg CO₂e/ BOE in 2022 to 38.7 kg CO₂e/BOE in 2030 despite its production will be increased from 2022. It means that the emission intensity in 2030 will reduce by 28% from 2022, with a reduction rate of about 3-4% a year. This statistic shows Pertamina has made good progress in the current operation's practice before implementing NZE roadmap, even though it is not enough to catch up with the NZE target. Considering the NZE roadmap target, Pertamina has to do an acceleration of reduction starting from 50.32 kg CO₂/BOE in 2022 to only 26 kg CO₂e / BOE in 2030 (blue line), or about 48% reduction in 2030 compare to 2022 rate, or about 6% reduction per year.

After calculating the reduction rate of emission intensity, the researcher created a benchmark with the major players in the upstream industry who has established scope 1 and 2 emission intensity target. Those companies are Conoco Phillips, Exxon Mobil, Chevron, Saudi Aramco, and Petrobras, which were chosen since other major companies in the upstream industry have straightly scope 1,2 and 3 net zero emissions targets. Besides, the researcher was also adding a target from Oil and Gas Climate Initiative (OGCI). OGCI is a CEO-led initiative that consists of the 12 largest oil and gas producers in the world that support the Paris Agreement and work collaboratively to accelerate the transition to low carbon in the future. They have created an

ambitious target to reduce methane emissions to well below 0.20% and an upstream carbon intensity target of 17.0 kg CO₂e / boe in 2025.

Table 15

Comparison of Emission Reduction Target and Emission Intensity Target from Various Oil and Gas Producers and OGCI

Company / Org	Short to Medium Target	Calculated Annual Emission Intensity Reduction Target
Pertamina	Emission reduction 32% in 2030 compare to 2022	6%
Conoco Phillips	Reduce GHG intensity 40-50% in 2030 relative to 2016 baseline	2.9% - 3.5%
Exxon Mobil	40-50% reduction in upstream greenhouse gas intensity in 2030 vs 2016 levels	2.9% - 3.5%
Chevron	40% reduction for oil and 26% reduction for gas in upstream carbon intensity in 2028, compare to 2016	3.33 % for oil and 2.17% for gas
Saudi Aramco	Reduce upstream carbon intensity by at least 15% by 2035, against our 2018 baseline	0.88%
Petrobras	Total operational emissions reduction target to 30% by 2030 compared to 2015 Reducing methane emissions intensity in upstream activities to 55% by 2025 compared to 2015	2% for total operational emissions 5.5% for methane emission in upstream
OGCI	Reduce carbon intensity of their upstream oil and gas operations from 23 kg of greenhouse gases per barrel of oil equivalent in 2017 to 17 kg by 2025	3.26%

Note : Annual Emission Intensity Reduction Target was synthesized from each company's open online information

As seen in Table 15, most of the companies and organizations have declared their own emission intensity reduction target within the 2.17% - 3.5% range. The outliers are only Saudi Aramco which only declared 0.88%, and Petrobras, which declared 5.5% methane emission for its upstream business unit. In addition, IEA also projected that in 2030, the global average of scope 1 and 2 emission intensity from oil and natural gas production would be about 45% than its 2018 level (IEA, 2020). It means that, on average, the annual emission intensity reduction is about 3.75%, which is still a close range of what most companies use. Using this 2.17 – 3.5% range, it means that Pertamina's target for emission intensity reduction (6%) is about double of industry's practice. Understandably, Pertamina's target is forced by the national target, which mandates 32% emission reduction in 2030. IEA also emphasizes the reduction of scopes 1 and 2 as fundamental steps in achieving the NZE target (International Energy Agency, 2020). However, without any specific additional strategy to further reduce the emission, it will conclude that only offset strategy can fill the reduction emission gap.

Conclusion

The results indicate that the energy efficiency initiatives will be the highest contributor to emission reductions in the short term (2022-2025) and the second highest contributor in the mid-term (2026-2030). The loss reduction initiatives, such as flaring and venting reduction, will dominate the mid-term period, followed by green power generation initiatives, both in the short-term and mid-term. Looking at the type of initiative used, Pertamina is on the right track compared to various studies and research on decarbonization initiatives. However, some clear warnings should be addressed by Pertamina, specific to gas flaring reduction high expectation in the R&P business unit and CCUS high expectation in the upstream business unit. Although the long-term

period initiatives are only discussed at a glance due to data limitations, it is clearly seen that CCUS will have the most prominent role in the long-term emission reduction plan. Thus, the extra effort in research, development, and cooperation with leading players specific to CCUS technology should be conducted promptly.

After deep diving into the upstream business unit that will be the biggest emitter in the short and long term, the declared emission reduction initiatives will only account for 58% of the NZE target. Thus, there will be a gap between the emission reduction target based on the NZE roadmap and with emission reduction target based on declared initiatives. Some ways can be proposed to overcome the gap. The first is using carbon trade in a particular year, especially in 2023, when the gap is only 1.16%. However, Pertamina is expected to use carbon trading to cover only some of the gap from 2025 onwards because the gap is relatively high, about 30%, and will increase significantly to 60% in 2030. Beside carbon trading, Pertamina can increase the emission reduction effort in the IML business unit, whose emissions contribution in 2022 was about 12% and in 2030 about 11%. Beside energy efficiency, alternative cleaner fuels such as biofuel and LNG should be considered further in the IML business unit during the short and mid-term period.

In addition, there are many green business initiatives whose contribution still cannot be calculated due to data limitations, difficulty in quantifying the contribution in the early implementation stage, or less priority compared to current decarbonization initiatives. Therefore, there is potential for further research on the green business building contribution in Pertamina's NZE roadmap, specifically to fill the gap during the short and mid-term periods. It is also critical to note that the emission reduction percentage to comply NZE target, which is 32%, is considered very high compared to the industry standard. Using the emission intensity reduction calculation,

Pertamina's expectation of reducing its emission intensity by about six percent per year is, unfortunately, double of industry standard.

Overall, this research has answered the research question and demonstrated the hypothesis declared by researcher was right. Although the energy efficiency was projected to become the major contributor, the announced decarbonization initiatives are not effective enough to cover all of the emission reduction targets in the upstream business unit because it's only cover 58% of the target. This research will give a broader view to Pertamina in realigning its strategy and target to achieve the NZE target in 2060.

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