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INDONESIA'S CARBON TAX: TO WHAT EXTENT IS IT EFFECTIVE IN ACHIEVING THE GOALS?

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ABSTRACT
Research Originality — This study offers another perspective on carbon taxation in Indonesia by presenting sector-specific estimates of potential revenue and emission reductions using a more grounded input-output framework. Unlike many studies that rely on macro-level assumptions, this research integrates detailed CO_2 emission data by sector and applies a forecasting approach to generate practical insights for policy implementation.
Research Objective — The main objectives are to estimate the carbon tax revenue that could be collected and to assess how much emission reduction could be achieved through this policy, particularly in relation to Indonesia's enhanced Nationally Determined Contribution (NDC) targets.
Research Methods — Using the 2016 input-output table enriched with a CO_2 satellite account, and applying the double exponential smoothing method to forecast future emissions, the study simulates the impact of a carbon tax set at IDR 30,000 per ton.
Empirical Results — The results indicate that annual revenue from the carbon tax could reach between IDR 25.195 trillion and IDR 25.21 trillion during the 2025–2030 period, totalling approximately IDR 151.19 trillion. By 2030, national emissions are projected to fall to 839.93 million tons of CO_2, which is 49.68% lower than the business-as-usual (BAU) level, 35.94% below the counter measure 1 (CM1) level, 31.33% below counter measure 2 (CM2), and 17.28% lower than projections without tax implementation.
Implications — These findings highlight the important—though not solitary—role of carbon taxation in closing the emission gap and supporting Indonesia's transition toward a low-carbon and climate-resilient economy. The approach used in this study may serve as a useful reference for other countries considering similar measures.

Keywords: Carbon tax, climate policy, emission reduction, Indonesia, input-output analysis, nationally determined contribution (NDC)
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INTRODUCTION

Indonesia's dedication to addressing climate change is shown through its substantial commitments, one of which is the ratification of the Paris Agreement. Indonesia is obligated to adhere to specific targets aimed at decreasing carbon emissions inside the country and combating global warming under its agreement. According to the Nationally Determined Contribution (NDC), Indonesia has committed to reducing its greenhouse gas emissions by 29 percent by the year 2030. With assistance from international sources in terms of technology and financing, this reduction could potentially reach up to 41 percent. Indonesia has demonstrated its heightened dedication by submitting an Enhanced NDC to the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC) by 23 September 2022. The emission reduction objective was unconditionally raised from 29% to 31.89%, and with foreign cooperation including technology and financing, it was boosted from 41% to 43% (Minister of Environment and Forestry, 2018; Indonesia, 2022).

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APPLICATIONS FOR PRACTICE

- Indonesia's carbon tax, particularly in the energy sector, could generate significant government revenue, potentially reaching IDR 23.61 trillion by 2025.
- The carbon tax can effectively reduce greenhouse gas emissions, aligning with Indonesia's climate goals, including the Enhanced Nationally Determined Contribution (NDC).
- Effective implementation by 2025 depends on industry preparedness, economic impact management, and public acceptance.
- The government should ensure industries are ready for the carbon tax by providing guidance and support.
- Continuously evaluate the tax's impact and adjust rates or coverage as needed.
- Educate the public about the benefits of the carbon tax to gain support and address concerns.

Indonesia, a major contributor to global greenhouse gas emissions, is facing international pressure to implement land-management reforms. This pressure has intensified following a severe regional haze crisis caused by extensive land and forest fires. The responsibility lies with the practices of palm oil, pulp, and paper production. The inexpensive method of slash-and-burn used to clear peatland results in the significant emission of carbon into the atmosphere.

Simultaneously, energy consumption substantially contributes to the accumulation of carbon emissions, which subsequently contribute to the development of greenhouse gases. Therefore, Indonesia's NDC places particular emphasis on the energy sector. Regarding this matter, implementing a carbon tax is a prompt and more suitable approach. Indonesia has enacted legislation that incorporates a carbon tax as a means to fulfil its commitments under the Paris Agreement. The carbon tax is regarded as a crucial element of sustainable growth and a mechanism to tackle the adverse impact of carbon emissions. The carbon tax will be implemented at a rate of IDR 30 per kilogram of carbon dioxide equivalent (CO2e). The strategy of implementing a limited carbon fee will be initiated in the Coal Steam Power Plant (PLTU) sector starting in 2022. Nevertheless, the implementation of the carbon market across all sectors has been delayed until 2025, when it is projected to be completely operational.

The carbon tax is crucial in Indonesia's plan to attain its NDC targets. The purpose of the tax is to minimize the release of greenhouse gases by increasing the cost associated with carbon dioxide emissions. This incentivizes firms to decrease their carbon emissions and allocate resources towards cleaner technologies. The Indonesian Government has implemented a comprehensive regulatory framework that includes the carbon tax, together with the updated NDC and multiple measures on carbon pricing (Indonesia Law Digest, 2021; Jaelani et al., 2024).

The contribution of the carbon tax towards meeting Indonesia's NDC targets can be substantial. Indonesia's most recent NDC report to the United Nations climate agency states that the country needs around $29 billion annually to fulfil its unconditional NDC targets by 2030. To fully accomplish this, the government would have to rely not only on carbon tax but also on market mechanisms such as cap and trade, with an annual rate of $80.5 per ton, similar to the rates observed in Finland and Norway. Indonesia's NDC targets might be partially funded by the carbon tax (Indonesia Law Digest, 2021).

The efforts should be measurable and run effectively. Hence, the inquiry arises as to whether Indonesia can attain the carbon emission reduction objective following the implementation of the Enhanced NDC, and how the execution of a carbon tax can bolster the attainment of the said objective. Consequently, the present study aims to: 1. Determine the approximate amount of carbon tax revenue that can be generated. 2. Assess the projected decrease in carbon emissions resulting from carbon tax policies and evaluate the extent to which these taxes can contribute to meeting emission reduction targets outlined in the NDC.

Indonesia's carbon tax will incentivize firms to reduce emissions by adopting cleaner technologies, directly supporting the country's NDC targets. Revenue from the tax may also provide crucial funding for climate initiatives, enhancing Indonesia’s compliance with its emission reduction goals. By applying the tax effectively across sectors, the policy is expected to yield measurable greenhouse gas reductions, aligning with Indonesia’s broader objectives for sustainable development and climate resilience.

LITERATURE REVIEW

A carbon tax is a type of carbon pricing levied on the carbon content or activities that emit carbon (Badan Kebijakan Fiskal, 2021b). It is levied on the carbon content of fossil fuels. The tax is imposed on the carbon emissions generated by the combustion of fossil fuels, including coal, oil, and natural gas. The main objective of implementing a carbon tax is to highlight the concealed societal expenses associated with carbon emissions. A carbon tax is a form of Pigouvian tax that is levied on activities producing negative externalities which refer to expenses paid by a producer that are not accounted for in the market price and are instead borne by society (Groosman, 1999; Rennert & Kingdon, 2019). The objective of this tax is to rectify market inefficiencies and absorb the societal costs associated with these activities. A carbon tax is implemented to mitigate greenhouse gas emissions by raising the cost of fossil fuels.

A carbon tax is crucial in mitigating greenhouse gas emissions. The objective is to dissuade the utilization of fossil fuels and promote a transition towards less environmentally harmful fuels, thereby restricting the emission of carbon dioxide (CO2) (Parry, 2019). Studies in some European countries indicate that carbon prices have a significant impact on reducing emissions (Shapiro & Metcalf, 2023; Jonsson et al., 2020; Prasad, 2022; Schmalensee & Stavins, 2017). A consensus among economists exists and states that carbon prices are the optimal approach to addressing climate change (World Bank, 2021, 2023).

The establishment of the carbon tax level in the United States resulted in actual price rises, as seen by the response observed (Kay & Jolley, 2023). Industries heavily relying on carbon, such as agriculture, extraction, transportation, utilities, and chemicals, may see a significant rise in product costs, ranging from 10 to 30 percent if a tax rate of $200 per ton of CO2 equivalent is implemented. Other sectors will also encounter price hikes, albeit to a lesser degree, as a result of rising input prices linked to taxes. Furthermore, the results obtained from modelling utilizing the Input-Output analysis tool indicate that companies operating under flexible pricing systems may experience a significant decrease in revenue due to implementing a carbon tax.

Introducing a carbon price in the power generation sector and its associated industrial chains has the potential to significantly decrease greenhouse gas (GHG) emissions, particularly in the United Kingdom (Gugler et al., 2020). Through the application of the regression discontinuities approach, the researchers discovered compelling and consistent data indicating that the implementation of a carbon tax may result in a significant decrease of 60% in overall emissions. Emissions experienced a 40% decrease between 2012 and 2016. Implementing a significant rise in the carbon tax rate may result in the exclusion of "dirty" coal from the market as it is replaced with "clean" gas. Carbon taxes can also raise significant revenue for governments, which can be used to counteract economic harms caused by higher fuel prices and also for environmental initiatives. It is then a powerful tool that can play a significant role in achieving climate goals.

A carbon tax can also reduce fiscal pressure due to declining state revenues, as in Iran (Moosavian & Zahedi, 2022). Moosavian and Zahedi aim to evaluate carbon tax policies in Iran amidst a state budget deficit due to declining oil exports and revenues. The analytical tool used is general equilibrium with non-linear equations. This research shows that the implementation of a carbon tax which is compensated by a policy of reducing labor income tax is effective in improving environmental quality as indicated by a reduction in pollutant emissions accompanied by an increase in welfare and employment opportunities.

A study examining the impact of a US carbon tax on the agriculture market demonstrates the adaptability of its implementation. In 2019, a carbon tax of $15 per ton of carbon dioxide equivalent (t-1 CO2-e) would be implemented. This tax would apply to entities like refineries, coal mines, and natural gas producers. The fee incrementally increased by $10 annually and could be adjusted based on the extent to which annual emission reduction targets were met or exceeded. The endeavour was deemed triumphant and anticipated to achieve the objective, namely by ensuring that the greenhouse gas (GHG) emissions remained at or below 10% of the GHG emissions recorded in 2016 (Dumortier & Elobeid, 2021). Implementing a substantial carbon tax (about $30 per ton of carbon or higher) on the agricultural industry in the United States has the potential to generate extra income for farmers by promoting the production of biofuels.

For carbon taxes to have a significant impact, the tax rate must be sufficiently high to incentivize alterations in consumption habits. Based on a comprehensive analysis of many countries and regions, the majority of tax rates have been insufficiently high to substantially effect on emissions (Haites et al., 2018). The research gathered data on 17 carbon taxes implemented in 12 different jurisdictions. The findings revealed that out of these levies, only six were effective in achieving actual reductions in emissions. The implementation of the UK's carbon price floor led to a substantial decrease in emissions. Furthermore, it indicates that to sustain political backing, market-oriented strategies such as carbon taxes should be complemented with non-market-oriented measures, such as public awareness of a sustainable economy and participation of political and grassroots constituents.

Carbon taxes are widely regarded as a highly effective strategy for mitigating and managing carbon emissions. They have been successfully adopted in several nations, including Japan, Australia, the Netherlands, Norway, Sweden, and Colombia. Implementing the increasing tariff blocks (ITBs) model results in greater welfare and social fairness through taxation compared to regular tariffs (Zhou et al., 2019). Block carbon plans are equally effective as regular carbon taxes in controlling carbon emissions. Implementing high levies on manufacturers can effectively alleviate their burden by incentivizing the use of low-carbon techniques.

Carbon taxes are a policy tool that is both environmentally and economically efficient. If accurately predicted and implemented, they have the potential to gain popular support and result in substantial reductions in emissions. In 1991, Sweden implemented a carbon tax of USD 30 per metric ton of CO2. Gradually, the tax rate escalated to USD 132 per ton of CO2, making it the most elevated carbon tax cost globally. Sweden successfully reduced CO2 emissions from the transport sector by 10.9% per year between 1990 and 2005 with the application of a carbon price (Andersson, 2019). The tax is imposed by considering the significance of the carbon tax's elasticity of demand for gasoline, which has been determined to be three times more than the price elasticity of gasoline demand. Over an extended period, customers tend to adapt more to tax increases than to equal price adjustments. This results in a transition towards the use of more fuel-efficient vehicles and alternate modes of transportation.

The planned trajectory of the carbon tax implementation in Indonesia delineates the steps, commencing with the establishment of legislation, followed by a preliminary carbon tax, and ultimately a comprehensive implementation by 2025. The strategy additionally incorporates the implementation of a carbon trading market and the intended extension of carbon taxes to other industries (Badan Kebijakan Fiskal, 2021b; Suryani, 2021). Nevertheless, the execution has been delayed on two occasions as a result of multiple obstacles that need to be addressed. The successful implementation of the carbon tax by 2025 hinges on the preparedness of the industry. Industries may face difficulties if they are not adequately prepared for the implementation of the carbon tax. The implementation of a carbon price may result in substantial economic consequences, especially for companies that largely depend on fossil fuels. Managing these repercussions and ensuring a fair transition could be a challenging task. Lastly, it is crucial to consider the public's acceptability and comprehension of the carbon tax. It is crucial to effectively convey the advantages of the carbon tax and promptly resolve any apprehensions.

Table 1 Multiplier Formula for Output, Income and Employment

Value	**Multiplier**		
	Output	**Income**	**Labor**
Initial Effect	1	h_j	e_j
First Round Effect	$\Sigma_i\alpha_{ij}$	$\Sigma_i\alpha_{ij}h_i$	$\Sigma_i\alpha_{ij}e_i$
Industrial Support Effect	$\Sigma_i\alpha_{ij}$-1-$\Sigma_i\alpha_{ij}$	$\Sigma_i\alpha_{ij}h_i$-h_j-$\Sigma_i\alpha_{ij}h_i$	$\Sigma_i\alpha_{ij}e_{ij}$-$e_j$-$\Sigma_i\alpha_{ij}e_i$
Consumption Induced Effect	$\Sigma_i\alpha^*_{ij}$-$\Sigma_i\alpha_{ij}$	$\Sigma_i\alpha^*_{ij}h_i$-$\Sigma_i\alpha_{ij}h_i$	$\Sigma_i\alpha^*_{ij}e_i$-$\Sigma_i\alpha_{ij}e_i$
Total Effect	$\Sigma_i\alpha^*_{ij}$	$\Sigma_i\alpha^*_{ij}h_i$	$\Sigma_i\alpha^*_{ij}e_i$
Flow-on-Effect	$\Sigma_i\alpha^*_{ij}$-1	$\Sigma_i\alpha^*_{ij}h_i$-h_i	$\Sigma_i\alpha^*_{ij}e_i$-e_i

Information:
α_{ij} : output coefficient
Hi : household income coefficient
e_i : labor coefficient
α_{ij} : Leontief's Inverse matrix open model
α^*_{ij} : Leontief's inverse matrix close model

Source: Daryanto (1990) in Sahara (2017)

Indonesia has announced its intention to reach the highest level of its national greenhouse gas emissions by 2030 at the international level (Indonesia, 2022). Simultaneously, it is investigating potential situations that could result in achieving net zero emissions by 2060 or earlier. Indonesia has successfully incorporated its long-term objective into essential planning documents in the energy and forestry sectors.

Indonesia can adopt a carbon tax as a means to decrease carbon emissions and create income for the government. The purpose of implementing a carbon tax is to incentivize industrial entities to transition towards environmentally friendly economic activities that have minimal carbon emissions. The study employs qualitative methodologies utilizing a content analysis framework to assess state income and mitigate carbon emissions resulting from carbon taxes in Indonesia. The findings indicate that the energy industry alone has the potential to generate IDR 23.61 trillion in state revenue by 2025 (Pratama et al., 2022). Additionally, it has proven to be beneficial in mitigating greenhouse gas (GHG) emissions, as observed in several other nations.

The implementation of a carbon tax in Indonesia, accordingly, is predicted to encourage both industries and consumers to reduce carbon footprint, thereby contributing to a significant decrease in greenhouse gas emissions. For the government, the carbon tax will become a substantial source of revenue, which could be reinvested in further environmental initiatives or cushion the economic transition.

METHODS

This research uses the main analysis tool, namely the 2016 input-output table published in 2021. This input-output table is the latest input-output table published by the Statistics Indonesia (BPS). Input-output (IO) analysis is one of the analytical tools that can be relied on to observe interactive relationships between economic sectors through the transaction coefficients formed therein (Badan Pusat Statistik, 2021).

Following the aim of this research, namely to determine the impact of imposing a carbon tax on energy use, this IO table was developed by adding a carbon emissions row to the other primary input technical row in the IO table structure. It aims to integrate carbon emissions from energy use into all 73 business sectors transactions. The author uses the table that has been constructed for the previous research on ICT carbon (Imansyah et al., 2023). The calculation of carbon emissions was carried-out based on energy use in each business sector with the assistance internal experts at BPS.

The potential impact of a carbon tax on energy is introduced through a shock to final demand. The amount of shock that will be applied is the value of the carbon tax for each sector. The impact of shocks has the potential to cause changes in the level of energy consumption and output simultaneously, which in turn affects the level of carbon emissions. The magnitude of these changes will be shown in the results of the energy IO table analysis.

The basic equation of the input-output matrix to use (Sahara, 2017) is:

$$AX + F = X \quad or \quad (I - A)X = F \quad \ldots\ldots (1)$$

Where:

A	:	Leontief input coefficient matrix n x n
X	:	Output vector
F	:	Final demand vector
I	:	Identity matrix whose elements contain the number one on the diagonal and zero on the other
(I – A)	:	Leontief matrix

Next, to proceed with the multiplier analysis and calculate the impact, this basic equation is reformulated again as:

$$(1 - A)^{-1}F = X \quad \ldots\ldots (2)$$

Where:

$(I - A)^{-1}$	:	Leontief input coefficient matrix n x n

The matrix (I – A) contains the technical coefficient element aij, while the matrix $(I - A)^{-1}$ contains the multiplier coefficient element αij. The final matrix containing the multiplier is what the author functionally operationalizes to obtain the value of the potential impact of implementing a carbon tax on carbon emissions.

As an illustration on Table 1 of how the response or multiplier effect works, the types and how it works mechanistically can be described. The multiplier effects of output, income, and employment can be classified as follows (Sahara, 2017):

1. Initial Impact

   The initial impact is the initial response to an external shock. The magnitude of the shock measured in monetary units can be an increase or decrease in demand. The initial impact on the output side is equal to one monetary unit of sales on final demand. This condition affects the primary input, namely the income side which is shown by the household income coefficient (hi) and the labor side by the labor coefficient (ei).

2. First-Round Effect

   The first-round effect is in the form of direct effects from transactions in each sector due to changes in output by monetary units. The magnitude of the effect of the first round of output is the direct coefficient value (input-output coefficient/αij). The first-round impact, due to effects on the output side, is (Σiαijhi) on the income side and (Σiαijei) on the labor side.

3. Industrial Support Effect

   The effect of industrial support on the output side is the effect of the second round of increased output. In terms of income and employment, the effect of industrial support shows the impact of increasing income and employment in the second and subsequent rounds due to industrial support that produces output.

4. Consumption-Induced Effect

   The consumption induction effect from the output side shows the existence of an induction effect (increased household consumption) due to increased household income. From the income and labour side, the consumption induction effect is obtained respectively by multiplying the output consumption induction effect by the household income coefficient and the labour coefficient.

5. Flow-on-Effect

   Follow-on effects are effects (from output, income, and employment) that occur in all economic sectors in a country or region due to increased sales from a sector. Flow-on-effects can be obtained by reducing the total effect from the initial effect.

There are two types of multiplier analysis, namely type I and type II Nazara in Sahara (Sahara, 2017). The formulation of these two types of analysis is as follows:

$$Type\ I = \frac{Initial\ Effect + First\ Round\ Effect\ + industrial\ Support\ Effect}{Initial\ Effect}$$

$$Type\ II = \frac{Initial\ Effect + First\ Round\ Effect\ + industrial\ Support\ Effect + Consumption\ Induced\ Effect}{Initial\ Effect}$$

Type II multiplier analysis also called the closed input-output analysis model has included households as an endogenous factor. Therefore, it displays not only direct and indirect effects of changes in exogenous demand factors, but also includes additional effects in the form of inductions from household factors. This model follows the principles of Miyazawa's I-O analysis which integrates household institutions into the intermediate demand matrix or as an endogenous variable. For this reason, researchers use a closed model or Type II multiplier analysis.

Forecasting techniques are also used in this research, apart from simulation through Input Output analysis. What needs to be predicted is the future level of carbon emissions until 2030 based on historical data published by BPS (Badan Pusat Statistik, 2022). Thus, forecasting is carried out using the double exponential smoothing forecasting technique. This method is used because of the graphical depiction of Indonesia's carbon emission data which contains Level and Trend, making it suitable for this method. The data fluctuates over time with certain trends.

An important step in data processing is to carry out data extraction in the construction of the input-output table. Through in-depth analysis, the level of carbon emissions produced by each sector is obtained. The results of this extraction are then integrated with data obtained from BPS publications on the same carbon emissions information. The integrated data becomes the basis for estimating the level of carbon emissions in the required period. Data on carbon emission levels in 2025 is a starting point for introducing a carbon tax shock through input-output analysis. The results of the analysis are presented to answer the questions based on the research objectives.

RESULTS AND DISCUSSION

The first aspect that needs to be understood is the existing condition of carbon emissions in Indonesia. Data on the condition of carbon emissions within the available period in Indonesia serves as the basis for calculating potential carbon tax estimates. After that, the effectiveness of the carbon tax will be estimated to support the achievement of the NDC target.

The Estimation of Carbon Emission Inventory

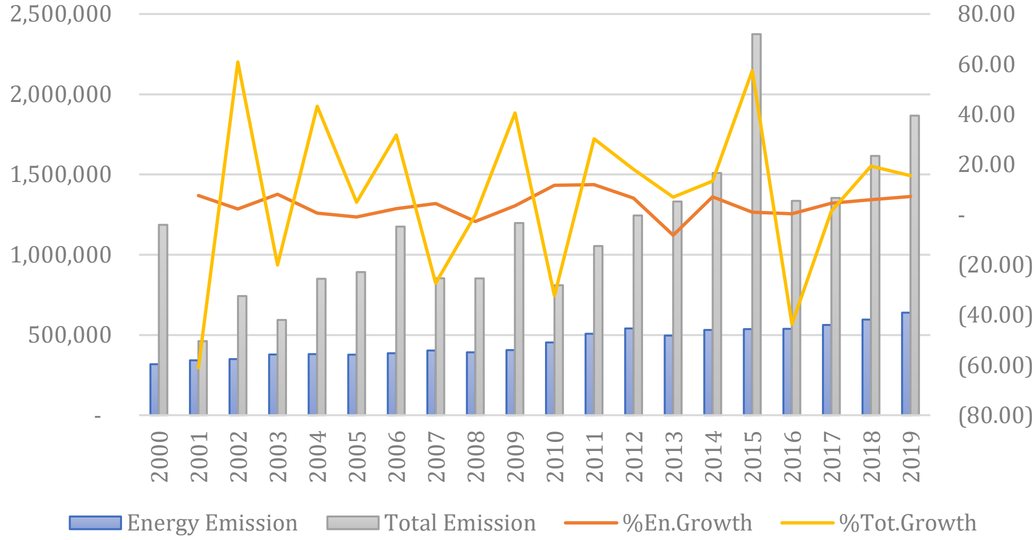
The development of carbon dioxide equivalent gas emissions from 2000 to 2019 tended to increase as shown in Chart 1. Sources of carbon emissions in Indonesia are divided into four major categories, namely the energy sector, the industrial product and product use (IPPU) sector, the agriculture-forestry and land use (AFOLU), and the peat fire and waste sectors. The energy sector is the most dominant sector among the sources of carbon emissions. This research focuses on sources of carbon emissions from the energy sector, considering that the upcoming carbon tax that will be implemented based on energy.

Chart 1 shows that the total carbon emissions were 1,186.23 million tonnes in 2000, of which 317.61 million tonnes came from the energy sector. Throughout the year, the total carbon emissions continued to increase but also experienced fluctuations and declines. The average growth rate of total carbon emissions during the 2000-2019 period was 8.35%, with 3.86% of emissions from the energy sector. There was a rapid increase in 2015, where total carbon emissions increased by 865.43 million tons or 57.35%. At the same time, emissions originating from energy reached 536.31 million tons, but the increase was not drastic compared to that of the previous year, namely 0.97%. The most significant decline occurred in the following year, namely 2016, with a change of -1,038.88 million tons or -43.75%. Until 2019, data showed that Indonesia's total carbon emissions were 1,866.55 million tons, while the energy sector's contribution was 638.31 million tons or 34.22%.

The forecasting carried out for the 2020 - 2030 period, shown in Chart 2, obtained results where total carbon emissions until 2025 are estimated to be 2,514.74 million tons. Meanwhile, in the same year, carbon emissions resulting from the energy sector were estimated at 840.37 million tons or 33.42% in share. The growth of total emissions will be 5.36% per year and the energy sector will grow to 4,32% of the annual emissions on average. Under existing trends, the increase is not drastic and even tends to be small. This condition occurs because control measures are carried out by all parties, with the government as the leading sector. According to the government, among the very influential factors are steps to use new and renewable energy as alternative energy to replace fossil fuel energy (Katadata.co.id, 2023).

This condition aligns with several studies showing the potential for a positive response from the community and business actors. Through various policies implemented, there is a shift towards green

Chart 1 Green House Gas Emission from the Energy Sector and The Total (Thousand Ton CO2e) 2000-2019



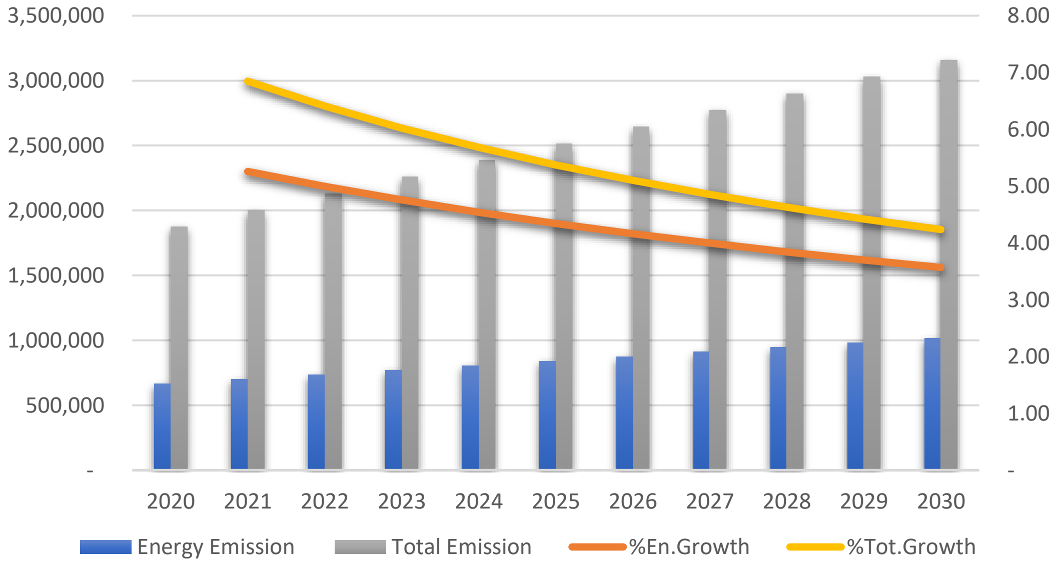
Source: Badan Pusat Statistik, 2021 (processed)

practices both in terms of consumption and production at various levels (Metcalf & Stock, 2020; Prasad, 2022). This condition resulted in the inventory of carbon emissions showing no significant spikes over the past period. This trend is predicted to continue until 2030, even though a carbon tax has not yet been implemented.

In the production structure of the Indonesian economy, represented by the input-output table, carbon emissions from energy use can be seen based on the sources of the business sectors that produced them. 73 business sectors in this input-output table model are categorized into four main sector groups. As shown in Table 2, the manufacturing sector is the largest contributor to all carbon emissions. The level of carbon emissions in this sector in 2025 is estimated at 754,90 million tonnes or 89,83% of all emissions totalling 840,37 million tonnes. This trend of large dominance of the manufacturing sector is also predicted to continue until at least 2030.

The characteristics of the manufacturing sector, which is more capital intensive, make it consume more energy. On the other hand, the economic scale contribution of the manufacturing sector is only around 19%

Chart 2 The Estimation of Green House Gas Emission from the Energy Sector and The Total 2020-2030 (Thousand Ton CO2e)



Source: Processed by the author

of the entire economic structure. Thus, the high carbon emissions from this sector in the production process are more influenced by the level of intensive energy use.

The service sector is the second largest contributor, but it lags far behind the manufacturing sector. The mining sector follows far below the services sector. Meanwhile, the agricultural sector has the smallest contribution. The distribution pattern of carbon-producing emission sources is essential in making policies. The implementation of a carbon tax will have different intensity impacts on each sector.

The Estimated Value of Carbon Tax to be Potentially Collected

The value of the amount of carbon emissions that can be estimated, combined with the tax rate of IDR 30,000 per ton, provides the basis for calculating potential carbon tax revenues. Throughout 2025 - 2030, it can be estimated that the value of carbon tax will be in the range of IDR 25,21 trillion and IDR 25,195 trillion (see Table 3). A downward trend can be seen due to the potential for carbon tax revenue coming from the amount of carbon emissions that continue to decline, assuming that the implementation of the tax can be effective. In line with the theoretical basis and research assumptions previously expressed, the existence of a carbon tax has the potential to reduce economic levels, especially in the short term. For this reason, the amount of carbon emissions will continue to decrease. Apart from that, there is a transition from fossil energy to green or environmentally friendly energy. In this estimate, there has been a consistent decrease in the potential tax value. In 2025, the potential value of the carbon tax is the largest, but it will continue to decline until 2030. This aspect must be a consideration for taking mitigation steps to help fiscal space in implementing policies that support society (Känzig et al., 2023; Moosavian & Zahedi, 2022; Prasad, 2022).

From the source, the value of carbon tax revenue is dominated by the manufacturing sector. This condition is aligning with the sector's contribution to producing carbon emissions in the air. Therefore, the sector that will be most impacted by the carbon tax is the manufacturing sector.

On the other hand, in terms of the goal of achieving the national determined contribution target, financing that supports climate control measures is crucial. The total predicted funding requirement until 2030 is IDR, 3,779,63 trillion. The financing need for the energy and transportation sector alone is IDR 3,500,00 trillion (Badan Kebijakan Fiskal, 2021a). This value, when compared with the carbon tax revenue estimated in this research, is significantly above estimates. The share or role of the carbon tax, which in 2025 - 2030 will total IDR 151,1902 trillion, is only 4,00% of the total financing needs or 4,32% of the financing needs in the energy and transportation sectors. This result shows that the gains obtained from the carbon tax are very far from the expectation to support Indonesia's climate control financing.

Table 2 Estimation of Carbon Emission Inventory by Sector 2025 – 2030 (MTon CO2e)

Sector	2025	2026	2027	2028	2029	2030
Agriculture	0.34	0.36	0.37	0.38	0.40	0.41
Mining	10.00	10.42	10.83	11.25	11.66	12.08
Manufacture	754.90	786.33	817.76	849.20	880.63	912.06
Service	75.13	78.25	81.38	84.51	87.64	90.76
Total	840.37	875.36	910.35	945.34	980.32	1,015.31

Source: Processed by the author

Table 3 Estimation of Potential Carbon Tax 2025 – 2030 (IDR, Trillion)

Sector	2025	2026	2027	2028	2029	2030
Agriculture	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102
Mining	0.2999	0.2999	0.2998	0.2998	0.2997	0.2998
Manufacture	22.6435	22.6399	22.6363	22.6327	22.6291	22.6327
Service	2.2534	2.2530	2.2527	2.2523	2.2520	2.2523
Total	25.2071	25.2031	25.1990	25.1950	25.1910	25.1950

Source: Processed by the author

Table 4 GHG Emission Inventory and Reduction Due to Tax Imposition 2025 – 2030

	Inventory (in Thousand Ton)		Reduction	
Year	Without Tax	With Tax	to Without Tax	%
2025	840,369.57	840,235.78	133.78	0.02%
2026	875,358.31	840,102.02	35,256.29	4.03%
2027	910,347.05	839,968.28	70,378.77	7.73%
2028	945,335.79	839,834.56	105,501.24	11.16%
2029	980,324.54	839,700.86	140,623.68	14.34%
2030	1,015,313.28	839,834.54	175,478.74	17.28%

Source: Processed by the author

The carbon tax is also influenced by the applicable tariffs. The predicted results of the carbon tax value follow the estimated results of the amount of carbon emissions that have been carried out multiplied by the declared tax rate. When compared with one of the previous research results, this value is slightly higher. The predicted value of the carbon tax that can be received as state revenue per year in 2025 is IDR 23,65 trillion (Pratama et al., 2022) slightly lower compared to the results of this research, IDR 25,195 trillion. Other research uses a much higher tariff rate, namely IDR 280,000, - (approximately $30) per ton of CO2e as a calculation that can stabilize emissions in Indonesia (Yusuf & Resosudarmo, 2015). These results are in line with the success of other countries, like Canada, Swedia, and others (Metcalf & Stock, 2020; Office of the Auditor General of Canada, 2022).

The Estimated Carbon Emissions Reduction Through Carbon Tax Policies

In this part, the amount of carbon emissions that can be reduced, while measuring the extent to which carbon taxes can support the achievement of emission reduction targets under NDC, is calculated. The existence of a carbon tax certainly affects the level of carbon emissions. A carbon tax is even considered to be a mainstay instrument in achieving this goal. Through simulation analysis in the input-output table, the magnitude of the impact of implementing a carbon tax at this rate on carbon emissions from each use of fossil energy can be obtained.

Table 4 compares the carbon emissions inventory between emission levels without the implementation of a carbon tax and those with a carbon tax in the period 2025 – 2030. The existence of a carbon tax can be seen to result in a reduction in the level of carbon emissions compared to conditions without the tax. The estimated level of carbon emissions in 2025 without the implementation of a carbon tax is 840,37 million tons, which will decrease to 840,24 million tons with the implementation of a carbon tax. This condition will result in a reduction of 0,13 million tonnes of CO2e. The effectiveness of the carbon tax in reducing emissions increased from 2006 to 2030. At its peak in 2030, the carbon tax succeeded in reducing carbon emissions by 175,48 million tons or 17,28% compared to without the carbon tax.

The reduction in carbon emissions cannot be separated from the role of the business sectors. The carbon tax applied to each business sector is transformed into additional costs that have an impact on the business activity chain, which in turn can reduce carbon emissions. The response taken is either in the form of reducing the use of fossil energy or switching to new and renewable energy. Throughout 2025-2030, each business sector has succeeded in reducing its carbon emission levels compared to the conditions if they are not taxed. In Table 5, of the total reduction in emissions that occurred, the role of the manufacturing sector was the largest. The average share of the manufacturing sector in reducing carbon emissions during this period was 89,93%. The role of other sectors was far below. In general, it can be concluded that a carbon tax has the potential to reduce carbon emissions at the level of business sectors.

Table 5 Estimation of Carbon Emission Reduction Due to Carbon Tax and Sectoral Share 2025 - 2030 (MTon CO2e)

Sector	2025	2027	2029	2030	Total	%
Agriculture	0.0001	0.0286	0.0570	0.0712	0.2139	0.04%
Mining	0.0016	0.8374	1.6733	2.0880	6.2752	1.19%
Manufacture	0.1202	63.2212	126.3222	157.6325	473.7387	89.83%
Service	0.0120	6.2915	12.5711	15.6870	47.1447	8.94%
Total	0.1338	70.3788	140.6237	175.4787	527.3725	100.00%

Source: Processed by the author

Following the carbon tax roadmap prepared in Indonesia, success indicators are oriented towards achieving the commitment to reduce carbon emissions as outlined in the NDC. The Enhanced NDC document mandates a reduction in carbon emissions from the energy sector to 1,311 MTon through independent efforts or 1,233 MTon with international assistance. This is a decrease in business as usual (BAU) conditions of 12,50% and 15,50%, respectively (Indonesia, 2022).

Based on inventory estimates, total carbon emissions would amount to 1,015 MTon in 2030, without the implementation of taxes (see Table 6). The problem is that the estimated value of the carbon emissions inventory is already lower than the estimated BAU value in the NDC, namely 1,669 MTon. This estimated result is even lower than the counter measure 1 (CM1) and CM2 targets, respectively of 1,311 MTon and 1,223 MTon.

This can be interpreted in two ways. The first aspect is that the carbon tax achievement is estimated to be lower than the target set to be achieved in the NDC. This result means that without any additional efforts, the carbon reduction target has been exceeded, amounting to 29.12% in CM1 and 20.46% in CM2; showing that throughout the period since Indonesia committed to the Paris Agreement (took effect), it has succeeded in achieving a reduction that exceeds expectations. On the other hand, setting the NDC target can be considered too pessimistic because it still sets the level of carbon emissions high. With more serious

Table 6 Comparison of 2030' Scenarios to Enhanced NDC Targets

SCENARIO	BAU 1,669	CM1 1,311	CM2 1,223	Without Tax 1,015	With Tax 839,83
CO2e Reduce to W/o Tax	654	296	208	0	-175.48
	64.38%	29.12%	20.46%	0.00%	-17.28%
CO2e Reduce to BAU	0	-358	-446	-654	-829.17
	0.00%	-21.45%	-26.72%	-39.17%	-49.68%
CO2e Reduce to CM1	358.00	0.00	-88.00	-295.69	-471.17
	27.31%	0.00%	-6.71%	-22.55%	-35.94%
CO2e Reduce to CM2	446.00	88.00	0.00	-207.69	-383.17
	36.47%	7.20%	0.00%	-16.98%	-31.33%

Source: Processed by the author

efforts and a stronger will, the carbon emission reduction target set could be even greater than the existing target.

If this achievement is added to the effect of implementing taxes, the estimated value of carbon reduction will be even greater. Total carbon emissions under the conditions of implementing a carbon tax will amount to 839,93 MT in 2030. This result is -49,68% lower than the BAU level, -35,94% lower than CM1 and 31,33% lower than CM2, and -17,28% lower than the estimated inventory of carbon emissions without tax implementation.

If the results of this estimate are used as an excuse, it could lead to the implementation of a less urgent carbon tax for Indonesia, if the implementation of the carbon tax is solely oriented towards achieving the NDC target. However, if it is connected to the actual problem of global warming, this effort must be a continued path.

Various aspects need to be further examined to sharpen the results of this research. When compared with countries that have successfully implemented a carbon tax, the existence of a carbon tax has a significant effect on carbon reduction. This condition is also shown by the estimation results in this research which are in line with the results of previous research. Carbon taxes are effective in terms of reducing carbon emissions. Nevertheless, practices in the field (in industries, mining, and transportation) need to be deepened through further research. This research approach, which is based on macroeconomic data, has limitations in searching for more detailed information. Accurate data in the field can enrich information that can be used as a basis for setting appropriate carbon emission reduction targets for Indonesia in the future.

Discussion

Total carbon emissions until 2025 are estimated to be 1,889,50 million tons with the energy sector being a dominant contributor (44,48%). The trend of the increase over time tends to be small. This trend is predicted to continue until 2030, even though a carbon tax has not yet been implemented. This condition happens because there are control measures carried out by all parties through the government as the leading sector. Among the very influential aspects are steps to use new and renewable energy as alternative energy to replace fossil fuel energy (Katadata.co.id, 2023). This is in line with several studies showing the potential for a positive response from the community and business actors. Through various policies implemented, there is a shift towards green practices both in terms of consumption and production at various levels (Metcalf & Stock, 2020; Prasad, 2022).

The potential amount of collectible carbon tax will consistently decrease because carbon emissions as the base of the tax will decline. This must be a consideration for taking mitigation steps to help fiscal space in implementing policies that support society (Känzig et al., 2023; Moosavian & Zahedi, 2022; Prasad, 2022).

The potential contribution of tax revenue to support Indonesia's global warming combat program at the current proposed tariff is very low. It is only 4,00% of the total financing needs, or 4,32% of the financing needs in the energy and transportation sectors. The estimated carbon tax revenue in this study is slightly higher than in previous research. Pratama et al. (2022) estimated IDR 23,65 trillion in 2025, while this study projects IDR 25,195 trillion. That is why other research believes in using a much higher tariff rate to stabilize emissions in Indonesia (Yusuf & Resosudarmo, 2015).

In terms of achieving a reduction in carbon emissions, carbon taxes have proven to be effective. This shows that the carbon tax is quite elastic towards energy demand which in turn is elastic in reducing carbon emissions. Concerning the emission reduction target that Indonesia has committed to in the NDC, some matters require synchronization. The results of forecasting based on historical carbon emissions inventories show that in 2030 the amount of carbon emissions will be below the reduction target agreed in the NDC, even without the implementation of taxes. This means that the targets set are still too loose. Meanwhile, the urgency of reducing carbon needs is fundamental. Therefore, further studies need to be carried out to determine the accuracy in setting targets that are appropriate for the actual situation in

Indonesia. The results obtained from input-output (I-O) table analysis exhibit certain weaknesses, particularly inherent in the methodology itself. I-O analysis relies on the assumption that technology remains constant, which, in reality, is not always the case. Industries experience dynamics that allow production patterns to vary and evolve. Consequently, carbon emission levels may grow disproportionately compared to the static assumption.

To address this limitation, future research should incorporate dynamic elements rather than relying solely on static analysis. For instance, employing a dynamic input-output model or other multi-period analysis frameworks would better capture the changing dynamics of industrial production.

Despite these limitations, I-O tables offer distinct advantages. They allow for tracking changes across entire industrial sectors, including production, value-added, and employment, in response to external shocks such as a carbon tax. Given their comprehensive coverage of various sectors, the aggregate impact on technological advancement levels remains moderate, avoiding drastic shifts. Moreover, I-O analysis has demonstrated its effectiveness in predicting emission reduction and tax revenue trends.

CONCLUSIONS

The tax revenue of carbon emissions that can be collected is estimated in the range of IDR 25,21 trillion and IDR 25,195 trillion per year during the 2025–2030 period (consecutive decrease). The total amount of the tax in this period will equal IDR 151,1902 trillion, which is only 4,00% of the total financing needs or 4,32% of the financing needs in the energy and transportation sectors of Indonesia's global warming combat program.

Implementing a carbon tax is estimated to be effective in greater reduction in carbon emissions. Total carbon emissions under the conditions of implementing a carbon tax will amount to 839,93 MT in 2030. Compared to indicators in the enhanced NDC document, this is -49,68% lower than the BAU level, -35,94% lower than CM1 and 31,33% lower than CM2, and -17,28% lower than the estimated inventory of carbon emissions without tax implementation. If the results of this estimate are used as an excuse, it could implement a carbon tax less urgent for Indonesia, if the implementation of the carbon tax is solely oriented towards achieving the NDC target. However, if it is connected to the actual problem of global warming, this effort must be a continued path.

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