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Carbon Emissions In Asia: The Role Of Renewable Energy, Non-Renewable Energy, Carbon Tax, And Net-Zero Emissions Commitments

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ABSTRACT

Net-zero emissions are the main target for countries to immediately address the current carbon emission problem due to the degradation of the natural environment. Asia is the largest emitter of carbon emissions and the largest user of energy. Most of these carbon emissions result from the excessive use of non-renewable energy as the main energy input. Renewable energy is believed to have a dual effect of reducing carbon emissions and replacing the role of non-renewable energy. The transition is an important issue nowadays for countries supported by domestic climate policies and country commitments. The purpose of this study is to determine whether renewable energy, non-renewable energy, carbon tax, and net-zero emissions will affect carbon emissions. The results show that renewable energy and net-zero emissions have a negative significant effect, non-renewable energy has a positive significant effect, and carbon emission has no significant effect on carbon emissions in Asia. Even so, the implication of this research is as input and consideration for countries to transition to sustainable energy sources and strengthen the design of carbon tax to be more effective along with the country's commitment. The sample used is 36 countries in Asia from 2011-2020. The method used is panel data analysis to determine the effect.

INTRODUCTION

Energy, economic growth, and the environment are three crucial interconnected factors in a country's development (Mai, 2023; Yolcan, 2023a). Managing all those three elements in balance is essential for consistent growth. It is well known that large amounts of energy are needed to maintain economic growth and development (Laldjebaev et al., 2021; Roslan, 2021; Viktorovna et al., 2021). Energy is the main input for industrial activities in the economy for both goods and services. The importance of energy to society is increasing to ensure quality of life and the smooth running of other elements in our economy (Lin et al., 2024; H. Liu et al., 2022).

Along with the growth of the economy and population, there will also be more needs demanded by the community, it also encourages companies to increase the amount of production and consumption, including one of which is energy needs. While useful for economic growth, energy use also need to be environmentally conservative and limited (Maradin, 2021; Noor et al., 2024), excessive use can potentially damage the environment (Maradin, 2021; Olabi & Abdelkareem, 2022; Yolcan, 2023b). Climate Watch Data (2021) shows data that 74.69% of CO2 in the world comes from the energy sector—the effects of CO2 lead to climate change, ozone depletion, and other environmental problems. Excessive energy consumption is a big problem for the environment because it produces various harmful effects (Mai, 2023; stergaard et al., 2022). Therefore, efforts are needed to build more sustainable energy production to avoid overusing fossil fuel sources or exploiting natural resources. The form that can be done is with renewable energy with lower carbon emissions and can be used more than once (L. Li et al., 2022; Maradin, 2021; Vakulchuk et al., 2020). Renewable energy can cost less than conventional energy (Mai, 2023) so the benefits obtained are not only reducing carbon emissions. It can be said that renewable energy is the most effective solution to deal with carbon emission problems, reducing the risk of energy scarcity, and improving environmental protection (Adrian et al., 2023; Guchhait & Sarkar, 2023; Manso & Behmiri, 2020; Rai et al., 2023; Sayed et al., 2023; Shah et al., 2023; Vakulchuk et al., 2020; Widianingsih et al., 2024). Its role is vital in the sustainability of the country and economic development.

Across all regions, Asia is the largest energy producer for the 10th consecutive year (International Renewable Energy Agency, 2024). Asia's total energy generation averages 49.5% per year of the world's total energy generation, twice of Europe and one and a half times of America. This shows that the energy demand in Asia is huge, as the population is 60% of the world's total and hence the demand for energy is also high (United Nation, 2020). However, Asia still relies on the use of non-renewable energy rather than renewable energy. International Renewable Energy Agency (2024) shows that until 2020, the use of renewable energy is still only 23.67% of the total energy produced. Most renewable energy sources used are hydropower at 60%, followed by wind at 18%, and solar at 14% of the total renewable energy generated in 2020. This renewable energy generation continues to increase year on year with an average of 10% each year. However, the use of non-renewable energy remains very high, in 2020 it was still 76.32% of the total energy generated. Most of the non-renewable energy sources used are fossil fuels at 92% of the total non-renewable energy generated. BP (2024) Shows the level of consumption and production of fossil fuels in the form of gas, oil, and coal, through this data it is indicated that there is an imbalance in that the production of oil and gas is smaller than its consumption, which is -55.6 exajoules and -8.2 exajoules respectively. Meanwhile, coal production is above consumption by 4.1 exajoules. Even if production is below consumption, Asian countries still import non-renewable energy from outside.

To meet energy demand, non-renewable energy is still the main contributor to the energy sector even though it is not sustainable and harmful to the environment. Gases such as CO2, methane, and nitrous oxide are produced in large quantities during the combustion of fossil fuels (Olabi & Abdelkareem, 2022). This effect is also expected to continue to increase along with economic growth and population, if it continues to accumulate, it has the potential for an irreversible impact (Riyono & Widianingsih, 2024). The impact will affect the ozone layer, climate change, environmental issues, and increased health risks (Dulal et al., 2013; Mengova, 2024). Therefore, it is necessary to transition from non-renewable energy to renewable energy to reduce further adverse impacts. Even so, there is still a lot of resistance from companies to participate in the transition to renewable energy due to large investment costs (Green, 2021; J. Khan & Johansson, 2022), limited technology (Albaker et al., 2023; Avotra & Nawaz, 2023), change the business operation cycle of both the supply chain and infrastructure (Lin et al., 2024; Roslan, 2021; Yolcan, 2023a), and company culture using conventional energy (Mai, 2023; Noor et al., 2024; Viktorovna et al., 2021). To encourage the use of renewable energy, regulations are also

needed to encourage the adoption of cleaner energy technology and limit the level of carbon emissions generated by the company. Companies will not adopt green policies due to large investment costs, but if there is a potential to affect expenses or reduce company profits directly, companies will take the matter more seriously (Gevrek & Uyduranoglu, 2015). The most effective regulation to limit companies' carbon emissions is a carbon tax (G. E. Metcalf, 2021; Parry, 2019; Tsai, 2020). Carbon taxes adhere to the 'polluter pays' principle, if a company produces carbon emissions more than the predetermined limit, it is obliged to pay a carbon tax burden. The implementation of a carbon tax has a devastating effect on society and is very constructive (Carattini et al., 2018; G. Metcalf, 2019). Carbon tax encourages polluters to adopt greener production and activity through renewable energy to reduce carbon pollution emissions. Companies will avoid higher tax burdens so as not to reduce their profits by minimizing their carbon emissions. Carbon tax regulation is effective by limiting productivity that produces carbon emissions and encouraging the use of renewable energy (Mintz-Woo, 2024).

Beyond regulation, countries also need a commitment to net-zero emissions to encourage companies to have a vision and mission that is aligned with their country (Albaker et al., 2023; Olabi et al., 2022, 2023). This form of commitment is an effort to overcome the problem of carbon emissions, by bringing all stakeholders to work with the same goal. With the commitment of the state, the regulations and policies are formed to lead the net-zero emissions target. Net-zero emissions motivate companies to also take part with the regulations formed to move stakeholders and the community to take part in it (Avotra & Nawaz, 2023; Ioannou et al., 2022). By making this commitment, countries, organizations, and individuals will work together to shape a more sustainable future for future generations. Although Asian countries have made considerable efforts to transition to renewable energy over the past decade, the longitudinal effects and emission outcomes of this mission still need to be explored further. Limited research tracks the long-term effects of renewable energy development on carbon emissions. Although renewable energy is more efficient than ever, studies lack an assessment of how these advancements translate into real-world emissions reduction over extended periods, especially in Asia as the largest energy producer. Long-term effects and behavioral changes over time of carbon tax are not well understood in Asia, most Asian countries face economic and developmental constraints that will affect the feasibility of carbon tax. Research on how carbon tax will affect carbon emissions while supporting economic growth in Asia is lacking, it is critical to ensure policies that balance both environmental and economic development needs. Especially since most Asian countries are still developing countries, it is interesting to see whether its implementation in Asia will be as effective in the long run. Meanwhile, the reality and goal of net-zero emissions commitments is far from simple, requiring enormous effort and changes in various aspects of life. There are various concerns to achieve the goal, with many countries and companies not yet fully committed to the issue of carbon emissions and the effort required to achieve net-zero.

The novelty in this research is the use of the index of renewable energy generation and non-renewable energy with measurement by generation, whereas previous studies used measurement by consumption. The measurement by generation is intended to better show the total renewable energy usage index not from the user's perspective. If the measurement consumption only shows what is used but the actual generation in total is not visible, then the carbon emissions released are more real with measurement generation. The effect of the carbon tax and net-zero emissions commitment has also not been directly tested in Asian countries by previous studies, so it is also interesting to examine whether it will be effective in encouraging lower carbon emissions or not. The purpose of this study is to provide empirical evidence on the long-term effects of renewable energy, non-renewable energy, carbon tax, and net-zero emissions commitment on carbon emissions in Asia. The contribution of the research results will enrich the development of research in the field of sustainable management and government

regulation. As well as understanding the cultural, social, and political drivers behind public acceptance or resistance regarding the transition to renewable energy and carbon tax.

LITERATURE REVIEW

Natural-Resources Based View

The natural-resources based view is based on a long-term strategy and competitive advantages that will drive the company towards environmental-oriented and sustainable operational activities (Hart & Dowell, 2011). The basis of the theory is strategies for pollution prevention, product stewardship, and sustainable development (Hart, 2017). With these driving forces, it can reduce emissions and waste, minimize the life-cycle cost of products, and reduce the burden of company growth and development (Hart & Dowell, 2011). This theory is intended to build a shared vision that is sustainability-oriented for each stakeholder to move the flow of production and activities in a green direction, which will also have an impact on sustainable development.

Hypothesis Development

To achieve long-term environmental sustainability, many studies show that the transition from conventional to renewable energy is instrumental in reducing carbon emissions and mitigating global warming (Guchhait & Sarkar, 2023; Manso & Behmiri, 2020; Maradin, 2021; Olabi & Abdelkareem, 2022; Østergaard et al., 2022; Vakulchuk et al., 2020). Carbon emissions produced by renewable energy are much lower and even reach zero carbon than conventional energy in both the short and long term (Şanlı et al., 2023; Yolcan, 2023a), although the effect may vary depending on the stage of renewable energy development (Salem et al., 2021). Renewable energy sources are also not disposable and can be used continuously, making their use more sustainable. (Levenda et al., 2021; Majeed et al., 2023; Osman et al., 2023). The active involvement of communities and companies is needed to accelerate the transition to cleaner and more sustainable energy.

The renewable energy transition is in line with the natural resource-based view theory that with the push for the transition, companies, and communities will begin to change the realm of mindset to be environmentally oriented (Ruggiero & Lehkonen, 2017; Shin et al., 2018). An environmental-oriented mindset changes the pattern of activity to be conservative towards the surrounding environment to minimize carbon emissions produced (Dulal et al., 2013; Østergaard et al., 2022). With this, company and community stakeholders will begin to think about how to carry out energy management to be more sustainable and greener in every operational activity. With a green orientation, companies can mitigate excessive carbon emissions. (Amin et al., 2023; Şanlı et al., 2023; Widianingsih et al., 2024), reduce the degradation of the company's surrounding environment (Alvarado et al., 2018; Vo, 2022), and produce environmentally friendly products or services (Maradin, 2021; Vakulchuk et al., 2020; Yolcan, 2023b). Based on this information, the hypothesis formed is:

- H1: Renewable energy affects carbon emissions

Non-renewable energy sources such as coal, oil, and natural gas are the biggest contributors to carbon emissions (Noor et al., 2024; Viana Espinosa de Oliveira & Moutinho, 2022; Zhang & Zhang, 2021), which is also a major driver of climate change. Especially most countries in Asia also use non-renewable energy as their main input. The effect of burning non-renewable energy produces large amounts of carbon emissions (Nakhli et al., 2022; Rai et al., 2023; Shah et al., 2023; Vural, 2020). The use of non-renewable energy will degrade the surrounding environment (Amin et al., 2023; Noor et al., 2024; Zhang & Zhang, 2021) and potentially irreversible impact (Riyono & Widianingsih, 2024). Therefore, it is crucial to mitigate further degradation by transitioning to renewable energy.

Non-renewable energy is also connected to the natural resource-based view theory. Seeing the degradation of the surrounding environment, the country will be more concerned about the condition of its territory than its economic activities (Osman et al., 2023; Ruggiero & Lehkonen, 2017). Economic activities and business activities will be hampered if the environmental conditions are not favorable. Energy management needs to be done to mitigate excessive carbon emissions from operational activities, so in addition to focusing on economic development, it must also be environmentally oriented (Albaker et al., 2023; Avotra & Nawaz, 2023; Ioannou et al., 2022). Then the state will encourage the transition to renewable energy to companies and their people to reduce further adverse effects on the environment due to non-renewable energy. Based on this, the hypothesis formed is:

- H2: Non-renewable energy affects carbon emissions

Various studies show that carbon tax is the most effective and easy-to-implement regulation to reduce carbon emissions in countries (Center for Climate and Energy Solutions, 2013; King et al., 2019; G. E. Metcalf, 2021; Parry, 2019). Carbon tax can mitigate excessive carbon emission spending in a company with an upper limit of emission spending, the rest will be subject to carbon tax burden. With the tax burden, companies will begin to adopt green technology or innovation to reduce carbon emissions produced (Naef, 2024). The implementation of a carbon tax is in line with the natural resource-based view theory that the regulation will move all stakeholders to have the same vision and mission, namely greener practices. The company becomes concerned about how to keep the company growing but also with the realm of green. Green production activities make the company produce lower waste, less emissions emitted, and green product innovation (Chen et al., 2020; Prasad, 2022). Based on the description above, the hypothesis formed is:

- H3: Carbon tax affects carbon emissions

With state commitment, the transition to net-zero emissions can be accelerated in the form of government support in the form of subsidies for renewable energy or green technology, domestic climate policy, and support for companies and communities to adopt a green lifestyle (Koven et al., 2023; P. Z. Liu et al., 2022; United Nations, 2022). The higher the country's commitment, the more aggressive it will be in its green development and motivate all parties to have the same realm of net-zero. So there will be behavioral changes in the country that focus on green adoption apart from economic development (Pradhan et al., 2022). In line with the natural resources-based view, that commitment is able to move the parties to have a shared vision together, namely net-zero by utilizing renewable resources. The hypothesis formed is:

- H4: Net-zero emissions commitment affects carbon emissions

METHODS

Sample, Variable, and Measurement

The sample used in this study are countries in Asia within 1 year of decade observation in 2011 - 2020. The number of countries used in the research sample is 36 countries, so the total observation is 360 data. The data sources used are obtained from secondary data, renewable energy, and non-renewable energy obtained from the International Renewable Energy Agency (IRENA). Net-zero emissions commitment is obtained from the United Nations database. While carbon emissions, urbanization, and GDP are obtained from the World Bank database.

The study's dependent variable is carbon emissions, measured in kilotons (kt). The independent variables include total renewable energy generation, non-renewable energy generation, carbon tax, and net-zero emissions commitments. Control variables are urbanization and GDP. Total renewable energy generation consists of electricity from sources like bioenergy, solar, and wind, while non-renewable generation includes fossil fuels and nuclear energy. A carbon tax is marked as 1 for countries that have implemented it and 0 for those that have not. Net-zero emissions commitment is based on the sustainable development goals index for 13

Asian countries, indicating higher commitment with a higher index. GDP reflects the total economic value, and urbanization measures population movement.

Analysis Method

The analysis method used in the research is the panel data method which goes through various stages of testing first. There are two models formed to separate renewable energy for the first model and non-renewable energy for the second model. The first stage is testing the better estimation model with common effect, fixed effect, or random effect, the test uses the chow test, lagrange multiplier, and hausman test. The second stage is the assumption test and model suitability. Then if it has met all the requirements, the results will be interpreted with the F-test value, r-squared, and t-test value.

RESULTS

Descriptive Statistic

Table 1 shows the results of the descriptive results with 360 observations consisting of 36 countries with a period of 1 decade from 2011 - 2020. The variables of carbon emissions, total renewable energy, total non-renewable energy, and carbon tax in this study have a wide variation of data, where the standard deviation value is higher than the mean. Meanwhile, net-zero emissions commitment, GDP, and urbanization have a lower standard deviation than the mean, which means the variation is smaller than other variables. The 10-year average of countries with higher carbon emissions has a greater use of renewable energy than countries with lower carbon emissions, showing the country's efforts to transition to renewable energy due to high carbon emissions. Meanwhile, countries with high carbon emissions use more non-renewable energy than renewable energy, indicating that carbon emissions can be caused using non-renewable energy.

Table 1 Descriptive Statistics Result

Variable		Mean	Std. Dev	Min.	Max.	Obsv
Carbon emissions	Overall	495870.7	1676957	1012.8	1.09e+07	
	Between		1695759	1422.2	1.01e+07	
	Within		93148.5	-312325.8	1349806	
Total renewable energy	Overall	62224.7	251300.2	1.058	2149057	
	Between		244130.4	1.4187	1463160	
	Within		71037.32	-617887.2	748121.3	
Total non-renewable energy	Overall	258952.9	801541.5	20.2	5518446	
	Between		801919.3	178.9945	4701600	
	Within		124562.5	-512285.6	1606183	
Carbon tax	Overall	.0305556	.1723497	0	1	N = 360
	Between		.1527265	0	.9	N = 36
	Within		.0834493	-.8694444	.8305556	T = 10
Net-zero emissions commitment	Overall	75.77668	26.20935	1.723	98.85733	
	Between		26.45609	9.1186	98.61997	
	Within		2.133485	67.60861	86.56318	
GDP	Overall	7.49e+11	2.06e+12	2.77e+09	1.47e+13	
	Between		2.05e+12	4.09e+09	1.14e+13	
	Within		4.05e+11	-2.06e+12	4.08e+12	
Urbanization	Overall	4.60e+07	1.45e+08	16318	8.67e+08	
	Between		1.46e+08	26352	7.76e+08	
	Within		1.15e+07	-5.01e+07	1.37e+08	

Source: Data Processed, 2024

Research Model Testing

The Chow test is used to determine which estimation model is better, PLS or fixed effect (Satria, 2018), if the result is significant below 0.05 then the best is fixed effect, while if it is not significant or above 0.05 then the one taken is PLS. The Hausman test is conducted to determine whether random effect or fixed effect is better (Belotti et al., 2017), if the results show significant or below 0.05 then the fixed effect is taken, while if it is not significant then the random effect is taken. Langrange multiplier test is intended to better PLS or random effect (Sohag & Bamanga, 2018), if the results show significance, then the best is random effect, otherwise the best is PLS.

The results of the model testing for the second model in Table 2 show that the chow test is significant with a number below 0.05, so while the best is fixed effect rather than PLS, followed by the results of the hausman test which is not significant above 0.05, then instead of fixed effect it is better random effect, to confirm whether it is true that the best random effect then enters the langrange multiplier test, the results show a significant number below 0.05, so the best model for model one is random effect. Because the results use random effects, there is no need for classical assumption tests such as multicollinearity, heteroscedasticity, and autocorrelation (Belotti et al., 2017; Pillai, 2016).

Table 2. Model Testing Result for Model 1

Test	Results
Chow Test (Prob > F)	0.0000
Hausman Test	0.9506
Langrange Multiplier Test	0.0000
Model Best Fit	RE

Source: Data Processed, 2024

As seen in Table 3, the model testing results for the second model also show a significant chow test below 0.05, so while the best is fixed effect rather than PLS, the hausman test results show insignificant numbers above 0.05, so it is better random effect, to make sure again, continued in the langrange multiplier test, where the results are also significant below 0.05, so the best model for model one is random effect.

Table 3. Model Testing Result for Model 2

Test	Results
Chow Test (Prob > F)	0.0000
Hausman Test	0.5692
Langrange Multiplier Test	0.0000
Model Best Fit	RE

Source: Data Processed, 2024

Hypothesis Testing

As in Table 4, the f-value results in this model show that the model can be used to explain the conditions of its influence on the dependent variable with a significant figure of 0.000. The results of hypothesis testing for the first model show that renewable energy has a significant negative effect on carbon emissions with a significance value below 0.05, so hypothesis 1 is accepted. While carbon tax here has no significant effect on carbon emissions with a significance number above 0.05, then hypothesis 3 is rejected.

Net-zero emissions commitment shows a significant negative effect on carbon emissions with a significance above 0.05, so hypothesis 4 is accepted. Meanwhile, GDP and urbanization have a positive significant effect on carbon emissions with a significance below 0.05. This model

can explain 89.56% of the influence on carbon emissions while the rest is explained by other variables outside of the model. This shows that the independent variables used in this model are the main drivers for reducing carbon emissions.

Table 4 Hypothesis Testing Results For Model 1

Variable	Coef.	z	P > |z|
Renewable Energy Generation	-.8963874	-5.63	0.000
Carbon Tax	10731.11	0.20	0.842
Net-Zero Emissions Commitment	-2979.071	-2.52	0.012
GDP	1.63e-07	5.72	0.000
Urbanization	0.0093909	26.02	0.000
Prob > chi2			0.0000
R-squared			0.8956

Source: Data Processed, 2024

The results of the f-value of the second model, as shown in Table 5, indicate that the model can be used to explain the condition of influence or there is at least one variable that has a significant effect with a significant number of 0.000. The results of the hypothesis test for the second model show that non-renewable energy has a positive significant effect on carbon emissions with a significance value below 0.05, so hypothesis 2 is accepted. While the results of a carbon tax are consistent with model 1 that there is no significant effect on carbon emissions with a significance number above 0.05, then hypothesis 3 is rejected. The result of net-zero emissions commitment is consistent with the previous model that shows a significant negative effect on carbon emissions with a significance above 0.05, so hypothesis 4 is accepted. While GDP is inconsistent with the previous model 2 has no significant effect on carbon emissions with results above 0.05, while urbanization still has a positive significant effect on carbon emissions with numbers below 0.05. This model is also the main driver of the effect on carbon emissions, shown by the very high r-squared result of 90.60% while the rest is explained by other variables outside the model.

Table 5 Hypothesis Testing Results For Model 2

Variable	Coef.	z	P > |z|
Non-Renewable Energy Generation	.1884519	3.62	0.000
Carbon Tax	-30334.38	-0.62	0.534
Net-Zero Emissions Commitment	-2898.257	-2.37	0.018
GDP	-1.39e-08	-0.78	0.436
Urbanization	0.0085934	21.06	0.000
Prob > chi2			0.0000
R-squared			0.9060

Source: Data Processed, 2024

DISCUSSION

Almost all countries in Asia continue to use non-renewable energy as the main input of the energy sector to meet the needs of their people. Rapid population growth and economic development are driving greater energy demand. Only a small number of countries use more renewable energy than non-renewable energy, including Afghanistan, Kyrgyzstan, Lao PDR, Mongolia, Tajikistan, and Türkiye. This is also influenced by the characteristics of the countries

that are still categorized as developing countries and their populations are lower than other Asian countries, so the average energy demand is still low. The countries are also supported by geographical areas that encourage the use of renewable energy, such as solar, wind, and hydro as the main input. Therefore, the use of renewable energy also depends on the geographical area and characteristics of the country (Ekonomou & Halkos, 2023; Vakulchuk et al., 2020). The application of renewable energy is hampered if the country has inadequate geography, so the country is forced to continue using non-renewable energy to meet energy demand.

The results of this study show that the transition and implementation of renewable energy can reduce carbon emissions in a longitudinal effect. These results are in line with previous studies that renewable energy is very effective in achieving the decarbonization goal and reducing environmental degradation (Guchhait & Sarkar, 2023; Mai, 2023; Manso & Behmiri, 2020; Olabi & Abdelkareem, 2022; Østergaard et al., 2022; Sayed et al., 2023; Shah et al., 2023; Vakulchuk et al., 2020; Viana Espinosa de Oliveira & Moutinho, 2022; Yolcan, 2023a). The greater the renewable energy used, the lower the amount of carbon emissions. Renewable energy is believed to produce lower carbon emissions than conventional energy (Azam & Adeleye, 2024; Bartowitz et al., 2022; B. Wang et al., 2023). This transition is the most effective way to reduce carbon emissions because most of the carbon in circulation is caused by non-renewable energy. By replacing it with renewable energy, the use of non-renewable energy can be reduced. Renewable energy can be in the form of solar, wind, and hydro where the energy sources used are not disposable and do not have the potential to produce large amounts of carbon emissions (H. Khan et al., 2020; Şanlı et al., 2023; Viktorovna et al., 2021). Through renewable energy dual objectives are met, meeting the increasing energy demand while pursuing a sustainability agenda. Countries such as Japan, Korea, Singapore, China, India, Malaysia, and Thailand are aggressively investing in renewable energy. This shows that in addition to focusing on rapid economic development, environmental conservatism is also necessary as industrial activities increase. This is aimed at avoiding a greater burden in the future because the effect of accumulated carbon emissions is potentially irreversible if it is too much (Riyono & Widianingsih, 2024). So renewable energy plays a vital role in the development of the country and it is also necessary to pay attention to energy management.

However, the implementation of renewable energy takes a relatively long time in the production stage of the energy sources. Of course, there will also be a large cost in investment at the beginning, but in the long run, the source can be used sustainably, so the burden will be lower. The application also needs to be careful during the production stage because it has the potential to produce carbon emissions during the factory and transportation. However, according to the production stage, the results obtained will be more sustainable and environmentally friendly than conventional energy.

The results show that the use of non-renewable energy will produce carbon emissions, and each additional use will result in the degradation of the surrounding environment. These results are in line with previous studies that the process of burning fossil fuels and processing non-renewable energy into usable energy will generate large amounts of carbon dioxide gas (Ali et al., 2022; Amin et al., 2023; Nakhli et al., 2022; Noor et al., 2024; Rai et al., 2023; Şanlı et al., 2023; Shah et al., 2023; Viana Espinosa de Oliveira & Moutinho, 2022; Vural, 2020; Zhang & Zhang, 2021). Non-renewable energy in the form of fossil fuels such as coal, oil, and gas is very limited in availability and tends to take a long time. Continued use will increase the price of energy due to scarcity (Awodumi & Adewuyi, 2020; Y. Li et al., 2022; Roslan, 2021). Therefore, its use in the long term is very ineffective, the results obtained are also bad for the surrounding environment and also hamper industrial operations. Asian countries are also indicated to import a lot of fossil fuels from outside to meet the energy needs of their countries. This indicates that Asian countries are still highly dependent on the use of non-renewable energy to meet the demand for energy along with economic and population growth. The problem of non-renewable

energy is also faced in Asia where the development of renewable energy is still not optimal and sufficient for the needs of its people.

The effect of carbon tax in Asia has yet to be felt in the long term, as the results show that carbon tax has no significant effect on carbon emissions. This result is like previous research by Nar (2021) that in 36 OECD countries, carbon tax also does not affect carbon emissions. Developing countries have a harder time implementing an effective carbon tax to reduce carbon emissions than developed countries (Parry, 2019). In the research sample used, most Asian countries are developing countries. The effect of carbon tax is still not as effective as in other more developed regions. This is due to the complexity of the carbon tax which is influenced by many factors, such as consumption patterns, production structures, distribution of co-benefits from improved environmental quality, and most importantly the carbon tax design (Q. Wang et al., 2016). The effectiveness of carbon tax depends on the design, especially on the carbon tax income. The creation of effective designs is complex due to political and economic issues, such as lack of income, resources, social injustice, and poverty (Muhammad, 2022), especially in Asia where there are still many such problems. The implementation of carbon tax has not yet reached the optimal point to reduce carbon emissions in Asia, but it should also be noted that not many countries in Asia have implemented carbon tax for a long time. So, it makes sense that the effectiveness of carbon tax to reduce carbon emissions in the country has yet to be felt.

In reality, if the carbon tax has been utilized effectively, it will be very possible to achieve sustainable economic development with low carbon emissions (Le & Azhgaliyeva, 2023; Sulisnaningrum et al., 2023; Q. Wang et al., 2016). A carbon tax must be able to limit energy demand, encourage the adoption of green technologies, and support environmentally friendly operations. The carbon tax can generate additional revenue for the government (Beck et al., 2015; Marron & Morris, 2016; Yuan et al., 2017), so that it can be designed to use it to influence environmental effectiveness and socio-economic impacts (Amdur et al., 2014; Steenkamp, 2021). The revenue can be used to subsidize households, cut other tax burdens, subsidize environmentally beneficial technologies or policies, and reduce state debt. With this, the implementation of a carbon tax can be more beneficial for both the country and the company, so it is not a burden but a driver to encourage the implementation of green practices

The results show that with a net-zero emissions commitment the country can further reduce the amount of carbon emissions in circulation. In line with research by Hausfather & Moore (2022), United Nations (2023), and Zaman (2023) Countries and organizations that have committed to net-zero will take a leadership role to address this common problem. Government commitments are needed to execute these sustainability actions, especially on the ability of governments to integrate these commitments into various sectoral policies and long-term strategy formulations (Riyono & Widianingsih, 2024). For the state, a domestic climate policy will be formed to address this issue and provide support in the form of subsidies to encourage the implementation of green practices as a form of effort. The company also realizes the effort to support the country's target, so the company will also try to reduce its carbon emissions by adopting sustainable practices, renewable energy sources, and research and development for greener technology. Countries and companies will work together to achieve the target of reducing carbon emissions that have been determined to a level that can be said to be sustainable. However, this commitment also needs to be backed up with credible action and integrity for the company, country, and stakeholders, so that it is not just a verbal commitment.

The results of this study empirically verify the theory of the natural resource-based view. Based on this theory, the country will change from conventional energy to renewable energy. The increasingly degraded environment makes the state more conservative towards the surrounding environment and in the form of minimizing its adverse effects. So the role of this transition is very important to reduce the main source of carbon emissions, namely non-renewable energy. Sustainable development and environmental-oriented are the main targets of the country to reduce pollution in the country. The target is also surrounded by net-zero

commitments, to emphasize the country's future targets. This can motivate all companies and individuals to also lead to more sustainable activities by adopting greener practices. However, the carbon tax has not been able to influence carbon emissions in Asian countries because its implementation has not been effective and has not reached the desired target due to political and economic concerns.

CONCLUSION

The results of this study show that the use of renewable energy generation can reduce the amount of carbon emissions in circulation. Renewable energy produces much lower carbon emissions than conventional energy and can be used sustainably. So the transition from conventional or non-renewable energy will prevent environmental degradation and global warming in the long run. While the use of non-renewable energy generation will produce carbon emissions. Then the use of non-renewable energy will worsen the condition of the surrounding environment and cause pollution. The use of non-renewable energy is still the main source of energy input in Asia because the implementation of renewable energy has not been able to meet the energy demand. So the implementation and development of renewable energy needs to be increased more to mitigate the accumulation of carbon emissions and pollution in the future. The carbon tax has no effect on carbon emissions in Asia at present. This is due to the lack of effectiveness of carbon tax which is influenced by various factors in Asian countries. Asian countries still face economic and political concerns that make the implementation of carbon tax less effective in mitigating carbon emissions. However, these efforts still have the potential to be developed in the future to mitigate carbon emissions by designing the income tax revenue obtained to subsidize the implementation of green practices, encourage the use of renewable energy, and support more sustainable operational activities. With green technologies and activities, carbon emissions can be minimized. Net-zero commitments can reduce carbon emissions in circulation, the committed country will support the implementation of green practices for all companies and individuals. All operational activities will be motivated to be environmentally-oriented to support the achievement of the country's carbon targets. The implication of this research is to support countries in transitioning to renewable energy and reducing their dependence on non-renewable energy. It is also an input for Asian countries to strengthen the influence of carbon tax on environmental and socio-economic impacts and motivate countries to be more committed to achieving net-zero emissions.

Suggestions for future research are to try the effect of renewable energy and non-renewable energy on the country's economy. It can also be tried with developing countries and developed countries to find out if there are differences in behaviour. Behavioural changes are also interesting to be studied further from the perspective of a company for the implementation of renewable energy.

LIMITATION

The carbon tax sample used in this study is also still very limited because there are still not many Asian countries that apply carbon tax, so it needs to be tested again when many have started to effectively apply it.

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