CHEMICAL ENGINEERING TRANSACTIONS
VOL. 106, 2023
A publication of AIDIC
The Italian Association of Chemical Engineering
Online at www.cetjournal.it
Guest Editors: Jeng Shiun Lim, Nor Alafiza Yunus, Peck Loo Kiew, Hon Huin Chin

ISBN 979-12-81206-05-2; **ISSN** 2283-9216
DOI: 10.3303/CET23106070

Price of Unpreparedness: Macroeconomic Impact of the Sudden Change in Emission Mitigation Target

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Indonesia revised its mid-term emission mitigation target through the Enhanced Nationally Determined Contribution (Enhanced-NDC). If previously Indonesia targeted to achieve emission reductions of 29 % by 2030 compared to the BAU level, in the enhanced NDC, the country targets to increase its emission reduction commitment to 32 %. In most of the literature, limiting emissions can result in an economic slowdown compared to Business as Usual (BAU) conditions, especially if there are no innovations and policy reforms regarding emission mitigation activities. This study used the Computable General Equilibrium (CGE) model to simulate how far these policy changes impact the economy. This study also tried to simulate how much investment in emission reduction technologies can help Indonesia reduce the GDP loss caused by climate policy shocks. Based on the simulation results, GDP loss under the NDC (29 % reduction) and enhanced NDC (32 % reduction) schemes will be around 0.86 % and 1.04 % by 2030. The GDP loss may also be followed by the "employment loss", as a production reduction may lead to an employment cut-off. In terms of employment rate, if compared to the BAU, the more aggressive emission restriction may lower labour absorption by around 2 % by 2030. Investment in more advanced and efficient mitigation emissions can help reduce this GDP loss at varied levels, depending on the technology's introduction level. A 1 %-2 % additional investment may lower the GDP loss by around 0.05 %-0.11 % by 2030 compared to the BAU. With the same range of additional investment money, employment loss can also be reduced to 0.31 %-0.34 % by 2030.

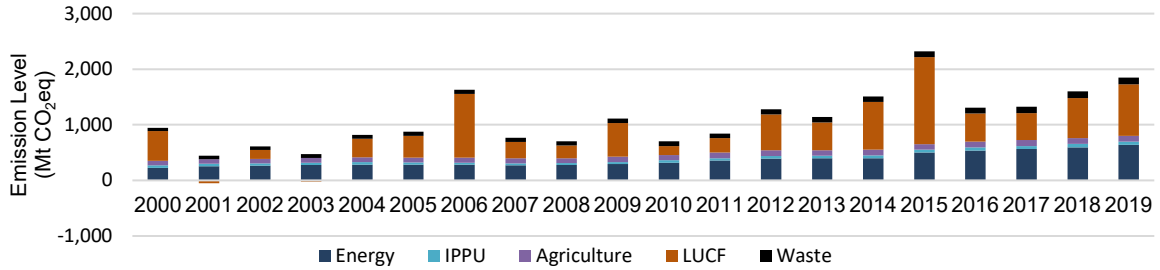
1. Introduction

Following submitting its long-term emissions mitigation target, Indonesia pledged to a more ambitious carbon emissions cut. In 2022, Indonesia revised its carbon emissions reductions through its Enhanced Nationally Determined Contributions (Enhanced NDCs) by 31.89 % (hereinafter called a 32 % reduction target) on its own or 43.2 % if there is international support by 2030. This increase in emission reduction targets was decided by considering Indonesia's ambition as well as the commitment to achieve net zero emissions, where Indonesia's initial target of 29 % on its own and 41 % with international support by 2030 is considered insufficient to achieve the 2060 long-term target (Sulaiman, 2023). This increase in short-medium-term emission reduction targets shows Indonesia's seriousness in participating in global emission reduction missions. On the other hand, there is also a setback because Indonesia is still experiencing many obstacles in reducing domestic emission levels. By reviewing Indonesia's emission profile, it can be seen that in the last two decades, Indonesia has not experienced significant emission reductions (Figure 1). It makes achieving 32 % of emissions by 2030 quite challenging, considering less than ten years left to achieve the target. Indonesia also does not have enough climate budget to finance emission mitigation projects, especially in the energy sector, which requires a high investment level.

From an economic perspective, sudden emission cuts, which were not accompanied by careful calculations and increased investment in various sectors, were feared to cause a blow to the economy as they suddenly needed to reduce their production levels. The sudden emission cut without adequate preparation will also result in a buildup of a burden on one particular sector which is considered to provide the fastest reduction in emissions, for example, the land use and forestry sector, while the achievement of emission reduction cannot be achieved without all sectors involved (Krupnick and Parry, 2012). As the production level may be reduced, the industries

Paper Received: 31 May 2023; Revised: 27 July 2023; Accepted: 22 October 2023
Please cite this article as: Malahayati M., Masui T., 2023, Price of Unpreparedness: Macroeconomic Impact of the Sudden Change in Emission Mitigation Target, Chemical Engineering Transactions, 106, 415-420 DOI:10.3303/CET23106070

may gradually increase their efficiency by investing in more efficient technologies and cutting some labour. Lack of preparedness may also create a difficult situation for some labour, especially low-skilled labour with limited skillsets to adjust to the new situation (Liu et al., 2021). These studies were done to see the global pattern, while there are still few country-level assessments on this issue. It makes a study related to the impact of changing emission targets on the economy very important for Indonesia, especially because there are still no studies on this matter because this policy has just been launched. With the sudden change in the emission reduction target seven years before 2030, the Indonesian government must carry out policy reforms to accelerate the development of emission mitigation projects because, if not, emission restrictions will force economic actors to reduce their activities, which can result in a reduction in production levels and even some decrease in employment level.



Notes: IPPU: Industrial Process and Product Use, LUCF: Land Use Change and Forestry

Figure 1: Indonesia Green House Gases Emission (GHG) Profile, 2000-2019. Source: processed from KLHK (2021)

This study tried to provide a preliminary simulation of how this new target may affect the macroeconomic aspects of Indonesia, especially at the Gross Domestic Product (GDP) level and labour rate, by utilising a country-level Computable General Equilibrium (CGE) model. An additional simulation on the investment injection effect to offset the loss caused by the emission mitigation policies is also carried out to add more insight to the study. It is hoped that this study can become input for policymakers in developing countries, especially Indonesia, to pay more attention to the preparation of GHG emission mitigation policies, considering that every detail of this policy will also have implications for national macroeconomic conditions. The simulation aims to see what may happen to the economy if the government lacks preparedness when applying the mitigation policy in such a limited time. It is also to see the role of additional investment in supporting the economy during the transition period.

2. Method and Data

This study uses the country-level model of Computable General Equilibrium (CGE). The CGE model is a tool for resource allocation and income distribution analysis in the economy, making it useful for environmental economics analysis (Bergman, 2005). The model describes the interlinkages between sectors in the economy, and the supply-demand in the market is always assumed to reach the equilibrium as it will be balanced through the price mechanism in the market (Figure 2).

There are three main blocks: Production block, international trade block, and consumption block. The production block produces the goods and services and provides them to the consumers through the market. In this block, technology holds a very important role as it can boost productivity by increasing efficiency during production. Some specific technology, like emission mitigation technology, can also help reduce the emission level during the process. Despite all production combinations chosen, the producers are always assumed to satisfy the “profit optimisation” assumption, meaning that the goal of each producer is to make the highest profits possible. All products produced are distributed to the consumer through the market. The consumer in this model consists of the household and the government. Both of them consumed the same resources produced by the producer. The household, on the one side, also holds a role in providing labour. The government collects and redistributes the tax through the transfer payment to the household sector. More capital can be accumulated through more savings (or investment) and creating a fixed capital formation. The production sector can utilise that capital to produce more goods/ services.

In the model, there is also an international trade block and using a small-open economy assumption, meaning that Indonesia is connected to the global market through international trade. It is also assumed that Indonesia is small enough to affect the global economy, but the global economy may affect the national economy. Using this assumption, some policies, like increasing global energy prices, may also affect the Indonesian economy. The simulation of the model is done by utilising the General Algebraic Modelling System (GAMS) version 36.2.0.

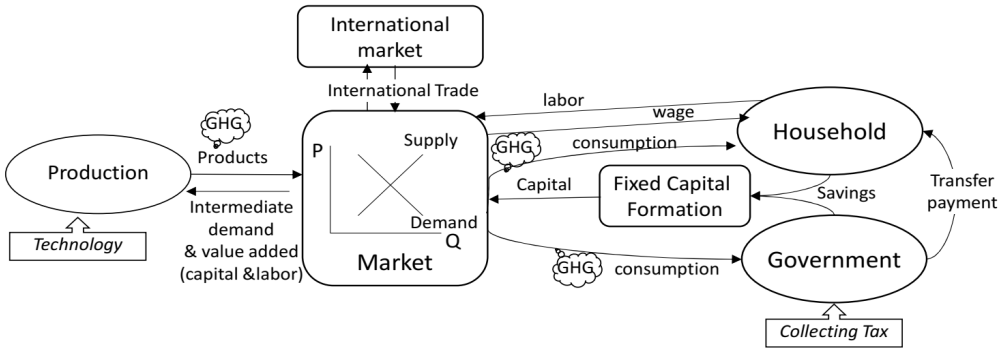


Figure 2: General Scheme of the Computable General Equilibrium (CGE) model of this study

For this study, a dynamic CGE model with the base year 2016 is built, meaning that the model will simulate the result from 2016 to 2030 as the final year. 2016 is chosen as the base year considering the most recent Indonesia Input-Output Table (IO Table) that is used as the database foundation for this CGE model. The IO Table is chosen as the foundation database to build this model because it consists of information on sectoral supply-demand interaction in the country. This Indonesia IO Table 2016 is provided and published by Indonesia's Statistical Bureau (BPS) (BPS, 2021). To make a simulation through 2030, some other statistics and information need to be added.

The primary statistical information includes GDP growth, GDP projection, population growth, and population projection. The GDP and population growth information is borrowed from the actual statistics provided by the BPS (BPS, 2022). The economic slowdown during the period 2020 and 2021 is also considered as the impact of the Covid-19 pandemic. For the projection, the population projection is gained from the projection given by the BPS based on the population census (BPS, 2013), while for the GDP projection, the middle-of-the-way projection (5.1 % from 2016-2020, 5.2 % from 2021-2030) is assumed based on the average GDP growth in the last decades. The information on the GHG emissions level is based on the data in Indonesia's 3rd Biennial Update Report (KLHK, 2021). To check the feasibility of the model, the result in the BAU condition is investigated first before running all the scenarios. The simulation result of GDP at the BAU level is then compared with the actual GDP data. As the discrepancy between the simulation and the actual data was less than 2 %, it is assumed the model is feasible.

3. Scenarios

Three scenarios are prepared for this analysis: 1.) Business as usual (BAU), 2.) MIT-29, and 3.) MIT-32. The "MIT" Scenario describes the simulation under the GHG emission level restriction. The MIT-29 and MIT-32 represented the emission mitigation levels of 29 % and 32 %, respectively. The MIT-29 scenario described Indonesia's emission mitigation under the NDC's scheme, while the MIT-32 scenario described the emission reduction target under the enhanced NDC scheme.

The base year is 2016, and the emission mitigation policies are assumed to be applied starting from 2020. The mitigation technology levels for all scenarios are the same, assuming that the Indonesian government is unable to increase the mitigation technology penetration along with the increase of mitigation targets. For this study, the impact of each scenario on the Gross Domestic Product (GDP) and employment will be compared.

As the initial simulation describes a "lack-of preparation" condition, an additional simulation is conducted to see how investment provisions during the application of emission mitigation policies will affect the macroeconomic conditions of Indonesia. This additional simulation was conducted by assuming an additional 1 % and 2 % of investment can be provided during the transition process. In this study, investment is directly transformed as additional capital that can be utilised by the industries to maintain their production level and may lead to maintaining its production level. In this case, 1%-2% additional investment means that it is assumed that each sector performed as they have additional capital (e.g., new machinery) from their BAU condition, meaning that they can produce more output than the initial condition. This strict assumption also becomes one of the limitations of this study, considering a country may set up the emission limit gradually from lose limit in the first three or five years and then shift to a very strong limit nearly to the target year.

4. Result

Reducing the emission can mean reducing the production and consumption level when it is not followed by sufficient emission mitigation technologies and investment. The lower level of production and consumption

means a lower Gross Domestic Product (GDP) compared to the BAU condition. This can be seen from the simulation result if compared to the BAU scenario, as the GDP level is lower when there is a limit to the emission level. It is also can be seen that the higher the emission limit, the higher the GDP gap to the BAU scenario. Without sufficient penetration of mitigation measures and investment, the first five years will be the most challenging time, as the GDP may lower by around 4 %. Along with the improvement of the GDP growth from 2025, this GDP loss gradually reduced to only around 1 % by 2030. If MIT-29 and MIT-32 scenarios are compared, the bigger emission limit gives a greater GDP loss of around 0.18 % in 2030.

Table 1. Simulation Results Comparison of GDP level under each scenario (unit: Trillion Indonesian Rupiah (IDR))*

Year	BAU	MIT-29	Gap compared to BAU (%)	MIT-32	Gap compared to BAU (%)
2016	12,297.97	12,297.97	-	12,297.97	-
2020	15,832.35	15,108.59	- 4.571 %	15,108.59	- 4.571 %
2025	19,983.52	19,117.06	- 4.336 %	19,115.99	- 4.341 %
2030	23,967.21	23,760.00	- 0.865 %	23,717.23	- 1.043 %

*) 1 US Dollar (USD) = around 14,000 Indonesian Rupiah (IDR)

The emission mitigation that followed by the reduction in production level may also affect the employment level because if the industries need to face emission constraints without sufficient technology improvement, it will affect the absorption of labour because companies will also reduce the number of workers to offset the decline income level which is the implication of emission restriction. Similar to the GDP level, there is also some employment loss. The higher the emission restriction level, the lower the employment absorption rate. If the 29 % emission reduction can absorb around 126.06 M of labour by 2030 compared to the BAU case, the 32 % reduction may reduce that absorption to only 125.96 M. It means that, without a transition planning on the labour, the absorption can be around 2 % lower compared to the BAU level in 2030 (Table 2). This indicates the importance of preparing mechanisms and transition plans for the workforce in line with implementing emission restriction policies.

Table 2. Simulation Results Comparison of employment level under each scenario (unit: M People)

Year	BAU	MIT-29	Gap compared to BAU (%)	MIT-32	Gap compared to BAU (%)
2016	117.36	117.36	-	117.36	-
2020	122.10	121.16	-0.770 %	121.16	-0.77 %
2025	126.34	124.33	-1.591 %	123.81	-2.00 %
2030	128.67	126.06	-2.028 %	125.96	-2.10 %

Increasing the level of investment is considered to be one of the important solutions in minimising the negative shock from limiting emission levels. Increased investment can be used to increase capital. This capital increase then helps to maintain production levels. In this study, it is assumed that the level of investment for additional capital increases by 1 % and 2 %. The simulation results show that, when compared to the BAU level in the final year (2030), the additional investment can offset the GDP loss to be 0.99 % (additional 1 % investment) and 0.93 % (additional 2 % investment). This value is lower than the GDP loss without additional investment, which reached 1.04 %. The existence of additional investment also increases the amount of employment. If, without investment, the number of workers absorbed was 125.96 M, the investment could increase employment to 126.36 M and 126.79 M people, respectively (Table 3).

Table 3. Results Comparison by the introduction of additional 1 % and 2 % investment in the final year (2030)

Parameter	BAU	MIT 32	Gap compared to BAU (%)	+ 1 %	Gap compared to BAU (%)	+ 2 %	Gap compared to BAU (%)
GDP*	23,967.21	23,717.23	-1.04 %	23,729.11	-0.99 %	23,743.70	-0.93 %
Employment**	128.67	125.96	-2.11 %	126.36	-1.80 %	126.79	-1.46 %

*) unit of GDP: Trillion IDR; 1 US Dollar (USD) = around 14,000 Indonesian Rupiah (IDR). **) unit of employment: M people.

5. Discussion and Policy Implications

The results of this study are in line with several previous studies. Château et al. (2011) highlighted that emission mitigation might slow down economic growth and employment absorption in the short-medium term, mostly because the emission limitation policy requires the industry to re-structure and reallocate production. The transition process will take time due to the need to adjust to the structure and regulation of the market itself. Technology changes will help restore economic efficiency, but it is also a fact that they will take time to materialise. Due to the "time lag" in emission mitigation policies, it is always recommended that a country not be delayed further the transition process, including preparing all the required infrastructure and technology penetration. The IMF mentioned that a delayed policy forced a rushed transition and created a bigger shock to the economy and may create a bigger shock to the GDP by around 1.5-2 times bigger than a gradual and credible policy. It will also negatively impact the government's performance, and the government needs to set stringent policies to reach the goal, especially if the emission cut is done without proper preparation (IMF, 2022). Indonesia's new mid-term emission mitigation target is a great step toward achieving net-zero emissions in 2060. The concern is that this target was introduced in a very short period, only eight years before the NDC target year in 2030. The readiness of all sectors in Indonesia is questionable, especially economically, as all sectors are just recovering from the impact of the pandemic. Many mitigation projects have been hampered because the government needs to focus on economic growth during and after the pandemic. Considering this situation, there are no other steps the government can take other than 1.) gradually continuing emission mitigation projects, especially those that have been neglected and actively looking for financing alternatives to increase investment and increase capital to accelerate technology penetration emission mitigation in all sectors, and 2.) Prepare clear and measurable regulations for each sector related to emission reduction mechanisms and prepare the workforce to follow the transition process.

Indonesian government itself continue gradually and consistently to continue existing mitigation projects and simultaneously continue to innovate in raising funds for climate mitigation in the country. The Indonesian government has tried to carry out Climate Budget Tagging (CBT) to plan national budget allocations for climate change needs. However, in practice, the available funds are limited and must be divided and allocated to other priority sectors. There is no guarantee that projects related to climate change can obtain a fixed allocation of funds every year if they only depend on the national budget. Other sources of funds are foreign add and other investment facilities such as green sukuk, which have been issued since March 2018. However, the accumulated funds have not been able to meet all the needs for financing emission mitigation projects which are quite expensive (BKF, 2019). The Indonesian government estimates that to achieve the emission reductions listed in the NDC (29 % emission reduction compared to the BAU condition by 2030), at least USD 247 billion is needed. With the emergence of a new emission target for Enhanced NDC, which is 32 %, the financing needs will also need to be increased. It is one of the reasons that the country is still struggling to pace up its mitigation process. There are also some plans to optimise other sources such as green bonds, carbon tax, and carbon market, but these policies are still unclear regarding when they will be implemented and how the implementation mechanism (Malahayati and Anggraeni, 2023).

Ambiguity in regulations and policies may lead to a harmful outcome. If the government decides to delay the policy, this will hinder the achievement of emission reduction targets. On the other hand, if the government insists on implementing emission cuts without the readiness of all economic actors, then it is feared that it will give a big fiscal shock because economic actors, especially in the production sector, cannot carry out instant transformation both in their production process and cost structure (Bosetti et al., 2009). The government also needs to realise that this transformation process is not only related to the production sector but also to workers who cannot immediately adapt to new, more efficient and low-emission technologies. If there is no capacity-building process, especially for low-skilled labour in "high-carbon" industries, then it is feared that there will trigger a “technological unemployment” phenomenon. As delaying technology innovation is not an option, that phenomenon can be mitigated by considering training and capacity building (Marchant et al., 2014).

6. Conclusion

This study tried to simulate how a sudden emission cut may affect the macroeconomic situation in Indonesia and how the investment may offset the effect. Despite a challenging situation to stabilise the economy and continue the emission mitigation projects post the Covid-19 pandemic, Indonesia decided to increase its emission reduction target to 32 % compared to the BAU condition by 2030, an increase of 3 % from its previous NDCs target. That upgraded mitigation target shows that Indonesia is serious about achieving its net-zero emission 2060 vision, but this also means that it requires Indonesia to accelerate the penetration and application of low-emission technologies, even though the country is also faced with a limited budget and financing sources to finance it. Many mitigation projects have also been hampered since the pandemic occurred. The situation

becomes more challenging as Indonesia has not shown a significant reduction in emission levels in the last two decades.

Using the CGE model, it is estimated that the sudden increase in the GHG emission reduction target, if not accompanied by technological transformation and additional investment, will increase GDP loss and total employment. In the 29 % emission reduction scenario, it is estimated that the GDP loss that can occur by 2030 is 0.87 % compared to the BAU level, and it becomes 1.04 % when the target is increased to 32%. The amount of employment will also decrease by up to 2.1% because if there is no sufficient mitigation technology, the industry will have no other choice but to reduce emissions by reducing production, which leads to a reduction in the number of workers.

This impact can be minimised if the government pours out investment as an incentive for the business sector in this transition process. The additional investment can be additional capital for the industry to transform its production processes. Based on the simulation results, the additional investments can minimise the impact of emission mitigation policies. With an additional 1 %-2 % investment, the GDP loss can be reduced by around 0.05 %-0.11 % by 2030. With the same range of additional investment, the amount of employment loss can also be reduced to 0.31 %-0.34 % by 2030. This shows the importance of additional investment in the emission mitigation process in the country. Clarity regarding policies and regulations is a very important point in achieving emission reduction targets. The government needs to prepare clear, directed and measurable sets of policies and regulations when setting emission reduction targets, bearing in mind that all economic actors cannot carry out an immediate transformation. Policy stipulation without sufficient preparation on the transition policy package may increase uncertainty and hamper realising a sustainable economy and achieving emission targets.

In future studies, it will be crucial to fill some limitations in this study by trying more scenario simulations (e.g., gradual emission limitation or adding the carbon tax) and looking deeper into the sectoral impact to see which sector will be most affected. A long-term assessment must also be conducted following the country's mission to achieve net-zero emissions by 2060.

Acknowledgement

This research was performed by the Environment Research and Technology Development Fund JPMEERF20221002 of the Environmental Restoration and Conservation Agency of Japan.

References

Bergman, L., 2005, Chapter 24 CGE Modeling of Environmental Policy and Resource Management. Handbook of Environmental Economics. 3, 1273–1306.

BKF, 2019, Indonesia Climate Change Budget Tagging 2019. Jakarta, Indonesia.

Bosetti, V., Carraro, C., Sgobbi, A., Tavoni, M., 2009, Delayed action and uncertain stabilisation targets. How much will the delay cost? Climatic Change 96, 299–312.

BPS, 2022, Produk Domestik Bruto (Lapangan Usaha) Seri 2010 (MilyarRupiah). <www.bps.go.id/indicator/11/65/1/-seri-2010-pdb-seri-2010.html> accessed 5.16.22.

BPS, 2021, Tabel Input-Output Indonesia 2016, Badan Pusat Statistik (BPS), Jakarta, Indonesia, (in Indonesian).

BPS, 2013, Proyeksi Penduduk Indonesia 2010-2035, Badan Pusat Statistik (BPS), Jakarta, Indonesia, (in Indonesian).

Château, J., Saint-Martin, A., Manfredi, T., 2011, Employment Impacts of Climate Change Mitigation Policies in OECD: A General-Equilibrium Perspective, Paris, France.

IMF, 2022, Indonesia: Selected Issues, IMF Staff Country Reports, International Monetary Fund (IMF), Washington, USA.

KLHK, 2021, INDONESIA: Third Biennial Update Report Under the United Nations Framework Convention on Climate Change, Jakarta, Indonesia.

Krupnick, A., Parry, I., 2012, What Is the Best Policy Instrument for Reducing CO2 Emissions?, in: Fiscal Policy to Mitigate Climate Change. International Monetary Fund, Washington D.C, 89–102.

Liu, M., Tan, R., Zhang, B., 2021, The costs of "blue sky": Environmental regulation, technology upgrading, and labor demand in China, Journal of Development Economics, 150, 102610.

Malahayati, M., Anggraeni, L., 2023, Potential of and challenges to the green Sukuk for financing the green economic recovery in Indonesia, Post-Pandemic Green Recovery in ASEAN, 234–257.

Marchant, G.E., Stevens, Y.A., Hennessy, J.M., 2014, Technology, Unemployment & Policy Options: Navigating the Transition to a Better World, Journal of Evolution and Technology, 24, 26–44.

Sulaiman, S., 2023. Indonesia pledges more ambitious carbon emission cut, <https://www.reuters.com/world/asia-pacific/indonesia-pledges-more-ambitious-carbon-emission-cut-2022-10-25/> accessed 5.26.23.