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Strategies to Control Industrial Emissions: An Analytical Network Process Approach in East Java, Indonesia

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Abstract: This study identified the main agents, problems, solutions, and strategies for lowering industrial carbon dioxide (CO_2) emissions in the cement industry in East Java, Indonesia, by applying an analytical network process. Respondents included government officials, industrial representatives, and environmental experts. This study revealed that (1) regulators are the critical agents controlling emissions; (2) the three major problems faced when aiming to reduce industrial emissions are limited environmental knowledge, inadequate infrastructure, and unsound regulations; (3) the main solutions are education, socialization, and infrastructure improvement; and (4) the institutional approach is preferable to command-and-control and economic incentives. This suggests that policymakers should collaborate closely with regulators, firms, and communities to more effectively control emissions and encourage environmentally friendly industrial practices. Economic incentives are not preferable strategies, most likely because of insufficient environmental knowledge, market distortion due to subsidies, and low viability. However, the institutional approach incurs higher costs due to political, administrative, and legal processes. Parties may agree on achieving socioeconomic demands but not environmental output. The institutional approach also requires extra investment in education and socialization as well as government support for infrastructure development and a better regulatory framework.

Keywords: analytical network process; sustainable energy; energy policy; low-carbon society; sustainable infrastructure; monitoring sustainable development; climate and production

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1. Introduction

1.1. Background

The East Java province is the second largest contributor to Indonesia's gross domestic product after the Special Capital Region of Jakarta (DKI Jakarta). The well-established manufacturing sector in East Java includes the chemical, petrochemical, cement, textile, and metallurgical industries. The rapid expansion of manufacturing and transportation activities in East Java has had a significant impact on the increasing carbon dioxide (CO_2) emissions [1,2]. The main contributors to emissions are large-scale and energy-intensive activities, such as the manufacture of iron, steel, and ferroalloys as well as those of the cement industry [3]. East Java contains at least five of the largest cement producers in Indonesia: PT Semen Indonesia, PT Holcim Indonesia, PT Indocement Tunggal Prakarsa, PT Euroasiatic Jaya, and PT Semen Padang. The first two are the largest cement producers in the country. According to Panjaitan et al. [4], the cement industry contributes approximately 13% of the total greenhouse gas emissions of the manufacturing sector in Indonesia (2005). The cement industry is a key sector for achieving CO_2 reduction targets in Indonesia. Other sectors, such as oil and gas refinery, steel, petrochemical, glass, palm oil refinery, and energy generation facility (increasingly powered by coal) sectors, also contribute large amounts of emissions [5].

The East Java provincial government is committed to mitigating climate change and achieving its national target of reducing greenhouse gas emissions by 30% by 2030. Efforts to promote sustainable development in the province include promoting clean energy, improving energy efficiency (generation, transmission, and use), reducing emissions from industrial and transport fuel combustion, protecting ecosystems, encouraging green finance [6], and diversifying the energy mix [7]. Achieving such ambitious targets depends on various factors, including policy support, infrastructure, business commitment, incentives, carbon taxes, access to green finance, and appropriate energy reforms [6,8].

Despite efforts to improve environmental quality in the country [6], Indonesia faces challenges in achieving its targets for emission control and meeting energy demands [9,10]. The country relies heavily on coal and fossil fuels, which results in high CO_2 emissions [5,9,11]. Electricity grids are also unstable [7]. Regulatory systems, that is, procurement, investments [12], and environmental control [11,13], are weak. There is a lack of consistent policy framework [9], and corrupt practices are prevalent [14]. Infrastructure limitations [15] and poor access to financing limit Indonesia's potential to reduce CO_2 emissions. However, studies have shown that emissions can be reduced by improving access to alternative energies [16–19] and green finance [6], implementing ecological policies [11,18], offering appropriate incentives [9], and improving environmental policy [7].

Studies in Asia assessing the environmental impact of the cement industry and alternative approaches to reducing carbon emissions tend to support improvements in energy efficiency [20], the use of alternative energies [21], a reduction in the "clinker-to-cement ratio" [4], and technological improvements [22] as main strategies to mitigate carbon emissions [23]. However, such alternatives require government support, attractive incentives, research and development efforts, access to finance, and broader infrastructure. The private sector is unlikely to voluntarily shift to greener technologies and more efficient production systems unless it lowers costs, raises revenues, boosts a firm's position, is motivated by government incentives, or regulators force companies to adopt such systems through regulation and control [4].

Previous studies have shown that carbon control requires multilayered efforts. Reports have proposed diverse strategies for handling emission controls, including economic incentives [24], institutional approaches [25,26], and command and control (CAC) [27]. Policies can be grouped into the following CAC categories: carbon taxes [28,29], carbon trading [30], alternative sources of energy [31], subsidies and incentives [7], energy reforms, and application-efficient technologies [32,33]. For example, in the USA and China, policies to control industrial emissions include introducing renewable energies, carbon taxes, carbon trading, energy-efficient technologies, electricity decarbonization, and energy waste reduction by optimizing energy consumption and improving the energy efficiency of buildings, as noted by Lei's [34] application of the analytical network process (ANP) method and other studies [35–37]. Challenges, such as those faced by China, include difficulty in setting appropriate pricing for CO_2 emissions from different energy sources and determining suitable incentives for the efficient allocation of resources [38]. Few governments can set optimal technology efficiency standards, emission prices, or incentives for businesses.

The use of such strategies has been effective for ensuring that energy-intensive systems adhere more closely to sustainable production, as in China [20], the USA, and other industrialized countries. However, in developing countries, where new technology availability is insufficient and cost is exorbitant [4], alternatives related to the use of more sophisticated technologies to shift away from fossil fuel use, or using "carbon capture, utilization, and storage" [34,36,39], are not currently practical strategies in the short term. Studies have examined strategies for improving the environmental friendliness of cement [4], palm oil [40], and other energy-intensive or natural resource-based sectors in Indonesia [26] and have highlighted the need for more supportive economic and energy policies to achieve carbon reduction.

Specific to East Java, achieving greater sustainability requires a better understanding of the challenges of controlling industrial emissions, accommodating energy demand,

reducing dependence on fossil fuel-based energies [32,41], introducing renewable energy sources [16,42], and identifying appropriate policies [10]. This requires the involvement of the business sector, environmental experts, and policymakers. 6This study aimed to identify the main agents, key problems, solutions, and preferred strategies for reducing carbon emissions in the cement industry in East Java, Indonesia. Insights were gathered from policymakers, environmental experts, and the business sector (representatives of the cement industry) by applying the analytical network process (ANP) method. The ANP approach was developed using the qualitative analytical hierarchy process (AHP) method, involving multiple variables and criteria. The advantage of this approach is that it works with interrelated (directly or indirectly) variable criteria, allowing for the prioritization of indicators and the assessment of strategic policies and technological alternatives. The ANP establishes a relationship between indicators and shows how the indicators in a network affect each other [43].

This study aimed to propose in a single framework a model that combined strategies and alternative solutions that are considered important and relevant to the Indonesian cement industry. First, a questionnaire was designed to obtain insights from policymakers, environmental experts, and industry players to develop an analytical hierarchical framework that could be employed to collect and evaluate data from stakeholders in the cement industry. Stakeholder insights were employed to identify problems and potential solutions. Agent insights from previous studies [44] were incorporated, and the evaluation of three sets of control policy strategies—market-based instruments, institutional approach, and economic incentives—was the focus.

1.2. Control Policy Strategies: Market-Based Instruments, Institutional Approach, and Economic Incentives

Emission control requires appropriate policies, regulations, incentives, taxation, and effective implementation. In Indonesia, strategies related to the market base (e.g., CAC), institutional approaches [25], and economic incentives [15] appear to be preferable for industry, government, and communities.

Pollution control can be carried out using market-based instruments, such as taxes, transferable discharge permits (TDPs), emission trading schemes (ETSs), and CAC [28–30,45]. The government can intervene in setting taxes, aiming to find a socially optimal tax [46] where industry players are encouraged to minimize pollution [47]. Setting the right level of carbon taxes and introducing progressive reforms can successfully reduce carbon emissions, as observed in Sweden [48]. However, taxes can negatively affect costs, efficiency, and innovation [49] or trigger stakeholder resistance [46]. Meanwhile, the TDP allows polluters to buy and sell pollution rights flexibly [50], encouraging companies to be more innovative in the production process (which eventually lowers emissions). CAC policies use administrative and statutory regulation schemes related to the amount of pollution and technology used by industries [27]. CAC generally consists of controls for input quantity, technology, output restrictions, location, and emission permits [27].

Pollution control instruments rely on CAC and incentives (market-based instruments), such as taxes on emissions, products, and resources; subsidies; emission trading licenses; deposit-refund systems; noncompliance fees; performance bonds; and compensation payments. These incentives incur higher administrative costs and risk, distorting markets. Burke and Kurniawati [51] found that reducing subsidies for fossil-powered electricity in Indonesia can boost renewable energy use because the price is more "cost-reflective" and competitive. Additionally, lowering Indonesian firms' dependence on on-grid subsidized electricity will allow national electricity companies to relocate their resources more efficiently.

Institutional approaches facilitate the internalization of externalities [52] to reduce, prevent, and mitigate environmental degradation. More specific regulations related to environmental damage can help build social responsibility [53]. Companies tend to respond to institutional forces and adjust their practices accordingly. In addition to influencing

a firm's practices, an institutional approach can discourage bad practices and stimulate environmental controls. Institutions provide certainty and stringent rules for stakeholders [54], accommodate energy demands and climate change concerns, and provide energy at competitive and affordable costs [13].

Legislated pollution control is a shared responsibility among the government, industry players, and the public. Legislation and regulations in Indonesia have limitations and have failed in the past [7,55]. The country has absorbed most of the capital cost to develop renewable energy because it has failed to convince investors [56] to find sustainable solutions to environmental problems and continues to subsidize fossil-fueled energy [5]. Poor transportation and communication facilities [57] and neglected infrastructure [15,58] can frustrate firms' environmental transformations.

2. Materials and Methods

2.1. Research Methods

This study applied an ANP with three critical stages [43]. The first stage consisted of in-depth and structured interviews with relevant parties [59], including environmental experts, government officials, and industry representatives. The second stage consisted of forming an ANP model and questionnaire to obtain data. The third stage consisted of estimating and analyzing the ANP model to identify problems and find strategies to inform policymaking.

The ANP was developed by Saaty [60]. The basic structure is the influence of the networks on the clusters. Priorities in the ANP are set using pairwise comparisons and judgments, similar to those in the AHP. Saaty [60] defined an ANP as a relative measurement used to derive a composite priority ratio scale from an individual priority ratio scale. The ANP reflects the relative measurement of the influence of hierarchically interacting elements on the control criteria. The main advantage of the ANP over the AHP is that it can capture interdependent results and provide feedback between the elements in a cluster, facilitating decision making (Table 1). In addition to hierarchy, feedback allows a network to form. ANP uses influence, whereas AHP uses preferences. An ANP is a unique case of an AHP with dependency assumptions regarding clusters and elements.

Table 1. Differences between the ANP and AHP.

No.	Difference	AHP	ANP
1	Framework	Hierarchy	Network
2	Relation	Dependency	Dependency and feedback
3	Prediction	Less accurate	More accurate
4	Comparison	Preferential/interest More subjective	Impact More objective
5	Result	Matrix, eigenvector Less stable	Super matrix More stable
6	Scope	Limited	Wide

2.2. The Basic Idea of an ANP

Saaty [61] noted that an ANP consists of seven basic ideas. First, an ANP is built based on a general model designed for decisions with a function to structure complex relations, provide measurements on a ratio scale, and synthesize results. Second, based on dependability, the ANP exceeds the AHP by including independent elements and making the AHP a unique case. Third, ANPs are related to the dependence of the elements inside (inner dependence) and outside a cluster (outer dependence). Inner dependence is the relationship between the elements in a cluster such that the cluster is connected and forms a loop. Outer dependence is the relationship between elements in different clusters so that one cluster is connected. Fourth, ANPs have a flexible structure, representing each decision regardless of the sequential order in the hierarchy. Fifth, ANPs have a nonlinear structure related to resources, cycles, and decline. The hierarchy in AHPs is linear, with the

goal at the top level and alternatives at the bottom level. Sixth, the priorities of ANPs are related elements and element clusters that are close to reality. Seventh, ANPs control the hierarchies to associate different criteria. Ultimately, ANPs lead to an analysis of benefits, opportunities, costs, and risks [62]. In addition, by relying on the controller elements, a parallel ANP can combine different data.

2.3. Population and Sample

Respondents were selected using a purposive sample by considering their understanding of the research problems. More importantly, the respondents were experts in their fields [34]. Saaty [61] noted that in ANPs, validity is not measured by the number of respondents but by their expertise. Therefore, the selected respondents were five representatives of each of the following groups in East Java: environmental management services, the cement industry, and environmental experts.

1. The Environment Agency of East Java Province in Indonesia or *Badan Linkungan Hidup BLH* (roles in the fields of environmental planning, monitoring, and assessment; environmental permission and compliance; education and outreach; and enforcement).
2. Environmental experts (impact analysis) and experts in environmental policy.
3. Industry players, project consultants, and employees (active or former) of Indonesia's largest cement companies.

3. Results and Discussion

3.1. The ANP Model Framework

The main goal of the ANP model framework was to reduce carbon emissions. The criteria for the ANP model were based on those of Field and Olewiler [44], who stated that emission controls are influenced by polluters, regulators, and the government through policies (in line with earlier studies by Tang et al. [49] and Toth et al. [43]). Subcriteria were obtained through in-depth and structured interviews. An ANP is a semiqualitative method in which subcriteria can be obtained through in-depth interviews. Policymakers, firms (cement companies), and environmental experts were asked to provide insights into emission control problems and solutions. The features of the guiding questions employed in the structured interviews are presented in Table A1 in Appendix A. Table 2 summarizes the structured interviews with insights from policymakers (government), companies, and environmental experts regarding the main problems and solutions to achieve emission controls in East Java.

Based on the results of in-depth and structured interviews with the experts, problems associated with emission control in East Java (Table 2) are summarized in Table 3. The ANP instrument gathered the most relevant insights during the in-depth interviews. Table 3 summarizes the main criteria (derived from Field and Olewiler [44]) and subcriteria: (1) polluters have limited environmental knowledge, (2) environmental recovery costs are insufficient, (3) law enforcement is weak, (4) infrastructure is incomplete, (5) regulation is inadequate, and (6) the incentive system is ineffective.

Based on Tables 2 and 3 (simplification), an ANP framework model was proposed. Lei et al. [34] noted eight stages of data processing in ANPs. The first stage is the modeling stage. Clusters and nodes are used to produce the foundation for the ANP network design. There, the clusters and nodes are the criteria and subcriteria, respectively, as listed in Table 2. The ANP emission control model in East Java is shown in Figure 1 and was processed using Super Decisions software to facilitate the computations.

Table 2. Summary of insights from the government (regulators), firms (emitters), and environmental experts on problems facing and solutions to achieve emission controls in the East Java province.

Government	Corporations	Environmental Experts
PROBLEMS		
Industrial players lack knowledge of and awareness about environmental preservation. The industry does not care about compensation costs for the environment. Law enforcement is low. Inadequate infrastructure. Insufficient resources (budget) to implement regulations.	Companies lack knowledge about environmental valuation. Limited funds available for environmental restoration. The industry has not yet used environmentally friendly technology. Deficient law enforcement. There are no strict regulations to control the amount of carbon emissions. The incentive system is not sufficient to motivate the industry.	Companies lack knowledge about the hazards and impacts of emissions. The budget allocated to tackle cost of emissions by firms is negligible. The government is reluctant to improve policies. The law enforcement rate remains low. Inadequate government resources. Inadequate incentives.
SOLUTIONS (ALTERNATIVES)		
Solutions to a lack of knowledge		
Socialization on environmental practices and environmental impacts on society and ecosystems.	Education and outreach related to regulations, incentives, and instruments to control emissions.	Training on environmental valuation and the impact of emissions on the environment.
Solutions to environmental restoration costs		
More intense supervision. Determination of the cost of restoration and compensation for environmental and community damages.	Facilitation by the government of tools, technologies, and systems to reduce emissions at affordable prices.	Monitoring of environmental cost–benefits to assess whether compensation funds sufficiently address the damage caused.
Solutions to the lack of law enforcement		
Supervision of government actions or activities and performance evaluation.	Monitoring and auditing by the government to reduce dishonest practices, violations, and corruption.	Monitoring and evaluation of progress after the implementation of regulations as well as compliance with the law.
Solutions to the limited infrastructure		
Support the establishment of low-carbon infrastructure, including renewable energy sources, waste recycling facilities, and railway infrastructure.	Facilitation by the government of firms accessing new infrastructure (clean energy sources, carbon capture and storage technology, recycling infrastructure, energy-efficient kilns, and transport).	Repairing or establishing new infrastructure to assist with supervision and monitoring.
Solutions to inadequate regulations		
Ensure that existing regulations are sufficient to deal with emission pollution control issues and are always being evaluated and reviewed so that they are relevant to existing conditions.	Regulatory improvements and laws governing emission management must be accompanied by better socialization.	Review of existing regulations, improve the process of socialization of regulations, and simplify the emissions assessment and monitoring process.
Solutions to a lack of incentives		
The government should facilitate lending for low-carbon projects, tax relief, and customs relief if firms want to import environmentally friendly technology.	Firms hope that financial and fiscal incentives can be provided to help reduce production costs, not only recognition as environmentally responsible firms.	Provide subsidies to polluters who reduce their amount of emissions.

Table 3. Criteria and subcriteria of emission controls in East Java province.

Number	Criteria	Subcriteria
1	Polluters	Limited knowledge of the environment Insufficient recovery costs
2	Regulations	Inadequate regulations Undervaluation (disincentives)
3	Implementing policies	Weak law enforcement Inadequate infrastructure

Source: in-depth interviews.

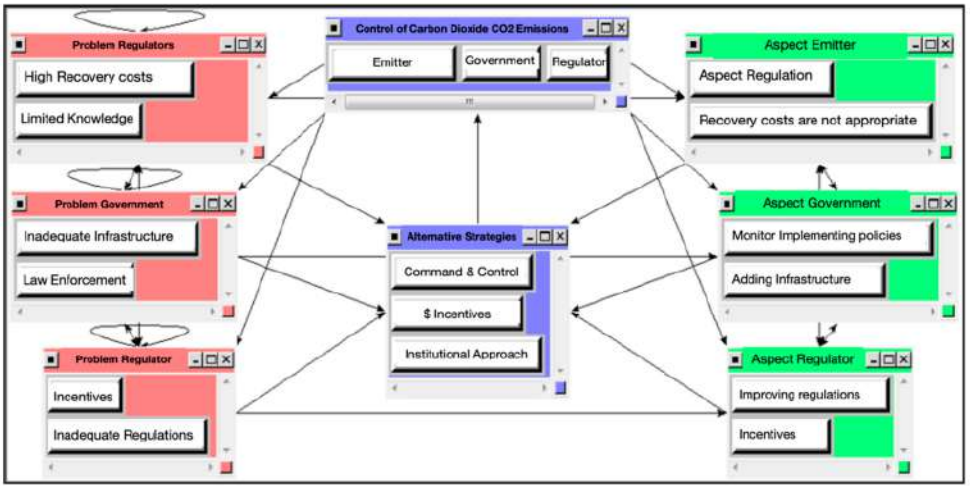

Figure 1. ANP framework applied to the case of East Java, Indonesia.

The second stage involves weighting using pairwise comparisons between the two elements, which helps determine the degree of relevance of the indicators employed. This comparison was followed using rating scales 1–9, as shown in Table 4. The third stage calculates the weights of the linkages between the clusters and nodes. The results are acceptable if the consistency ratio (CR) value ≤ 0.1. A CR value > 0.1 indicates that the questionnaire fill-out is poor. The fourth stage generates the cluster matrix and unweighted supermatrix. The fifth step involves arranging the priority weight results from the intercluster linkage weighting in the cluster matrix. Similarly, the priority weight results from the internode linkage weighting are arranged in a cell-appropriate matrix (unweighted supermatrix).

Table 4. The rating and numerical scales in the ANP framework to measure the degree of relevance of indicators to the target of emissions control.

Numerical Scale	Rating Scale
1	Equal (not important/influential/relevant)
2	
3	Moderate (less important/influential/relevant)
4	
5	Strong (important/influential/relevant)
6	
7	Very strong (very important/influential/relevant)
8	
9	Extreme (exceptionally important/influential/relevant)
2, 4, 6, 8	The median value of adjacent judgments

The sixth stage involved weighting the supermatrix by multiplying the cell values (cluster matrix) by the value of each cell (unweighted supermatrix). The seventh stage limits the matrix by multiplying it by the weighted supermatrix. The result was accepted when the priority value of each row was the same. The eighth stage normalizes the limiting matrix based on the clusters, such that the total priority value for each cluster is one.

3.2. Results on Scoring and Computations

In this section, the main results are discussed, namely the criteria that play the most important role in reducing carbon emissions, both overall and by group. The main problems, solutions, and most viable strategies are also identified.

The ANP results are presented in Table 5. Overall (refer to all samples in column 1), regulators are ranked as the most important agents with a value of 0.401, followed by polluters with a value of 0.323 and policy implementers with a value of 0.276. There are three main problems with emissions control in East Java: (1) limited knowledge of the environment (0.600), (2) inadequate infrastructure (0.523), and (3) ineffective regulations (0.510). The three selected solutions were (1) education and outreach (0.674), (2) the addition of infrastructure (0.569), and (3) regulatory improvements (0.535). Finally, the emission control strategy that ranked first with a score of 0.487 was the institutional approach, followed by the CAC strategy with a value of 0.325 and the economic incentive strategy with a value of 0.189. However, the ranking of agents, problems, solutions, and strategies differed for all samples (1) and the three subgroups of respondents (government, firms, and experts; columns 2 to 4 in Table 5).

Table 5. ANP results: priorities and weighting results of indicators.

Criteria	Value	Subsample Groups (Values)		
	Whole Sample (1)	Government (2)	Firms (3)	Experts (4)
Agents				
Regulators	0.401	0.671	0.089	0.444
Pollutants	0.323	0.132	0.700	0.137
Policy implementation	0.276	0.197	0.212	0.420
Problems				
Limited knowledge of the environment	0.600		0.876	
Inadequate infrastructure	0.523		0.800	0.505
Inadequate regulations	0.510	0.530	0.836	0.834
Weak law enforcement		0.735		
Insufficient recovery costs		0.536		0.540
Solution				
Incentive system			0.873	
Education and outreach	0.674		0.837	0.721
Infrastructure improvement	0.569		0.871	
Regulatory improvement	0.535	0.771		0.707
Monitoring policy implementation		0.655		0.510
Monitoring environmental recovery cost		0.536		
Strategy				
Institutional approach	0.487	0.369	0.668	0.423
Command and control	0.325	0.494	0.241	0.338
Economic incentives	0.189	0.137	0.091	0.239

Source: Super Decisions (processed by the authors).

3.2.1. Government

The ANP results indicate that the government is more concerned with regulatory aspects, as they become the reference point for emissions control for regulators and firms (column 2). Respondents from the government noted that weak law enforcement for the implementation of emissions control policies was due to inadequate infrastructure, causing existing regulations to be considered inadequate by firms. The government believes

that, to overcome these three problems, it is necessary to improve regulations, improve the monitoring of policy implementation, and provide more adequate assessment and monitoring of environmental recovery costs. The appropriate strategy to apply is CAC (0.494), as according to the government, current economic incentives and regulations are sufficient to control emissions in East Java.

3.2.2. Polluters (Firms)

To control emissions in East Java, polluters (column 3) should be the main focus as the main agents (0.700), and the government (executive) should also be a focus as the second most important agent (0.212). Companies have stated that the role of the executive is more important than that of the regulatory body, as the executive interacts directly with the company. The main problems of emissions control according to firms are a lack of knowledge (0.876), inadequate regulations (0.836), and inadequate infrastructure (0.800). Companies claim that they lack information on environmental impacts. Such knowledge limitations may explain firms' low environmental concerns about emissions and the main focus being on profits. Companies believe that the government does not provide sufficient incentives for firms trying to control emissions. In addition, the government does not provide adequate infrastructure; therefore, the implementation of emission control policies is ineffective. Firms argue that the provision of a better incentive system could encourage them to seek more active ways of controlling emissions. Moreover, firms have pointed out that the government must have adequate infrastructure to facilitate the implementation of regulations and that more active education and socialization programs are needed. The strategy chosen by polluters was the institutional approach (0.668), with the hope that the government would listen more to firms, accommodate their needs, and work closely with them to reduce emissions.

3.2.3. Environmental Experts

Environmental experts also believe that regulations and the government (policymakers) play important roles in controlling emissions in East Java (column 4). Regulations and their implementation should go hand in hand. In contrast, environmental experts rank polluters third (0.137) in terms of importance when it comes to emissions control, arguing that the most crucial role is that of regulatory design and implementation. However, the main problem is that inadequate regulation causes bias in the allocation of environmental restoration costs. Consequently, the main solution is to improve regulations. Regarding strategy, environmental experts believe that institutional approaches are the most crucial, in line with the opinion of polluters, signaling that the government should provide direction and guidelines to polluters regarding targets and the implementation of controls.

3.3. Discussion

Based on the results of the in-depth interviews (Table 2) and the ANP (Table 5), regulations scored the highest in terms of importance, suggesting that achieving sustainable development requires a more active regulatory body. The government's role in emission control is that of both legislative and executive parties, following Government Regulation No. 41/1999 on Air Pollution Control and Law No. 32/2009 on Environmental Protection and Management. The government representatives and environmental experts in this study believe that the role of the government as a regulator (policy design) comes first, and that government (implementation) comes second to achieve a sustainable environment. These results indicate that the government's role (implementation) is a bridge between regulators (policymakers) and polluters.

Earlier studies have also pointed out that the government, as a policymaker, plays a critical role in emission control, and that determining optimal levels of pollution requires accounting for industrial production and costs [34,43]. In line with earlier findings, Indonesian regulators and policymakers have noted that the government plays a key role in reducing carbon emissions by issuing appropriate regulations, introducing instruments

(policies) to promote alternative energies [56], setting emission limits, designing a regulatory framework [63], proposing reforms [7], and overseeing pricing strategies. Officials at the Environment Agency of East Java (DLH) believe that efforts to create a conducive environment for companies to encourage new investments in cleaner energies and better technologies are already in place, similar to earlier findings [32,64]. Environmental experts believe that monitoring is necessary because success depends on the capacity of authorities to implement and ensure that companies follow established regulations. Moreover, the government can provide instruments (e.g., incentives) for firms to encourage emission reductions [65,66].

In contrast, companies consider polluters to be the most important players (agents) in promoting a sustainable environment and regulators to be the least important. Companies prioritize themselves as the main actors responsible for emissions control. Decision-making regarding technology use, setting the optimal output of production, input selection, and setting prices depends on the firms themselves, rather than on regulators or the government. Companies also have strategies to lower emissions to avoid high production costs. Companies have a better understanding of the technologies available for inputs and the challenges of implementing control technologies, as noted in earlier studies [35,66]. Firms can also assess the cost–benefits of their sustainability practices [27]. The arguments of the polluters in Indonesia are in line with those that have been previously reported (e.g., cement industry in China), which indicated that implementing four strategies led to a reduction of more than 30% in CO_2 emissions: shifting towards greener energy, improving efficient use of energy, shifting to alternative raw materials, and "implementing carbon capture and storage" [20]. All four reduction strategies are within the scope of firms, rather than that of regulators or the government.

Regarding the main problems preventing the lowering of emissions, representatives from the East Java BLH (government) said that the polluters' limited knowledge about the environment reflects an attitude of "turn a deaf ear "to environmental conditions and the impact of their actions on the communities surrounding them. The environmental experts added that a lack of knowledge about environmental valuation encourages polluters to act selfishly without recognizing the severity of the environmental impacts. Furthermore, respondents from the cement industry lack knowledge of impact evaluation analyses, making companies unaware of their environmental impacts, especially their direct impact on health. Government respondents indicated that a lack of environmental knowledge led to subsequent problems, such as misallocating environmental funds (0.400), which could lead to market failure. Market failures may occur if environmental issues between parties (e.g., the government, firms, and communities) are not settled appropriately. For example, Kurniawan et al. [26] noted that more than 52% of community members were satisfied with the economic and social impacts of a nickel smelter project in Indonesia. However, nearly 45% of the respondents were unsatisfied with the environmental aspects, and nearly 25% did not provide a clear opinion (likely due to a lack of understanding). Such insights reveal that projects with high environmental impacts can push through when economic impacts outweigh the environmental costs. Companies and environmental experts agree that education and socialization should be top priorities over monitoring the cost of environmental restoration. The cost of solving this problem can also be reduced. Environmental restoration can be monitored simultaneously with education and socialization.

Besides low environmental knowledge, inadequate infrastructure represents an important limitation to effective emissions control. East Java agents from the BLH noted that infrastructure procurement has only focused on big cities, because it requires a relatively large amount of money. The budget for expanding infrastructure throughout East Java remains limited. In addition to human resources, time, and institutions, infrastructure is required for regulations to work properly, as noted by government representatives and environmental experts and previous studies [44]. A lack of infrastructure limits the options available to implement new policies, incurs high costs for firms, or causes policies to be

unenforced. The energy infrastructure in East Java is inadequate and scarce, making it difficult to monitor, regulate, and enforce regulations.

Previous studies have pointed out the limitations of decarbonizing infrastructure in East Java and Indonesia [15,58]. The limitations of infrastructure are partly an example of government omission failure [67] or even colossal government failure, as the government becomes a central source of the problem. A transition towards greener technologies and cleaner industrial activities will require additional effort from the government and private sectors to provide more infrastructure resources to support the cement industry, as previously noted [20].

Based on the ANP results shown in Figure 1, promoting education and more active socialization are key solutions for controlling emissions in East Java, followed by improving infrastructure. Environmental experts believe that regulations and policies need more socialization to increase companies' awareness of their impact on the environment and to facilitate compliance with the regulatory framework. In addition, more active socialization by the government can help firms adopt more sustainable practices, which can lead to lower production costs and emissions. Moreover, government officials argue that firms can benefit from government incentives if they are more aware of current programs and public initiatives. Experts believe that good socialization and education on environmental regulations, practices, and incentives can lead to a reduction in carbon emissions and more effective mitigation of environmental impacts. Firms also believe that socialization is important for lowering emissions, although they believe that the government needs to first provide more attractive incentives and improve infrastructure.

Improving infrastructure is the second preferred solution. Firms are especially inclined towards better infrastructure to lower emissions. Infrastructure is also required for the monitoring process [5], which is a preferred solution for the government and environmental experts. Krueger [67] pointed out that increasing government intervention in developing countries (in regulation and monitoring) is unfeasible if the infrastructure needed to facilitate the interventions is unavailable. Monitoring is also required to effectively implement regulations [68]. Monitoring and regulatory work require additional infrastructure to reduce pollution.

Based on the ANP results (Table 5, column 1), the best strategy for controlling emissions in East Java is the institutional approach, with a score of 0.487. Firms and environmental experts believe that the institutional approach is the most effective strategy. The government places greater emphasis on the CAC approach as a strategy, followed by the institutional approach. Firms believe that an institutional approach facilitates engagement among policymakers, regulators, and communities. Institutions provide stakeholders with certainty and clear rules [54]. Kudłak [53] noted that the institutional approach could help reduce, prevent, and mitigate environmental degradation, while building social responsibility among the involved parties. In Indonesia, the institutional approach is common (and often preferred as the best strategy), but does not always generate desirable outputs [25,26]. For example, palm oil plantations in Indonesia are not inclined towards environmentally sustainable practices and have low engagement with other stockholders, such as businesses, regulators, and communities [40]. The central government does not have the power to implement regulations and requires other actors to support stakeholder coordination. Indonesian firms respond more strongly to institutional forces [40,52].

The ANP results differ from those of previous studies [35,37,38], in which CAC or economic incentive (market-based) policies were found to be preferred. The results of the present study show that stakeholders prefer the institutional approach (firms and environmental experts) even though government officials have pointed out that CAC is their preferred strategy. This may be because CAC and market-based policies are more suitable for industrial regions or developed countries, such as China and the USA [27,35,48]. In Italy, CAC is preferable to market-based approaches because the latter require state intervention in resource and sanction management [69]. Previous studies tended to support market-based policies or CAC more than the institutional approach because they often as-

sociated institutional processes (political, administrative, and legal) with higher transaction costs [69]. In China, Tang et al. [49] noted that the impact of instruments, such as the TDP, highly depends on market perfection, pointing out that as institutional transaction costs increase, innovation and its effects decrease.

The results of this study suggest that policymakers are crucial for curbing emissions in East Java, as they are responsible for the policy framework, laws, regulations, incentives, resource allocation, and rules of operation. The institutional approach must be supported by government regulatory authorities and firms, education and outreach activities, infrastructure, and regulations. Policymakers can foster collaboration among stakeholders and strengthen the importance of environmental protection through active socialization and education programs. Regulators and governments can also explore other mechanisms that Indonesia lacks, such as CAC instruments and market mechanisms. Gunningham [13] stated that Indonesia requires a robust governance approach to strive for a balance between managing energy demand, climate change, and energy poverty.

4. Conclusions

4.1. Suggestions

Based on the results, the policy suggestions are as follows:

1. Based on previous studies and firm insights, incentives have been identified as effective instruments for controlling pollution (according to firms), especially in industrial regions. Therefore, the government must apply these measures to control industrial emissions in East Java. Thus far, economic incentives have been perceived as the least effective strategy, suggesting the need to reformulate the framework for taxes, TDPs, ETSs, and other tools to be used by industry players and regulators to achieve a more sustainable environment.
2. Regulators must intervene when excessive pressure on industries negatively affects the players. Firms believe that the government does not appropriately inform them of regulations and incentives, and that the available infrastructure is insufficient to reduce emissions.
3. Providing more market-based alternatives to industrial players is important as it offers choices to players when trying to meet regulatory measures. In addition, more active socialization of market-based incentives is necessary, as firms are unaware of the available market-based instruments offered by the government.
4. The institutional approach can feed regulators (as primary agents) with industry needs to help formulate new policies, design infrastructure projects, and organize new programs. Similarly, an institutional approach can encourage companies to implement sustainable practices, boost community engagement, innovate, and advance technical solutions to lower emissions.
5. The perception of limited infrastructure by agents suggests that the government needs to analyze infrastructure to support efforts to reach emission reduction targets.
6. The preference of key agents towards the institutional approach suggests that new policies, programs, and carbon schemes should be introduced through institutional channels. Agents must understand the environmental impact, regulatory framework, implementation, and timeframe to internalize the sustainability agenda.
7. The government may shift general subsidy programs to private incentives to encourage innovation and develop alternative energy sources. Current interventions through electricity subsidies to provide cheap energy have discouraged private initiatives from investing in alternative energy sources because they are not cost-competitive.
8. Alternative solutions that policymakers can explore include promoting financial support for new technologies, supporting the use of alternative energies, master-planning industrial areas, introducing green corridors, and promoting carbon-catching initiatives and green infrastructure projects.

9. The government may face challenges in meeting energy demands and tackling climate change. Therefore, financial access to support infrastructure development, technological innovation, and new investments must be improved.

4.2. Conclusions

This study applied an ANP to identify the main agents involved, problems to tackle, and strategies required to curb carbon emissions in East Java, Indonesia. Insights from government officials, industry representatives, and regulators were applied to identify six main problems in emissions control in East Java: (1) limited environmental knowledge (particularly of firms); (2) insufficient environmental recovery costs allocated by companies to counteract environmental damage; (3) weak law enforcement as the government claims that it lacks resources to carry out regulatory work; (4) inadequate infrastructure, which offers few alternatives to firms and inadequate means for regulators to apply norms; (5) inadequate regulations; and (6) ineffective incentive systems (firms are unaware of instruments, and the government has failed to socialize incentives).

The ANP analysis results showed that regulators are the main agents, although firms believe that they are mainly responsible for lowering emissions, as they entail production targets, cost of operation, and investment returns. Government and industry representatives consider policymakers to be the second most important agents, as they bridge the gap between regulators and industry players by designing a suitable regulatory framework. Education and outreach were the primary solutions, followed by infrastructure and regulatory frameworks. Firms and environmental experts believe that the government does not carry out effective socialization, with implications for companies that are unaware of the existence of incentives, ignorant of environmental assessments, and unconcerned with the need to remedy environmental failures. Regulatory enforcement is the least efficient solution to this problem.

According to the respondents, the institutional approach is the best strategy for controlling emissions in East Java, followed by CAC and economic incentives. In the institutional approach, institutions play a key role in linking regulatory aspects, monitoring and maintaining controls, and assisting firms, communities, and governments with reaching agreements. The lack of a centralized authority suggests the need for a wider regulatory settlement process involving different players. The institutional approach is suitable for Indonesia to coordinate regulators, firms, individuals, and communities, considering market imperfections, market distortion due to energy subsidies, deficiencies in the rule of law, and a lack of infrastructure. Nevertheless, the institutional approach also has a weakness, as it may facilitate mutual agreements (e.g., between industry and community) but may not achieve optimal environmental output. In addition, the institutional approach incurs more costs associated with political, administrative, and legal processes that may discourage other mechanisms, such as TDPs and ETSs, lower technological innovation, or disproportionately affect less-efficient players. Nevertheless, a well-implemented institutional approach can encourage changes in practices, regulators, and policymakers towards more innovative and diversified strategies to curb carbon emissions.

This study had limited data on the number of respondents, indicators, and criteria. Other problems, solutions, and strategies should also be explored to provide comprehensive environmental guidelines for industrial development in East Java. Future research can be expanded by increasing the number of respondents.

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Appendix A

Table A1. In-depth questions employed with government, industry, and environmental experts to collect insights for ANP framework.

Questions
1. How important is emission control given the good economic condition of East Java? (Very important, Important, Not very important, or Not important. Please explain)
2. Who has a role to control emissions in East Java (agents)? And what are their main responsibilities?
3. What are the constraints of each party that plays a role in controlling emissions in East Java? (Industry players, policy (regulation), policy makers, and policy implementers)
4. What are the possible solutions to obstacles faced by the different agents in controlling emissions in East Java? (Industry players, policy (regulation), policy makers, and policy implementers)
5. What have been done by business actors in the cement industry to restore the condition of the surrounding environment? Have any of the following actions being carried out (in line with the Regulation of the President of the Republic of Indonesia no. 41 of 1999 concerning Air Pollution Control article 25 paragraph 1): a. Replacing old machines with new machines with more modern technology b. Installation of special tools (complementing) on existing machines. c. Implementation of ISO 17020 and ISO 14000 d. Expanding Green areas around the factory area e. Partnership program with the community around the factory.
6. Have business actors in the cement industry implemented this policy? (Government Regulation of the president of the republic of Indonesia No. 41 of 1999 concerning air pollution control, article 52, and article 54 paragraph 1). If yes, how. If not, what are the reasons and challenges.
7. What obstacles have been encountered by business actors in the cement industry during the implementation of this policy? (No. 41 of 1999 concerning air pollution control)
8. Does the implementation of the policy by cement firms receive incentives from the provincial government of East Java as the operational implementer of the policy in the region?
9. What kind of strategy is appropriate to carry out emission control in East Java province?
10. Is the existence of regulations important in controlling emissions in East Java province?
11. Are existing regulations sufficient to improve emissions control in the cement industry? What are the problems, and how can problems be address?
12. What incentives and sanctions are applied by the environmental agency of East Java province as the party authorized by the provincial government of East Java in controlling emissions? (Refer to Regulation no. 41 of 1999 concerning air pollution control article 18 paragraph 1)
13. Has there ever been a subsidy given as a form of appreciation for polluters trying to reduce emissions? Or what sort of support programs exist?
14. What kind of strategy is appropriate to carry out emission control in East Java province?

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PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10

PAGE 11

PAGE 12

PAGE 13

PAGE 14

PAGE 15

PAGE 16

PAGE 17