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MORALITY BEFORE KNOWLEDGE

Assessing transition risks and financial implications of emission reduction in FMCG companies under Indonesia's ENDC framework

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ABSTRACT

Background: Indonesia has committed to limiting global temperature rise to below 2°C through Enhanced Nationally Determined Contribution (ENDC), impacting emission-intensive sectors like Fast Moving Consumer Goods (FMCG). PT X faces transition risks from carbon surcharges and emission reductions to meet ENDC targets. This study analyzes these risks, showing the company must reduce emissions to avoid additional costs and comply with ENDC. **Methods:** This paper uses qualitative and quantitative methods to assess transition risks for FMCG companies, focusing on carbon emission reduction policies. The quantitative analysis involves calculating climate financial risks through scenario analysis, while the qualitative approach analyzes regulations and sustainability reports. The study uses a bottom-up approach to assess emissions in Scope 1 and 2 and applies sensitivity analysis to evaluate the financial impact of emission reduction policies. **Findings:** The scenario and sensitivity analysis shows that if PT X conducts operational activities in accordance with Business as Usual (BAU) for a 1.6% reduction in emissions, the company will experience an emission deficit (emissions above the ENDC target), which raises additional carbon costs of USD 21,199.91 tons CO_2eq per year by the company. Meanwhile, in the scenario analysis and sensitivity analysis, the minimum level the company must reduce its emissions by 1.9% to get an emission surplus (emissions below the ENDC target). **Conclusion:** To reduce the impact of transition risk, companies can invest in the development of environmentally friendly technologies, and switch to renewable energy. The sale of carbon credits from surplus emissions can also be used by companies to cover carbon costs and mitigation actions. **Novelty/Originality of This Study:** This study lies in its application of climate financial risk analysis to assess the transition risks faced by Indonesia's FMCG industry, providing a quantitative evaluation of emission reduction thresholds and their financial implications under the ENDC framework.

KEYWORDS: enhanced nationally determined contribution (ENDC); fast moving consumer goods (FMCG); scenario analysis; sensitivity analysis; transition risk.

1. Introduction

Economic development in the industrialized world increases along with the increase in human needs (Fang et al., 2022; Jie et al., 2023; Liu et al., 2022). This dynamic reflects how economic activities, consumption patterns, and efforts to fulfill human needs have a direct impact on global environmental conditions. Exploitation of natural resources is often used only to meet economic needs without regard to their sustainability (Mihajlović & Đorđević, 2022; Tietenberg & Lewis, 2023). Since the industrial revolution in 1950, global resource consumption has experienced a marked increase, both in terms of quantity and types of

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resources used. According to data from Krausmann et al. (2009), about 68 billion metric tons of materials (biomass, fossil energy carriers, ores and industrial minerals and construction minerals) were extracted in 2009, which is almost ten times the amount used in 1900, with increases ranging from four times (biomass) to more than 40 times (construction minerals). In line with this, global energy consumption trends show an increase of up to 1.1% through 2030. The increase is included in the total energy consumption (TFC) of 442 EJ, which is divided into the industrial sector of 167 EJ, the construction minerals sector of 133 EJ, the transportation sector of 116 EJ, and other end uses of 27 EJ (International Energy Agency, 2023a).

Most of the global energy consumption is still dominated by fossil fuel sources, with one of the largest uses coming from coal. Global coal demand in 2022 reached 8.42 billion tons (Bt). This number has increased by 4% from the previous year from both the power and non-power sectors. The average increase in coal demand occurs in the Asian region, especially countries with large industrial growth such as China and India (International Energy Agency, 2023b).

The use of energy consumption, especially in industry, will produce residual emissions that are carried into the atmosphere (Buck et al., 2023; Munsif et al., 2021). The use of land for processing plantation activities also creates waste that is harmful to the environment (Kusnadi et al., 2025). One example in the FCMG industry, with products that fulfill daily food needs, is highly dependent on raw materials obtained from plantation and agroforestry products. Agricultural production produces residual gases in the form of CO_2, CH_4, and NO_2 as the three largest contributors to global warming and climate change (Maamoun et al., 2020). Extraction and processing of product raw materials will also generate polluting waste (Clauser et al., 2021). In addition, the burning of fossil fuels to generate electricity and drive machinery as part of industrial processes can produce harmful pollutants. In this case, the global food system is responsible for approximately 21-37% of annual emissions (Lynch et al., 2021). Along with these uses, there are negative impacts on the environment and health. Pollutants such as sulfur dioxide (SO_2), nitrogen dioxide (NOx) and other particulate matter have the potential to cause long-term human health problems such as respiratory diseases, heart problems, and cause premature death (Maamoun et al., 2020).

Climate change is one of the biggest challenges, where this phenomenon refers to long-term changes in weather patterns and global temperatures caused by human activities and natural factors (Mokhov, 2022; Naz et al., 2021). The environmental impacts of climate change include disasters or extreme weather, rising sea levels due to global warming, and disruptions to ecosystems (Cüce, 2023; Jha & Dev, 2024; Mariappan et al., 2023). Meanwhile, in the economic sector, climate change can affect infrastructure damage and market price instability, even potentially decreasing the selling price of an asset (World Bank, 2016). Developing countries are vulnerable to the impacts of climate change. With limited resources and state capacity, developing countries must make efforts using state capacity and international assistance to support climate change inclusiveness and adaptation (Hernández-Delgado, 2015). Therefore, the UNFCCC has bound countries in the world to sign a global commitment to reduce carbon emissions as an effort to mitigate climate change. The commitment is contained in the Paris Agreement by limiting global temperature rise to a minimum of 1.5 degrees Celsius and below 2 degrees Celsius in the pre-industrialization period (Nofansya et al., 2023).

In the alignment of ENDC policy, several sectors have been identified as contributors to carbon emissions in Indonesia (Hastuti, 2024). There are 5 sectors set as reference in carbon emission reduction, namely in the energy sector, waste sector, IPPU, agriculture, and FOLU (Forestry and Other Land Use) sector. Of the five sectors, energy contributes the largest level of greenhouse gases compared to other sectors. Through the country's capacity and capability (CM1), in the energy sector, the GHG emission reduction that can be done is 12.5% of the total BAU. Meanwhile, by using international assistance (CM2), the country can reduce carbon emissions with a target of 15.5% of the total BAU. This policy encourages adjustments to management and future development goals. Changes from the limitation policy create transition risks, which can affect the financial, market and operation risks of a

production (Habib, 2024). Therefore, conducting environmental risk management is very important to determine the potential risks so that mitigation actions can be taken with the aim of reducing the negative impact of these potential risks. This paper will discuss the transition risk, from the implementation of ENDC Indonesia, through the identification of potential risks that will be faced in the business process of FCMG industry. The risk will be quantified in the form of financial risk, by allocating resources that can be considered as a risk profile in the management of enterprise risk management.

2. Methods

This paper will calculate the transition risk scenario for FMCG companies, using qualitative and quantitative methods. The value quantification process is carried out using climate financial risk. While the qualitative method is used to provide a descriptive description and analysis of data using related regulations and literature, based on journals and company sustainability reports. The transition scenario is carried out over a period of 9 years from 2021 to 2030, in line with the provisions of Indonesia's Enhance National Determined Contribution (ENDC). The assessment of climate financial risk is carried out by identifying risks that could potentially arise due to the low-carbon transition process, mapping and measuring risk sources, calculating risks, and conducting risk management. The method is mapped based on the following Figure 1.

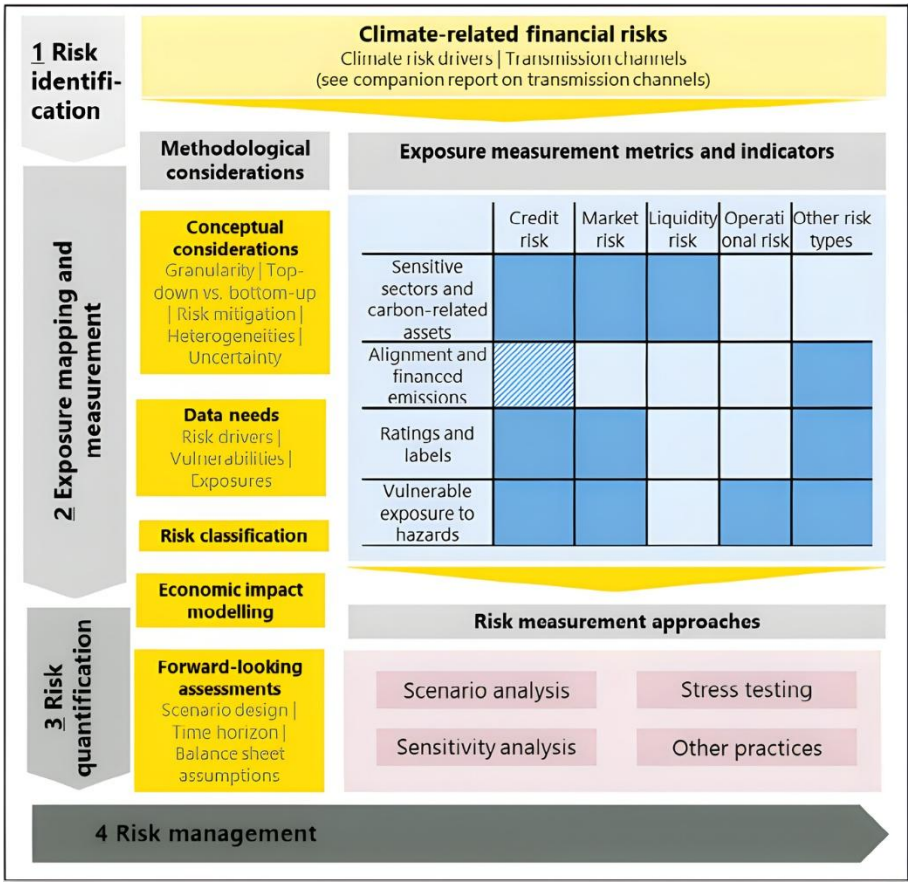

Fig. 1. Measurement methodology on financial risk
(Bank for International Settlements, 2021)

The measurement methodology on financial risk begins with the transition risk scenario, which considers the impact of low-carbon emission policies on economic activities within the framework of a low-carbon economy. Policies related to carbon emission reduction targets are assumed to lower the company's financial profile, as businesses are required to adapt operations and potentially incur additional costs. The Pollutant Pay

Principle is applied as an additional carbon cost through the imposition of a carbon tax on companies whose emissions exceed the reduction targets set in Indonesia's Enhanced Nationally Determined Contribution (ENDC). Another factor in the methodology is the existence of trading in the international carbon market through the Emission Trading System (ETS), with carbon prices assumed based on benchmarks from Asian countries such as China and Korea. The risk identification stage involves mapping risks into categories such as risk drivers, transition risks, and transmission channels, which ultimately influence the overall financial risk. This process is illustrated in the following diagram.

The concept used in assessing carbon emissions uses a bottom-up approach based on the electricity sector. The scope used in this paper includes scope 1 and 2. The analysis in scope 1 is carried out in calculating emissions directly sourced from company activities. Direct emissions come from the company's three main activities: stationary combustion emissions, emissions from land use change and plantation inputs, and waste emissions, which account for 82% of total emissions. Meanwhile, scope 2 calculations are carried out on indirect emissions in the production process. In this paper, indirect emissions come from power plants used to fulfill the company's operational processes, which account for 18% of the total emissions produced.

The data used in this study is Tier 2, by collecting emissions data from publicly available sources, namely in the sustainability reports of FMCG companies. Based on the emission reduction assumptions, a financial risk analysis was conducted using scenario analysis to assess the impact on the company's finances when a carbon emission reduction policy is implemented. A sensitivity analysis approach is then used to evaluate the influence of various factors. The sensitivity analysis in this paper is conducted using a scheme where the company must purchase excess carbon emissions through the ETS, compared to the sensitivity scenario if the company chooses to reduce emissions at BAU. The complexity of the nature of the risk will determine the company's risk profile. Risk level analysis is carried out by reviewing the results of the quantification of the company's financial risk, so that the company can determine the extent of risk that is ready to be faced (risk appetite) and the maximum acceptable risk limit (risk tolerance).

3. Results and Discussion

3.1 Risk analysis

The Paris Agreement has provided significant impetus for countries worldwide to formalize their commitments to reducing greenhouse gas emissions (GHG) through mitigation actions. This global framework has driven Indonesia to establish its Nationally Determined Contribution (NDC) policy, which was updated in 2021 to target five key sectors: energy, waste, industrial processes and product use (IPPU), agriculture, and forestry and other land use (FOLU). The alignment of these policies has the potential to impact corporate management, necessitating a shift from business-as-usual (BAU) practices to the implementation of emission reduction strategies in line with predetermined targets.

One of the sectors significantly affected by Indonesia's NDC policy is the Fast-Moving Consumer Goods (FMCG) industry, which comprises companies that supply essential consumer products. The FMCG industry has experienced rapid growth, driven by increasing consumer demand and strong market interest, a trend further amplified by Indonesia's rising population. Consequently, the FMCG sector has evolved into a major industrial segment (Susilo et al., 2023).

Table 1 Total emissions of PT X for the period 2021-2023

Emissions Data	Emissions in ton CO_2eq	Percentage decrease
2021	1,880,000.00	
2022	1,840,000.00	2.13%
2023	1,820,000.00	1.09%
Average decrease		1.61%

The operations of PT X, Tbk encompass the entire production chain, from raw material processing to the distribution of final products ready for the market. According to its Sustainability Report, the company has adopted environmentally friendly technological innovations to support a low-carbon economy. Based on a comprehensive risk assessment, the total emissions generated by PT X during the 2021–2023 period have been recorded and are presented in Table 1.

Based on Table 1, PT X successfully reduced its emissions from 1,880,000 tons of CO_2eq to 1,840,000 tons of CO_2eq, representing a 2.13% decrease from 2021 to 2022. Since 2021, PT X has actively contributed to the Sustainable Development Goals (SDGs) through the implementation of sustainability policies and programs aimed at balancing corporate growth with various sustainability initiatives that support SDG achievement. During the period from 2022 to 2023, PT X, through its four business segments comprising branded consumer products group, Bogasari Group, agribusiness group, and distribution group, achieved a further emission reduction of 1.09%. In 2022, PT X began integrating Environmental, Social, and Governance (ESG) principles as a key framework for establishing corporate performance indicators. The implementation of ESG in 2022 received positive responses from both internal and external stakeholders. Furthermore, in the same year, the Bogasari Group received international recognition at the Global Clean Energy Action Forum in Pittsburgh, United States, for its achievements in decarbonizing its supply chain and implementing digital automation systems to integrate production outputs with energy management systems.

3.2 Scenario analysis

The scenario analysis in this paper is conducted by developing emission reduction scenarios based on Business as Usual (BAU) projections, which are then compared to emission reduction scenarios designed to meet the Nationally Determined Contribution (NDC) targets. The baseline period spans from 2021 to 2023, with projections estimated through 2030 using both the BAU framework and the NDC target for 2030. The NDC target is derived from an emission reduction of 15.5% in the energy sector under the CM 2 scenario (utilizing an international scheme). This approach aligns with Article 6 of the Paris Agreement, which stipulates that through cooperative mechanisms, entities can voluntarily account for their mitigation outcomes in the international sector to contribute to nationally determined emission reduction targets (United Nations, 2015). Consequently, the emission reduction under the Enhanced Nationally Determined Contribution (ENDC) scenario is projected at 1.72% annually.

Table 2. Scenario analysis components

Components	Value	Unit	Source
Total Emissions	1,880,000.00	ton CO_2eq / year	PT X Sustainability Report 2021
ENDC Indonesia Energy Sector (CM2) until 2030	15.5%	Percent	ENDC Indonesia
Annual ENDC Reduction	1.72%	Percentage per year	ENDC Indonesia
Carbon Tax	30	Rp/kg CO_2eq	HPP Law Number 7 of 2021
Carbon Tax	30,000	Rp/ton CO_2eq	HPP Law Number 7 of 2021
Carbon Tax	2	USD/ton CO_2eq	1 USD is equivalent to 15,000

To quantify the cost associated with the emission gap between the BAU scenario and the NDC target, carbon pricing is applied. The carbon tax rate, as stipulated in Law No. 7 of 2021 on the Harmonization of Tax Regulations (UU HPP), is set at IDR 30 per kg CO_2eq, equivalent to IDR 30,000 per ton CO_2eq. This paper converts the cost quantification to USD, assuming an exchange rate of IDR 15,000 per USD, resulting in an estimated carbon tax of USD 2 per ton CO_2eq. The carbon tax is levied on entities that generate carbon emissions.

Its primary objective is to provide economic incentives that encourage individuals, companies, and governments to reduce carbon emissions as part of climate change mitigation efforts. Carbon taxation is considered an effective tool for achieving emission reductions at the lowest possible cost. This concept is rooted in the "polluter pays" principle, wherein entities responsible for environmental damage are required to bear the associated costs (Baranzini & Weber, 2023). The components of the scenario analysis are presented in Table 2.

The analysis shows that BAU emissions have decreased by 1.61% every year until 2030. Meanwhile, in the ENDC scenario, the emission reduction target is up to 15.5% by 2030. In 2022 or the first year after the baseline, emissions amounted to 1,840,000 tons CO_2eq. The total emission is below the NDC target of 1,847,664 tons CO_2eq. When compared to the following years, from 2023 to 2030 the total emissions each year are above the ENDC target limit. A comparison of BAU and ENDC emission reduction results is shown in Figure 2.

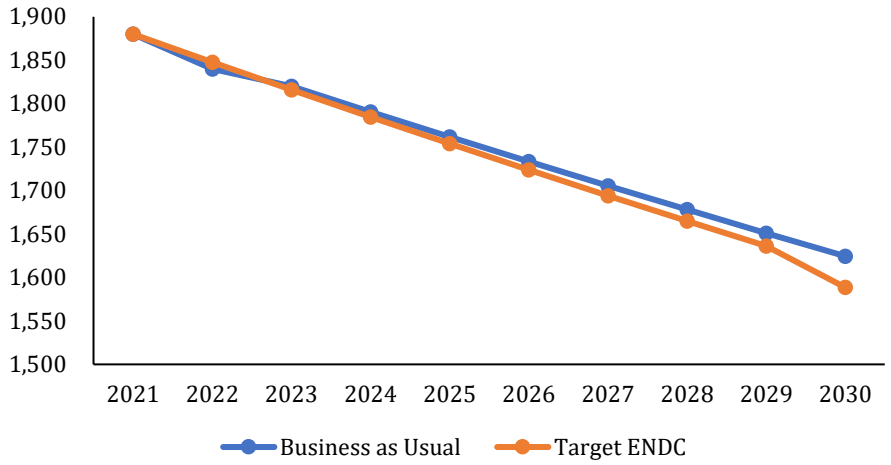

Fig. 2. BAU simulation graph with ENDC targets

A carbon tax is imposed when the level of emissions under the Business-as-Usual (BAU) scenario exceeds the targets stipulated in the Enhanced Nationally Determined Contribution (ENDC). The calculation of this tax is based on the excess emissions generated beyond the allowable threshold, with the monetary value determined by the prevailing carbon price. As shown in Table 3, the scenario analysis quantifies the total financial implications using a carbon price of USD 2 per ton CO_2eq, derived from the difference in CO_2 emission reductions under various reduction scenarios.

Table 3. Carbon pricing scenarios based on carbon taxes

Year	BAU emissions - 1.61% CO_2eq in tons	ENDC (-15.5% in 2030 Equivalent to 1.72%/year) CO_2eq in tons	CO_2eq difference in tons	Carbon Pricing (Assumed price of 2 USD per ton of CO_2eq)
2021	1,880,000	1,880,000		
2022	1,840,000	1,847,664	(7,664.00)	(15,328.00)
2023	1,820,000	1,815,884	4,115.82	8,231.64
2024	1,790,698	1,784,651	6,047.03	12,094.06
2025	1,761,868	1,753,955	7,912.79	15,825.58
2026	1,733,502	1,723,787	9,714.74	19,429.48
2027	1,705,592	1,694,138	11,454.50	22,909.00
2028	1,678,132	1,664,999	13,133.63	26,267.27
2029	1,651,114	1,636,361	14,753.68	29,507.36
2030	1,624,531	1,588,600	35,931.41	71,862.81
Average			10,599.96	21,199.91

Based on Table 3, it is found that in 2022 the difference in emission reduction shows a negative value. This shows that in that year, the company has excess emissions of 7,664 tons CO_2eq. Meanwhile, when viewed from the average annual emissions, it shows a positive value. This value indicates that the average BAU reduction still exceeds the upper limit of emissions required in the NDC. If the company wants to align the emission reduction target using the ENDC target until 2030, then the company must reduce emissions by an average of 10,599.96 tons CO_2eq/year. Therefore, the company will have to pay an additional carbon tax of USD 21,199.91 tons CO_2eq/year.

3.3 Analisis Sensitivitas (Sensitivity Analysis)

Sensitivity analysis was conducted with two schemes, namely sensitivity to carbon price changes, and sensitivity to BAU changes. Table 4 shows the sensitivity comparison using the carbon price approach from the Emission Trading System (ETS) in the carbon markets of South Korea and China. The period used in the sensitivity analysis is 9 years, from 2021 to 2030. In this case, the carbon price in the ETS is assumed to be the same from the selling price and the purchase price, to get the value of the carbon price in the international market. The choice to base the analysis on the carbon price mechanism in China and Korea is based on the high carbon price in these countries for the international market, especially in Asia. The carbon price in China's ETS is USD 12.57 per ton CO_2eq, while the carbon price in South Korea's ETS is USD 6.30 per ton CO_2eq (World Bank, 2024).

Table 4. Sensitivity analysis based on carbon price comparisons

Year	BAU emissions - 1.61% CO_2eq in tons	ENDC (-15.5% in 2030 Equivalent to 1.72%/year) CO_2eq in tons	CO_2eq difference in tons	Carbon Pricing (Assumed price of USD 6.30 per ton of CO_2eq)	Carbon Pricing (Assumed price of USD 12.57 per ton of CO_2eq)
2021	1,880,000	1,880,000			
2022	1,840,000	1,847,664	(7,664.00)	(48,283.20)	(96,336.48)
2023	1,820,000	1,815,884	4,115.82	25,929.67	51,735.87
2024	1,790,698	1,784,651	6,047.03	38,096.28	76,011.15
2025	1,761,868	1,753,955	7,912.79	49,850.56	99,463.74
2026	1,733,502	1,723,787	9,714.74	61,202.88	122,114.31
2027	1,705,592	1,694,138	11,454.50	72,163.35	143,983.07
2028	1,678,132	1,664,999	13,133.63	82,741.90	165,089.79
2029	1,651,114	1,636,361	14,753.68	92,948.19	185,453.78
2030	1,624,531	1,588,600	35,931.41	226,367.86	451,657.79
Average per year				66,779.72	133,241.45

Based on Table 4, in 2022 the company has an excess carbon gap below the scenario in the ENDC target. This shows that in 2022, PT X has an emission surplus of 7,664 per ton CO_2eq, and has the potential to sell its carbon on the international market with an income of around USD 48,283.20 per ton CO_2eq up to USD 96,336.48 per ton CO_2eq. Based on the analysis conducted from the current time period (2021-2030), it shows a decrease in carbon per year, but the decrease is still above the ENDC emission target. Therefore, the company must pay for the excess emissions by purchasing carbon from companies that have surplus emissions, and have accredited emission reduction certifications both nationally and internationally. Assuming a carbon price of USD 6.30 per ton CO2eq following the South Korean ETS, the average additional annual carbon cost borne by the company is USD 66,779.72 per ton CO_2eq. While at an assumed price of USD 12.57 per ton CO_2eq following the carbon price in the Chinese ETS, the average additional carbon cost is USD 133,241.45 per ton CO_2eq. Based on this price, it can change following the international carbon market in the ETS scheme. Companies must manage emission reductions from their operations. This is so that the company can avoid significant costs due to changes in carbon prices in

the international market. From the results of the analysis in Table 4, further analysis was carried out by assessing the emission reduction under the company's BAU condition. Under normal BAU conditions, an average reduction of 1.61% will be carried out sensitivity analysis with a BAU reduction of 1.9% and 2%. The results of the sensitivity analysis at a BAU reduction of 1.9% are in Table 5.

Table 5. Sensitivity analysis based on a 1.9% decline in BAU

Year	BAU emissions - 1.9% CO_2eq in tons	ENDC (-15.5% in 2030 Equivalent to 1.72%/year) CO_2eq in tons	CO_2eq difference in tons	Carbon Pricing (Assuming a price of USD 12.57 per ton of CO_2eq)
2021	1,880,000	1,880,000		
2022	1,840,000	1,847,664	7,664.00	96,336
2023	1,820,000	1,815,884	4,115.82	51,736
2024	1,785,420	1,784,651	769.03	9,667
2025	1,751,497	1,753,955	2,457.95	30,896
2026	1,718,219	1,723,787	5,568.37	69,994
2027	1,685,572	1,694,138	8,565.39	107,667
2028	1,653,547	1,664,999	11,452.10	143,953
2029	1,622,129	1,636,361	14,231.50	178,890
2030	1,591,309	1,588,600	2,708.71	34,048
Average			4,705.08	ton CO_2eq/year
Average Emission Surplus			4,705,08	ton CO_2eq/year
Surplus Emission Sales			59,142,91	USD ton CO_2eq/year

Based on Table 5, the minimum level of the company must reduce emissions at BAU by 1.9%. This results in higher costs for mitigation actions to reduce emissions, and a reduction in carbon costs incurred under normal conditions. At a 1.9% reduction, the company could generate an average emissions surplus of 4,705.08 tons CO_2eq/year. With the surplus emissions, the company has the potential to sell emissions and earn USD 59,142.91 tons CO_2eq/year, assuming a carbon price of USD 12.5/ton CO_2eq. With this analysis, if the company can only reduce emissions by less than 1.9%, there is a financial burden on carbon costs that will be incurred if the emission deficit exceeds the target. Sensitivity analysis was also conducted on the 2% BAU emission reduction shown in Table 6.

Tabel 6. Sensitivity analysis based on a 2% decrease in BAU

Year	BAU emissions -2% CO_2eq in tons	ENDC (-15.5% in 2030 Equivalent to 1.72%/year) CO_2eq in tons	CO_2eq difference in tons	Carbon Pricing (Assumed price of USD 12.57 per ton of CO_2eq)
2021	1,880,000	1,880,000		
2022	1,840,000	1,847,664	7,664.00	96,336
2023	1,820,000	1,815,884	4.115.82	51,736
2024	1,783,600	1,784,651	1,050.97	13,211
2025	1,747,928	1,753,955	6,026.97	75,759
2026	1,712,969	1,723,787	10,817.51	135,976
2027	1,678,710	1,694,138	15,427.76	193,927
2028	1,645,136	1,664,999	19,862.79	249,675
2029	1,612,233	1,636,361	24,127.53	303,283
2030	1,579,988	1,588,600	8,611.53	108,247
Average			9,941.47	ton CO_2eq/year
Average Emission Surplus			9,941.47	ton CO_2eq/year
Surplus Emission Sales			124,964.31	USD ton CO_2eq/year

Based on Table 6, by reducing emissions by 2%, the company has the potential to generate surplus emissions during the period 2021 to 2030 with an average of 9,941.47 tons CO_2eq/year. This can be utilized by companies to sell surplus emissions through international trade under the ETS scheme. Assuming a carbon price of USD 12.57 per ton

CO_2eq, the company could potentially receive a profit from carbon sales of USD 124,946.31 tonsCO_2eq/year. This shows that if the emission reduction target in the company's operations is more than 2%, it will get a larger emission surplus and benefits from carbon credit sales. In relation to the company's overall operations, the greater the emission reduction target, the greater the cost of mitigation actions, so it is expected that profits from selling surplus emissions can provide additional finance for the implementation of mitigation actions.

4. Conclusions

Transition risks arise in the shift to a low-carbon economy, particularly through efforts to mitigate climate change by reducing greenhouse gas emissions. This risk involves policy changes, technological advances, market dynamics, and regulations implemented by the country. PT X faces the challenge of transition risks associated with emission reduction targets under the Enhanced Nationally Determined Contribution (ENDC) policy. The most significant risk affecting the operations of PT X is financial risk, including credit risk and market risk. The polluters pay principle policy that requires entities that produce emissions above the ENDC target are required to pay for their emission deficits with additional costs in the carbon tax.

An analysis was conducted to quantify the financial risk using scenario analysis and sensitivity analysis. In the scenario analysis conducted at normal BAU (1.6%), the company must reduce emissions by 10,599.96 tons of CO_2eq/year, with additional carbon costs to be borne by the company of USD 21,199.91 tons of CO_2eq/year through the carbon tax scheme. Meanwhile, sensitivity analysis was conducted to determine the level of financial risk using the carbon price comparison scenario and BAU emission reduction. In the international carbon trading scheme through the ETS, at a BAU reduction of 1.6%, the company gets additional costs to buy carbon amounting to USD 66,779.72/ton CO_2eq - USD 133,241.45/ton CO_2eq. To avoid significant carbon costs, PT X must reduce BAU emissions by a minimum of 1.9%, which is an acceptable risk to the company for the mitigation costs that may arise when increasing the emission reduction target. A reduction below BAU of 1.9% results in carbon costs that must be borne by the company. The maximum tolerance limit for emission reduction considering mitigation costs, at BAU is 2%, for companies to sell their surplus emissions. The greater the emission reduction target, the greater the mitigation costs. Therefore, it is expected that the company can benefit from the sale of surplus emissions to provide additional income for the implementation of mitigation actions.

In meeting the ENDC target, PT X can implement Environmental Social Governance (ESG) in the company's management. In addition, the company can invest in the use of environmentally friendly technology in its operational activities and implement a low-carbon economy with efficient use of electricity sourced from renewable energy for manufacturing and office activities. Companies can also collaborate with the private sector, government, international parties and communities to raise awareness of the impacts of climate change. A proactive approach can be taken to minimize negative impacts while capitalizing on the opportunities created by the shift to a green economy. This approach not only protects business sustainability but also makes a positive contribution to achieving global climate targets.

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Author Contribution

D.A.K designed the research framework, developed the methodology, and constructed the data collection instruments, conducted the field survey and gathered the environmental data from the relevant locations, performed data processing and spatial analysis using GIS-based tools, interpreted the results in the context of environmental science, and prepared the original manuscript. The paper was revised based on academic reviewers' feedback and finalized under the guidance of my academic supervisors.

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Data Availability Statement

Not available.

Conflicts of Interest

The author declare no conflict of interest.

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