

## Carbon Accounting in the Age of Climate Change: An Integrated Multi-Criteria Decision Analysis for Policy Formulation

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### Abstract

Climate change is an urgent global challenge, driving the need to develop holistic and effective emission reduction policies. This research aims to develop a holistic emission reduction policy using a Multi-Criteria Decision Analysis (MCDA) approach. The research method involves an integrated analysis of various criteria, including environmental effectiveness, economic efficiency, social justice, community participation, resource availability, level of compliance, and political acceptability. This research shows that the MCDA approach provides a solid basis for designing effective and sustainable emissions reduction policies, combining multiple perspectives to achieve maximum impact. The results of this research can help policymakers identify strategic priorities and design policies that society can accept. Integrating multiple perspectives, this research contributes to designing holistic and widely applicable emissions reduction policies, bridging the gap between environmental goals and economic sustainability.

**Keywords:** Carbon Accounting, Emission Reduction Policy, Multi-Criteria Decision Analysis, Climate Change, Environmental Effectiveness.

### INTRODUCTION

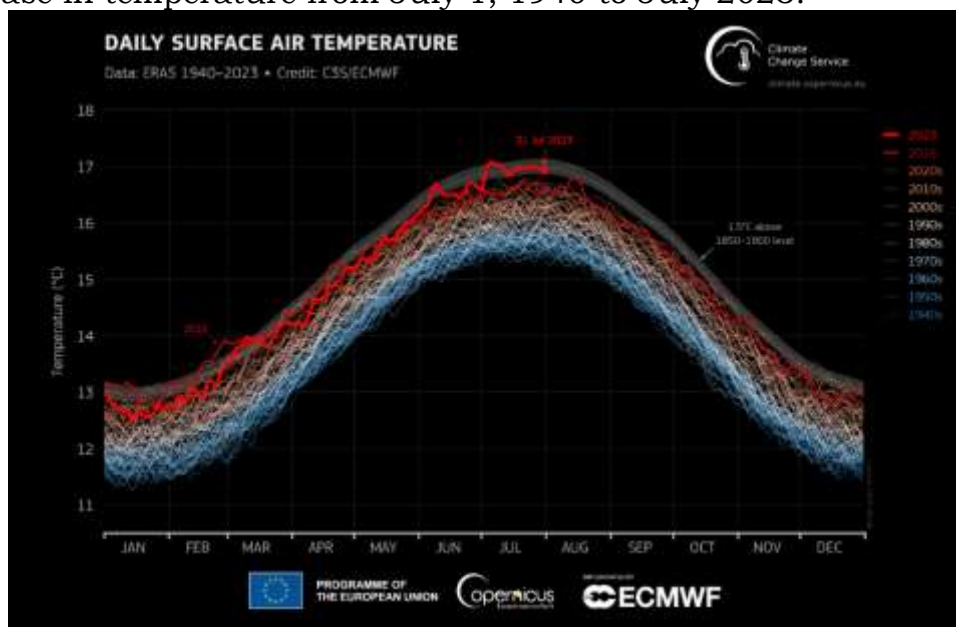
Climate change is one of humanity's biggest global challenges in the 21st century. This phenomenon significantly impacts Earth's climate, creating extreme temperature variations, unstable weather, and far-reaching ecological impacts (Keith et al., 2021; Tukker et al., 2020). Climate change is caused by increasing concentrations of greenhouse gases due to human activities, such as burning fossil fuels and deforestation. The impact of climate change not only impacts the environment, but also human social and economic life. Global communities face threats to food security, clean water, and critical infrastructure due to climate change (Hurd et al., 2022; H. Zhang et al., 2022).

The importance of carbon calculation is the main basis for mitigation and adaptation efforts to climate change. In an era where awareness of the negative impact of human activities on the environment is increasing, carbon accounting has a central role in measuring the carbon footprint of an activity or project (Brander et al.,

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2021; Gifford, 2020). The information obtained from carbon accounting provides a clear picture of how an activity contributes to greenhouse gas emissions, enabling policymakers, companies and communities to identify the most effective resources for reducing their carbon footprint (Chen et al., 2019; Yin et al., 2022). The data below shows a significant increase in temperature from July 1, 1940 to July 2023:



**Figure 1. Global Daily Surface Air Temperature (°C) from 1 January 1940 to 31 July 2023**

Source: Climate Change Service (2023)

The data begins with daily global average surface air temperature records broken for four consecutive days, from July 3-6. All days throughout July were hotter than the previous record of 16.80°C, set on 13 August 2016, making the 29 days from 3-31 July the hottest 29 days ever recorded. The hottest day was on July 6, when the global average temperature reached 17.08°C, and the values recorded on July 5 and 7 were only 0.01°C different from that. During the first and third weeks of the month, temperatures also temporarily exceeded the threshold of 1.5°C above pre-industrial levels – a limit set in the Paris Agreement, the first time this has happened during July. As anticipated in the C3S press release on July 27, C3S data confirms that July 2023 was the hottest July month in the ERA5 data record, which dates back to 1940 (See Additional Information section). The monthly average temperature was 16.95°C, well above the previous record in July 2019 (16.63°C) and almost identical to our best estimate of 1.5°C warming above pre-industrial levels in July (16.96°C).

Carbon accounting is also an important tool in meeting global commitments to reduce greenhouse gas emissions by international climate agreements. By understanding the carbon impact of economic activities, we can design and implement more efficient sustainable policies, encourage technological innovation, and create economic incentives for sustainable practices. Carbon accounting can help companies improve energy efficiency, reduce operational costs, and

create added value through environmentally friendly business practices (Hutajulu et al., 2023; Marlowe & Clarke, 2022; Sukarso, 2021). The importance of carbon accounting lies not only in understanding the contribution of activity to climate change but also in the key role it plays in shaping concrete policies and actions to protect the environment and achieve global sustainability goals, and this is related to the use of MCDM which is the benchmark in today's policy formulation (Briand et al., 2023; Lau, 2023).

MCDM is an abbreviation for "Multiple Criteria Decision Making." this is an approach or method used to assist decision-making where there is more than one criterion that must be considered. In the context of MCDM, decisions are taken based on several relevant criteria, and often, these criteria conflict with each other or have different weights (Balanay & Halog, 2023; Lau, 2022b). MCDM involves using quantitative and qualitative tools or techniques to model, analyse, and prioritise the various criteria involved in a decision. This can include mathematical methods, statistical analysis, or approaches based on subjective preferences and opinions. Applications of MCDM can be found in various fields, including economics, management, engineering, the environment, and many more. MCDM uses include project site selection, policy evaluation, resource allocation, and strategic planning, where decisions involve multiple interrelated criteria (Buana et al., 2023).

The rationale for using Multi-Criteria Decision Analysis (MCDM) in the context of carbon calculations and environmental policy formulation is very reasonable. Amid the complexity of the climate change challenge and the diversity of sustainable development goals, MCDM provides a robust framework for addressing several interrelated and often conflicting criteria. Selecting effective environmental policies requires consideration of various dimensions, such as ecological impacts, social impacts, and economic sustainability (Halim, 2023; Lau et al., 2022).

Using MCDM provides advantages in overcoming uncertainty and complexity in environmental decision-making. Decisions must cover sustainability aspects and consider the preferences of various policy stakeholders and community groups (Bączkiewicz et al., 2021; Lau & Lin, 2022; Ransikarbun et al., 2023). MCDM enables the integration of input from multiple perspectives, facilitates cross-sector dialogue, and promotes community involvement in policy formulation. MCDM can help prioritise the most effective solutions and actions in reducing greenhouse gas emissions (Arshed et al., 2023; Nasr et al., 2023). By analysing the relative contribution of various activities or projects to climate change, MCDM can help direct investments and resources in the direction that will have the most positive impact. On a broader scale, the rationale for using MCDM in carbon calculations and environmental policy formulation is to provide a more sophisticated and holistic tool for overcoming the complex challenge of climate change,

enabling informed and sustainable decision-making (Hounguè et al., 2022; Papapostolou et al., 2020).

Developing effective policies to reduce greenhouse gas emissions, adapt to inevitable impacts, and build resilience to climate change is important. Formulating these policies requires a holistic approach that combines science, public policy and innovative technology. With a focus on carbon accounting, this article seeks to contribute to understanding and responding to the challenge of climate change through multi-criteria decision analysis to form the basis of sustainable and effective policies.

## **LITERATURE REVIEW**

### **Carbon Calculation Method**

Various carbon accounting methods are used to measure and manage greenhouse gas emissions produced by human activities. One commonly used method is the Emissions Reporting and Verification Approach (GHG Protocol), which provides a standard framework for identifying, measuring, and reporting greenhouse gas emissions. This method divides emissions into three scopes: scope 1 (direct emissions), scope 2 (energy-related indirect emissions), and scope 3 (other indirect emissions). There is also the Life Cycle Assessment (LCA) method, which investigates the entire life cycle of a product or service to identify and evaluate environmental impacts, including carbon emissions, LCA involves analysis from the production stage to the use and end of a product's life. (Ishtiaque et al., 2019)

Other methods include Direct Emission Measurement, where direct measurements are made using equipment such as a gas analyser to measure greenhouse gas emissions from a source. In addition, measurement methods use mathematical models that combine various parameters to estimate emissions. Combining these methods provides a more holistic framework for understanding and managing carbon impacts, helping organisations and companies implement sustainable practices and reduce their carbon footprint (Al-Ghobari & Dewidar, 2021; Nasrollahi et al., 2021). There are also other international standard methods, such as ISO 14064, which regulates the measurement, monitoring and reporting of greenhouse gas emissions. ISO 14064 guides organisations to develop and maintain independently verifiable greenhouse gas emissions management systems.

There are even special carbon calculation methods in the agricultural sector, such as Agricultural Carbon Footprint Calculation, which includes evaluating carbon emissions and absorption along the agricultural supply chain, including production, processing, transportation and distribution. Energy Use-Based Emission Measurement includes analysis of emissions based on energy consumption, identifying how much energy is used and how much emissions are produced in the process (Cohen et al., 2019; McIntosh & Becker, 2020).

### **Advantages and Limitations**

Each carbon accounting method has advantages and limitations that must be considered by the organisation or entity conducting the measurement. One of the advantages of the Emissions Reporting and Verification Approach (GHG Protocol) is that it provides a global standards framework that enables consistent comparisons between different entities. This method also covers a wide scope, considering direct and indirect energy-related emissions. However, limitations of the GHG Protocol include its focus on emissions within the administrative boundaries of an organisation and may not fully cover the entire supply chain (Daksiya et al., 2021; Ransikarbum et al., 2023).

The Life Cycle Assessment (LCA) method has the advantage of covering the full life cycle of a product or service. This helps identify environmental impacts from the production stage to the use and end-of-life of a product. Limitations of LCA include the complexity of the analysis, requiring very detailed data and careful modelling, and the continuity of the data used can influence the results. The Direct Emission Measurement Method has the advantage of providing accurate and real-time data. This method is useful for measuring emissions from certain sources, such as factories or vehicles. Limitations of these methods involve limited reach and scale and can be impractical for measuring emissions across an organisation or supply chain (Acampa & Grasso, 2020; Bączkiewicz et al., 2021).

The ISO 14064 method has advantages because it is an international standard that can provide clear guidance for organisations that want to develop a greenhouse gas emissions management system. Most carbon accounting methods have limitations related to the need for accurate and consistent data, adequate resources for implementation, and challenges in measuring and quantifying emissions across supply chains that often involve many different parties.

### **Recent Studies in the Use of MCDM for Environmental Policy**

Recent studies into using Multi-Criteria Decision Analysis (MCDM) for environmental policy reflect a growing interest in holistic and sustainable approaches to addressing global environmental challenges. This research has highlighted the role of MCDM in assisting the formulation of more effective and sustainable policies by considering several complex and often conflicting criteria (Rosenbloom et al., 2020; Shi et al., 2022). The use of MCDM in environmental policy can include assessing the environmental impacts of various policy scenarios, selecting sustainable solutions, and allocating resources to projects that positively impact the environment. MCDM can also be used to design policies that consider the interests of various policy stakeholders, including society, business and government (Green, 2021; Kadefors et al., 2021).

Some aspects of recent studies involve the development of more sophisticated MCDM models, better integrating of data and information

technology, and increased public participation in decision-making processes. Recent research has also explored the use of MCDM in addressing pressing environmental issues, such as climate change, water management, and biodiversity conservation. MCDM can be invaluable in supporting efforts to balance economic growth, environmental protection, and social welfare (Du et al., 2022; W. Zhang et al., 2020).

Some recent research trends in using MCDM for environmental policy also involve adopting more inclusive and participation-based approaches. This includes efforts to integrate community views and preferences in environmental decision-making processes. By adopting a participatory model, MCDM can ensure that the resulting policies not only reflect technical and scientific considerations but also include the values and needs of local communities (Dewi et al., 2023; Sani et al., 2021).

Recent research also explores the integration of MCDM with new technologies, such as artificial intelligence and simulation modelling, to increase the accuracy and complexity of decision analysis. This technology can help model complex scenarios, account for uncertainty, and produce more reliable policy recommendations. Recent studies also highlight the challenges and opportunities in adapting MCDM to address future environmental issues, such as energy transformation, waste management, and ecosystem-based policies (Z. Chen et al., 2020; Sheng et al., 2020). By understanding and addressing these challenges, MCDM can continue to develop as an effective tool in supporting decision-making for environmental policies with positive long-term impacts. Continued research and development efforts in this area will contribute to achieving global sustainability goals (Ibrahim et al., 2020; Moran et al., 2020).

## **METHOD**

This research focuses on developing carbon emission reduction policies using the Multi-Criteria Decision Analysis (MCDA) approach, specifically the Analytic Hierarchy Process (AHP) method. The capital city of Jakarta, Indonesia, was chosen as a research location because of its significant role in economic activity and the real impact of climate change in the region. The data collection process involves two main aspects. First, carbon emissions data is obtained through access to national databases, sector industry reports, and collaboration with relevant government agencies. Interviews with companies and non-governmental organisations in Jakarta were also conducted to gain an in-depth understanding of emissions management practices. Second, identifying decision criteria involves a literature survey, expert consultation, and stakeholder interviews. This process is necessary to understand the critical factors that must be considered in policy development (Rahman et al., 2023).

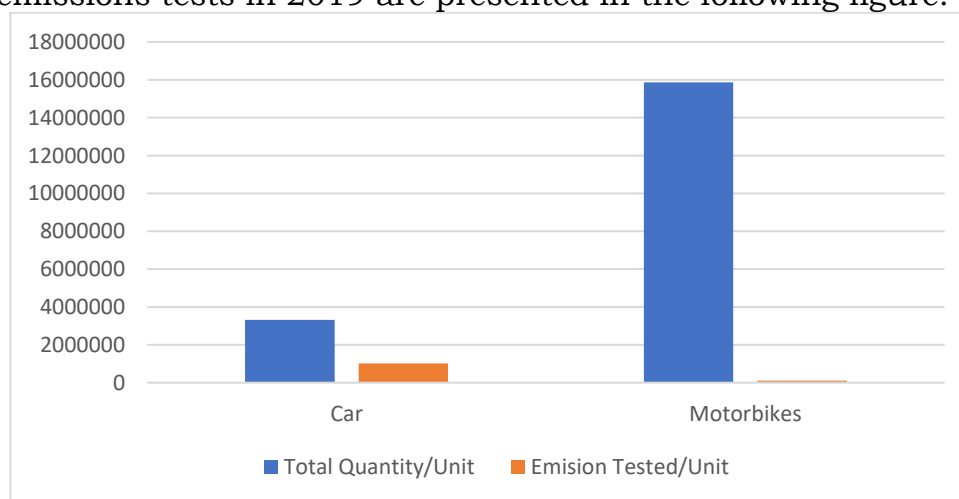
Data analysis was carried out using the AHP model. A hierarchy of criteria and subcriteria was developed based on literature review and

expert input. Criteria weights are determined through consultation with experts and stakeholders. Pairwise comparison data was collected from selected respondents, including experts and stakeholders. AHP software is used for mathematical calculations and consistency analysis. The results of the AHP analysis are then integrated into policy formulation. Evaluation of alternative policies is carried out based on the weight of criteria to reduce carbon emissions effectively. This method was chosen because it provides an in-depth understanding of the preferences and priorities of various factors in policy decision-making. This research combines aspects of carbon accounting, climate change and policy development to provide a strong foundation for more effective and sustainable policy strategies in facing the challenges of climate change.

## RESULT AND DISCUSSION

### Carbon Emission Data

Based on the provisions in DKI Jakarta Governor Regulation Number 66 of 2020, all private vehicles operating in the capital city must undergo emissions tests. This regulation also stipulates that cars and motorbikes that are more than three years old are a category of vehicles that must undergo emissions tests. The emissions testing process involves calculating the levels of carbon monoxide (CO), hydrocarbons (HC), carbon dioxide (CO<sub>2</sub>), oxygen (O<sub>2</sub>), and nitrogen oxides (NO) in exhaust fumes. Vehicles that successfully meet the safe emission limits for CO, HC, CO<sub>2</sub> and NO will be given a certificate of passing the emissions test, valid for one year. On the other hand, even vehicles that do not pass the emissions test can potentially receive sanctions, such as parking disincentives or ticket fines, ranging from IDR 250,000 to IDR 500,000. Estimated figures for vehicles that have had emissions tests in 2019 are presented in the following figure:



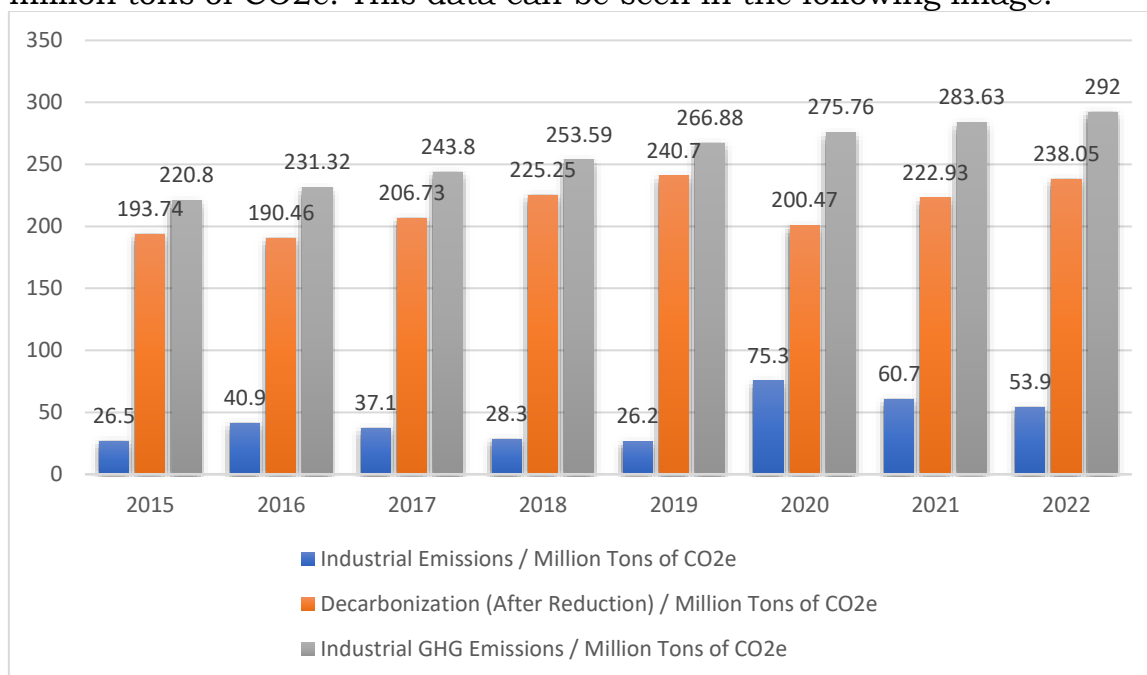
**Figure 2. Estimated figures from data on the number of vehicles in DKI Jakarta in 2019**

Source: databoks (2023)

Data from the site [ujiemisi.jakarta.go.id](https://ujiemisi.jakarta.go.id), as of September 7, 2023, at 14.30 WIB, records that around 1.02 million four-wheeled cars and 101.2 thousand motorbikes have undergone emissions tests. Even

though this figure is quite significant, the progress of emissions testing is still relatively low compared to the total number of vehicles in Jakarta. Meanwhile, data from the Central Statistics Agency (BPS) shows that in 2019, the number of cars in Jakarta that have now reached the age of over three years and are required to undergo emissions tests is around 3.3 million units, while the number of motorbikes reached 15.9 million units. By comparing this data, the progress of car emissions testing in Jakarta has only reached around 30.8%, while the progress of motorbike emissions testing is only around 0.64% until September 7 2023.

The industrial sector, represented by the Minister of Industry, Agus Gumiwang Kartasasmita, stated that increasing investment in the industrial sector has caused an overall increase in greenhouse gas (GHG) emissions. To overcome this challenge, Agus conveyed the need for large and organised decarbonisation efforts in the industrial sector. Based on 2022 data, Business as Usual (BaU) or industrial activities without mitigation show 292 million tons of CO<sub>2</sub>e emissions. Meanwhile, efforts to reduce industrial GHG emissions in the same year reached 53.9 million tons of CO<sub>2</sub>e. Therefore, the results of decarbonisation or actual post-mitigation emissions reached 238.05 million tons of CO<sub>2</sub>e. This data can be seen in the following image:



**Figure 3. Process for Reducing Greenhouse Gas Emissions in the Indonesian Industrial Sector (2015-2022)**

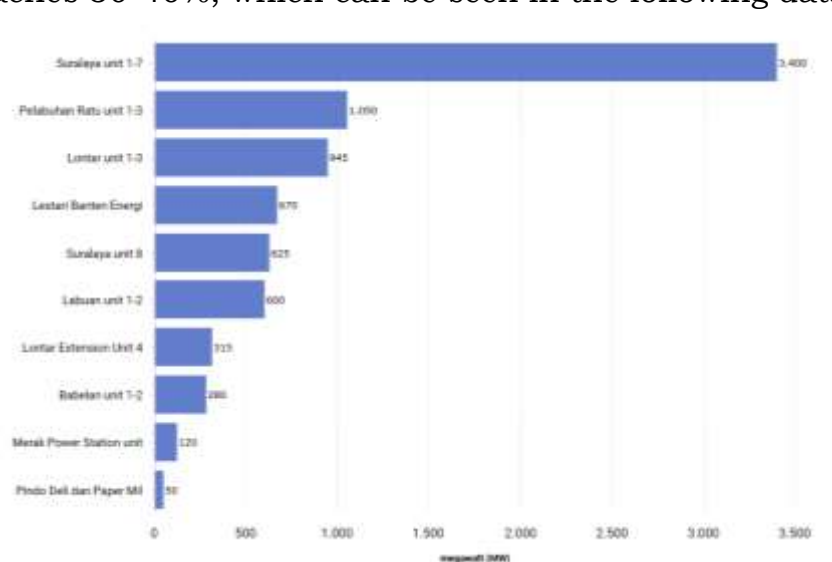
Source: databoks (2023)

The BaU trend has never decreased from 2015 to 2022, while reduction efforts have fluctuated, with the highest peak occurring in 2020 at 75.3 million tons of CO<sub>2</sub>e. This increase occurred during the COVID-19 pandemic when industrial activity was limited. Agus emphasised that decarbonisation efforts in the industrial sector can be carried out through four approaches. First, replace energy sources with more environmentally friendly ones, such as solar cells and hydrogen.

Second, energy management and efficiency by utilising equipment that can reduce energy consumption. Third, electrification strategy in the production process. Fourth, the use of Carbon Capture, Utilization, and Storage (CCUS) technology.

At the 2023 Ministry of Industry Working Meeting in Jakarta, Agus stated that CCUS technology, together with green ammonia and hydrogen technology, is considered a game changer in the decarbonisation and energy transition of the industrial sector. Therefore, Agus encouraged the draft presidential regulation governing the development of CCUS to include expanding the use of this technology for the industrial sector. Air pollution in the DKI Jakarta area and its surroundings is still a public concern. Several moving and stationary sources are thought to have worsened air quality recently. According to the Indonesian Forum for the Environment (WALHI), a mobile source contributing to increasing greenhouse gas emissions is smoke produced by motor vehicles emitting carbon dioxide; air pollution from the transportation sector can spread more quickly because it follows the movement of motorised vehicles.

Immovable sources include carbon dioxide removal activities that occur at a location and on an ongoing basis. Examples of these activities include constructing road projects, industrial activities in factory areas, and operating coal-fired steam power plants (PLTU). Muhammad Aminullah, Chair of the WALHI DKI Jakarta Campaign, indicated that smoke from coal-fired power plants in Banten and West Java is one of the main factors in reducing the air quality of Jakarta and its surroundings. Based on WALHI's calculations, PLTU contributes around 20-30% of air pollution in Jakarta, while the transportation sector reaches 30-40%, which can be seen in the following data:



**Figure 4. List of existing Steam Power Plants and Cessation of Company Operations**

Source: databoks (2023)

In efforts to decarbonise the industrial sector, Agus Gumiwang Kartasasmita, Minister of Industry, highlighted four approaches. First, replacing energy sources with more environmentally friendly ones such

as solar cells and hydrogen. Second, carry out energy management and efficiency by utilising equipment that can reduce consumption. Third, implement an electrification strategy in the production process. Fourth, utilising Carbon Capture, Utilization, and Storage (CCUS) technology.

To overcome the air pollution problem, the Ministry of Environment and Forestry (KLHK) has stopped the operations of four companies suspected of contributing to air pollution in Jabodetabek. This step was taken after the Ministry of Environment and Forestry discovered discrepancies between environmental documents and field conditions, a lack of environmental monitoring plans, and technical violations in installing sampling holes at several companies. The Ministry of Environment and Forestry is conducting further investigations to identify and address sources of emissions or pollutants that impact air quality in the region.

In interviews with several informants, the author interviewed a company and a non-governmental organisation as party representatives to assess Jakarta's emissions management practices. The first informant was from the company with the question: "I want to understand how it manages carbon emissions from its operational activities. Are there any special policies or strategies that have been implemented to reduce the impact of carbon emissions?" he answered that:

*"Of course, I am the Sustainability Manager at this company. We are committed to managing carbon emissions seriously. We have implemented various policies and strategies, including energy efficiency in production, use of environmentally friendly technologies, and optimisation of logistics routes to reduce emissions from transportation."*

The Sustainability Manager emphasises the company's commitment to managing carbon emissions and has implemented policies and strategies to reduce the impact of carbon emissions from company operations. The next question focus on "How does the company measure and monitor its carbon emissions? Is there a specific process or tool used to track emission levels from various operational activities?" he answered that:

*"I am also responsible for monitoring carbon emissions in this company. We use sophisticated monitoring systems to measure carbon emissions from every stage of our production process. This data helps us identify areas needing improvement and design strategies to reduce emissions."*

Sustainability Managers demonstrate responsibility for monitoring carbon emissions and use advanced monitoring systems to measure and monitor emission levels. The next question was: "Is the company involved in any special initiatives or projects to reduce its carbon footprint?" he firmly answered that:

*"I am also involved in environmental projects as part of the sustainability team. We are actively involved in several environmental projects to reduce carbon emissions, such as*

*investments in green technologies and participation in logistics greening programs. We believe collaboration with external parties is also important in achieving this goal.”*

The Sustainability Manager mentioned the company's involvement in environmental projects and belief in the importance of external collaboration. The next part of the interview was conducted with a non-governmental organisation with the following question: “How does this organisation view carbon emission management practices in companies in Jakarta? Are there any positive trends or challenges identified?” he answered that:

*“I am the Director of Environmental Programs at this organisation. Several companies in Jakarta have shown increasing commitment to managing carbon emissions. However, there are challenges, especially in corporate awareness and engagement, and we strive to provide support and guidance in improving sustainable practices.”*

The Environmental Program Director of a non-governmental organisation gave a positive view of the commitment of companies in Jakarta to managing carbon emissions. He highlighted positive trends and challenges, particularly regarding corporate awareness and engagement. Meanwhile, the second question had the following focus: “As a non-governmental organisation, are there any special initiatives being undertaken to increase awareness and company involvement in managing carbon emissions?”

*“I have a role in developing and implementing educational programs in this organisation. We have launched an education and training campaign for companies in Jakarta. This initiative aims to raise awareness of the importance of managing carbon emissions and provide resources for companies to implement sustainable practices.”*

The Director of Environmental Programs mentioned his role in developing educational programs to increase company awareness of the importance of managing carbon emissions. And the final question focused on: “How is cooperation with companies realised in achieving the goal of reducing carbon emissions?” he answered that:

*“I am also involved in partnership and collaboration activities with companies as a Program Coordinator. We work with companies through training programs, consulting and providing resources. We strive to help companies identify emissions reduction opportunities and provide support for sustainable policy implementation.”*

The Environmental Program Director emphasised his organisation's role in working with companies through training programs and partnerships to help companies implement sustainable practices.

Based on interviews with corporate Sustainability Managers and Environmental Program Directors from non-governmental organisations, it can be concluded that there are serious efforts from the business sector in Jakarta to manage carbon emissions. The

Sustainability Manager emphasises the company's commitment to implementing policies and strategies to reduce the impact of carbon emissions, using advanced monitoring systems to measure and monitor emission levels. The Environmental Program Director of a non-governmental organisation gave a positive view of the company's commitment to Jakarta, highlighting company awareness and engagement challenges. Both informants indicated involvement in environmental projects and collaboration with external parties as important steps in managing carbon emissions. The general conclusion shows a collaboration between the business sector and non-governmental organisations to achieve more sustainable carbon emission management practices in Jakarta.

### **Decision Criteria for Emission Management Policies**

Decision criteria in formulating emissions management policies are crucial because they provide a structured and objective basis for identifying, evaluating and selecting policy options most effective and appropriate to specific objectives. Some important reasons for using decision criteria in the context of emissions management policies include:

1. **Goal Orientation:** Decision criteria help formulate policies clearly in line with emissions management objectives. With the criteria, stakeholders can easily understand the direction and targets of the policy.
2. **Benchmarking Alternatives:** Criteria provide a framework for comparing policy alternatives. This enables objective comparison between different solutions, helping stakeholders choose the option that best meets their needs and priorities.
3. **Selection of the Best Solution:** Using criteria, policies can be designed to maximise desired outcomes and optimise the use of limited resources. The best solution can be selected based on a clear understanding of these criteria.
4. **Transparency and Accountability:** Decision criteria ensure transparency in decision-making, as stakeholders can see and understand the reasons behind selecting a policy. This also increases the level of accountability in policy implementation.
5. **Efficiency and Effectiveness:** Criteria help identify the most efficient and effective policies in achieving emissions management goals. Thus, resources can be allocated wisely to get the best results.
6. **Appropriateness to Local and Global Context:** The criteria enable the adaptation of policies to local environmental needs and characteristics while ensuring conformity with relevant global standards and commitments.
7. **Community Acceptance:** Selecting criteria that reflect community values and aspirations can increase acceptance and support for emissions management policies. These criteria reflect social justice and long-term sustainability.

Emissions management policies can be designed and implemented more systematically by detailing these decision criteria, ensuring that decisions taken consider various relevant factors and support the achievement of sustainable goals. For this reason, the author conducted interviews with experts and stakeholders in the Jakarta area; the results of these interviews are presented in the following paragraph:

The first informant in this interview was an Environmental Expert, with the question, "How do you assess the effectiveness of the emission reduction policies currently being implemented in the Jakarta area in reducing environmental impacts?" he answered:

*"The effectiveness of policies can be assessed from the extent to which emissions reductions are achieved and their positive impact on air quality and ecosystems. A thorough evaluation is essential to measure the achievement of environmental goals."*

Environmental experts stated the need for a comprehensive evaluation to assess the effectiveness of the policy. This indicates the importance of continuously monitoring environmental impacts and desired positive changes.

The next interview question with an Environmental Service Official (Stakeholder with Authority in the Environmental Sector) is as follows: "How does the implementation of emission reduction policies in Jakarta contribute to economic efficiency and impact on the environmental sector?" his answer was as follows:

*" This policy was designed by paying attention to efficiency in resource use and providing a positive impact on the environmental sector, including improving air quality."*

Environmental Service officials emphasised that this policy was designed by considering efficiency in resource use and providing a positive impact on the environmental sector. This indicates an effort to balance emissions reduction and economic growth.

Interview with a Social Justice Activist (Stakeholder with Authority in the Field of Social Justice): How do you see social justice in the distribution of the burden of reducing emissions among various community groups in Jakarta?" his answer was as follows:

*"It is very important to ensure that this policy does not burden certain groups and provides equal benefits for all levels of society. Social impact evaluation is key in this context."*

Social Justice Activists highlight the importance of fair distribution of the burden of reducing emissions. This reflects awareness of the risk of social inequality due to this policy.

Interview with Environmental Law Experts (Stakeholders with Authority in the Field of Environmental Law): What is the level of compliance and law enforcement with emission reduction policies in Jakarta, and are the regulations clear enough?" the informants' answers were as follows:

*"The compliance and enforcement aspects are very important. Legal readiness and regulatory clarity support optimal levels of compliance and effective law enforcement."*

Environmental Law Experts highlight the importance of compliance and law enforcement in supporting emission reduction policies. This shows that regulatory clarity and consistent law enforcement are important for the success of this policy.

Interview with Members of the Legislative Council (Stakeholders with Authority in the Political Field): What is the level of political acceptability of emission reduction policies in the Jakarta area, and is there political support for this policy?" his answer was as follows:

*"Political support is critical to the success of this policy. Has this policy received sufficient political support, or does it require further efforts?"*

Legislative Council members discuss the political support necessary for the policy to succeed. This shows that political factors and support from the authorities are very important in implementing this policy. Through these interviews, it can be seen that stakeholders have diverse perspectives but realise the importance of cross-sector collaboration and community participation in achieving effective and sustainable emission reduction policies in Jakarta. This interpretation can help further decision-making and policy adjustments to achieve desired goals.

So important points can be taken regarding the decision criteria in formulating emissions management policies in the Jakarta area, as follows:

1. Environmental Effectiveness

The ability of policies to effectively reduce carbon emissions and their impact on the environment includes continuous evaluation of the achievement of emission reduction targets, monitoring environmental impacts, and adapting policies to achieve optimal environmental outcomes. Policies must truly succeed in reducing emissions and their negative environmental impact. This involves ongoing evaluation to ensure policies align with emissions reduction goals and deliver positive environmental outcomes.

2. Economic Efficiency

The economic impact of a policy involves evaluating implementation costs, potential impact on economic growth, and strategies for achieving maximum results with minimal costs. These factors include cost-benefit analysis, resource allocation efficiency, and economic strategies that support sustainable growth. Policies must have good economic effects with controlled implementation costs. This includes calculating costs and benefits and efforts to achieve the best results with minimal costs not to burden the economy.

3. Social Justice

Fairness in distributing the burden of emissions reductions among various sectors and layers of society involves consideration

of the socio-economic impacts of policies. This evaluation includes fair treatment of vulnerable groups and strategies to address inequalities that may arise. Policies must treat all community groups fairly in addressing emissions. This involves thinking about how the impact of policies will be felt by different groups, including vulnerable groups, and measures to reduce inequalities.

#### 4. Community Participation and Involvement

The level of community participation and involvement in policy formulation and implementation involves efforts to increase public understanding and awareness. This includes educating the public about emissions management's importance, listening to various parties' input, and creating effective participatory mechanisms. The community must be involved in making and implementing policies. This includes providing the public with an understanding of the policy, listening to their opinions, and creating ways for the public to participate actively.

#### 5. Resource Availability

The availability of financial, technical and human resources is the key to successful policy implementation. The evaluation includes assessing financial capabilities, technical readiness to use emission reduction technologies, and the availability of skilled labour. Sufficient resources, including finance, technical knowledge, and a skilled workforce must support policies. Evaluation includes seeing whether enough money, technology and people are ready to support the policy.

#### 6. Level of Compliance and Law Enforcement

Readiness and success in enforcing policies involve evaluating the effectiveness of sanctions and incentives. This includes consistent enforcement of the law, transparency in the enforcement process, and efforts to ensure high compliance from the various parties involved. Policies must be implemented well and adhered to by all parties involved. This includes enforcing rules consistently, providing sanctions where necessary, and ensuring that people comply with policies properly.

#### 7. Political Acceptability

Policies that can be accepted by stakeholders and receive political support are crucial factors for the sustainability and effectiveness of policies. Evaluation involves consensus building, negotiation with stakeholders, and strategies to overcome potential political obstacles. Policies must be accepted by political leaders and receive sufficient political support. This includes building political consensus, communicating well with stakeholders, and overcoming potential political challenges.

### **Data Analysis and Discussion**

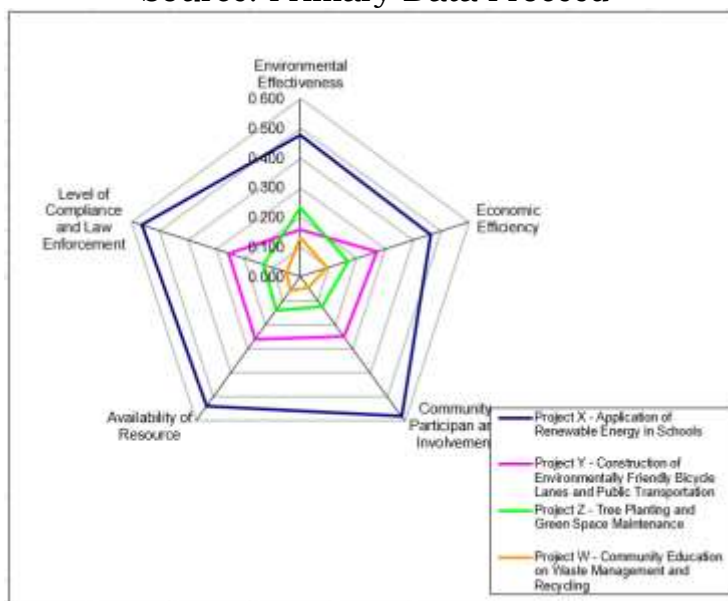
AHP, or Analytic Hierarchy Process, is a decision-making method developed by American mathematician and management expert Thomas L. Saaty, in 1970. AHP is used to solve complex problems by

considering various criteria and alternatives and measuring and grouping preferences or priorities (Rahmaditio & Gardian, 2023). The AHP test results and graphical presentation in this research based on the decision criteria in formulating emissions management policies in the Jakarta area, which we previously knew, are as follows:

**Table 1. AHP Test Results**

Summary	Environmental Effectiveness		Economic Efficiency		Community Participan and In		Availability of Resource		Level of Compliance and Law		Final Score
	Weighting	Score	Weighting	Score	Weighting	Score	Weighting	Score	Weighting	Score	
	Project X - Application of Renewable E	0.123	0.477	0.234	0.463	0.012	0.581	0.564	0.541	0.089	
Project Y - Construction of Environmer	0.987	0.158	0.567	0.273	0.678	0.250	0.890	0.260	0.089	0.255	0.734
Project Z - Tree Planting and Green Sp	0.456	0.233	0.876	0.169	0.901	0.125	0.126	0.140	0.089	0.131	0.396
Project W - Community Education on	0.789	0.132	0.347	0.096	0.237	0.043	0.254	0.059	0.089	0.050	0.167

Source: Primary Data Proceed



**Figure 5. Display of AHP calculation results**

Source: primary data proceed

To reduce carbon emissions and improve environmental quality, Project Y-Construction of Environmentally Friendly Bicycle Lanes and Public Transportation in Jakarta is a top priority in making carbon emission reduction policies for the government. This project has a direct impact on reducing emissions because it encourages the use of sustainable transportation, reducing dependence on private motorised vehicles that use fossil fuels. By improving bike lanes and public transportation infrastructure, this project can improve energy efficiency and encourage people to switch to cleaner transportation options (Lau, 2022a; Sugiawan et al., 2022). The importance of this project is also visible in the context of social justice, as it increases transport

accessibility for all levels of society, creating a cultural shift towards more sustainable mobility. With strong support from the community and the potential to deliver significant long-term results in emissions reductions, Project Y meets the criteria for community participation and involvement as well as resource availability. By prioritising this project, the Jakarta government is taking proactive steps in fighting climate change and building the foundation for more sustainable and inclusive transportation. This implementation can be detailed as follows:

1. **Direct Impact on Carbon Emissions**  
Project Y is a top priority because of its direct impact on reducing carbon emissions. By opening bicycle lanes and increasing the accessibility of public transport, this project effectively reduces the use of private fossil fuel vehicles, which are one of the main sources of emissions in urban areas.
2. **Energy Efficiency and Use of Fossil Fuels**  
The construction of bicycle lanes and public transportation promotes energy efficiency by encouraging the use of more efficient modes of transportation. Public transportation, for example, tends to use cleaner fuels, positively contributing to overall emissions reduction efforts.
3. **Encouraging Sustainable Behavior**  
Project Y focuses on physical infrastructure and plays an important role in shaping people's behaviour. This project encourages cultural change towards more sustainable and responsible mobility by providing an environmentally friendly transportation alternative.
4. **Social Justice and Accessibility**  
Project Y's priorities reflect a commitment to social justice by increasing transportation accessibility for all levels of society. This project reduces gaps in access to environmentally friendly transportation by providing infrastructure that supports inclusive mobility.
5. **Political Acceptability and Community Support**  
This project has a high political acceptability because it responds to societal demands for more sustainable transportation solutions. By involving communities in planning and implementation, the government ensures the broad support necessary for project viability and the sustainability of emissions reduction policies.

By considering the factors above, the Jakarta government can ensure that the emission reduction policies implemented are effective and meet the needs and aspirations of the community, creating a clean and healthy environment for the entire community.

## **CONCLUSION**

Based on the results of the analysis and discussion, it can be seen that the main focus on developing emission reduction policies based on multi-criteria analysis opens up opportunities to design more

effective and sustainable policies amidst the challenges of climate change. Using the Integrated Multi-Criteria Decision Analysis (MCDA) method, this research explores various aspects of emission reduction policies, including environmental effectiveness, economic efficiency, social justice, community participation, resource availability, level of compliance, and political acceptability. The research results provide a basis for policymakers to identify priorities in developing emission reduction policies that can have a holistic positive impact while creating policies accepted by the community and implemented effectively at the local level.

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