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Article

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Indonesia's Power Shift: Business Strategies for Renewable Energy and Social Justice

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ABSTRACT

The purpose of this study is to determine and analyze the effect of renewable energy integration variables and business approaches on improving the ability of the Indonesian electricity sector in a sustainable manner with carbon emission mitigation variables as a moderating factor. The subjects of this study are electrical energy users who are customers of PT PLN Persero as many as 85,600,000 people, where the variables in this study are endogenous variables, namely the variable integration of renewable energy and business approaches, while the exogenous variable is the improvement of the ability of the Indonesian electricity sector in a sustainable manner, and the moderating variable is the carbon emission mitigation variable, where the results of data analysis are processed through SEM analysis through SMART PLS 3.0 software. From the results of existing research, it is concluded that partially the renewable energy integration variable and the business approach variable affect the improvement of the ability of the Indonesian electricity sector in a sustainable manner and the renewable energy integration variable affects the mitigation of carbon emissions. Simultaneously, the variable of renewable energy integration and business approach affect the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable. With the renewable energy integration process we can mitigate carbon emissions in accordance with existing standards, where declining carbon emissions will create the ability of the Indonesian electricity sector in a sustainable manner, where the utilization of the sustainability of the electricity sector's capabilities requires a business approach that can be reached by underprivileged people so that later it can create affordable prices and make people's purchasing power easier, and avoid community losses due to global warming and climate change.

Keywords: Integration, Renewable Energy, Carbon Emissions, Business Approach, Mitigation, Electricity Sector, Sustainability
JEL Classifications: B22, F38, H21, G21, G32, G33

1. INTRODUCTION

Every country needs energy that will be useful for the sustainability of every human mat, where it is hoped that energy procurement efforts will become a necessity for a nation to continue to use energy in driving a transparent and accountable economy. Energy needs become a crucial thing in order to create a form of energy that exists into something that is beneficial to society, where the benefits that arise from the use of energy are for basic needs in community activities, where this energy is used in basic daily needs such as cooking, heating, and lighting. Lack of energy makes it difficult to perform many daily tasks, in addition to the use of energy is done for the activities of some of the economic activities of society, where most of the energy use is needed for most of the economic activities. Sufficient energy sources are required for modern technology, transportation, and production operations. Technological progress and sustainable economic growth often depend on the availability and effective utilization of energy (Situmorang, 2020). To improve people's living standards and welfare, energy is also necessary. This includes energy used by automobiles, housing, and various types of recreational facilities for heating and air conditioning systems. Energy is also critical to the operation of transportation networks. Vehicles such as cars, trains and airplanes need fuel or electricity to run. Connectivity and economic growth are supported by easy and effective access to transportation (Solangi, 2019).

Energy is needed for education and health facilities to function on a daily basis. Every device that supports health activities, from lights to high-tech medical equipment, requires a stable source of electricity. Manufacturing activities and processes in the industrial sector require substantial energy consumption. Production systems, industrial machinery, and other manufacturing processes are all highly dependent on a steady supply of energy (Nimesh et al., 2021). Energy is required for communication devices such as computers and cell phones to function. Access to information and connectivity around the world is guaranteed by the stable availability of energy. Energy can also be utilized in the agricultural industry for irrigation, tillage, and operation of farm machinery. The impact is food security and increased productivity (Song and Yu, 2018). The process of maintaining national and international security relies heavily on the availability of sufficient energy and the sustainability of energy supply. Reducing dependence on a single energy source can be done through the creation of environmentally friendly technologies and diversification of energy sources. Energy is very important, but the use of natural resources, in the form of excessive or unsustainable use of energy can damage the ecosystem. Therefore, creating sustainable and environmentally friendly energy solutions is essential (Goh et al., 2018).

The use of existing energy can be said to be very damaging to the natural ecosystem, where the use of this energy still uses fossil energy which can cause a reduction in carbon emissions which results in global warming, thus causing climate change which will tend to harm humans. Global warming is very detrimental to every human being, not least for Indonesian people who are mostly in the lower economic class, where the use of fossil energy is very much related to the social justice framework. The form of application can affect energy accessibility, where energy accessibility in various communities can be affected by the use of fossil fuels. Poor or oppressed communities often have less access to cheap and clean energy sources. They may use fossil fuels such as charcoal or firewood more often, which is bad for the environment and human health (Zahari and Mclellan, 2023). Poor communities often live near locations with fossil energy resources, including oil processing plants or coal mines. Air and water pollution by these companies can cause major health problems such as respiratory and pollution-related diseases. Climate change and fossil fuel use are closely linked. Greenhouse gas emissions can damage the environment and have different socio-economic impacts. Small islands and indigenous tribes, for example, may be more affected by climate change. Globally, fossil fuel use and wealth disparities between industrialized and developing countries are often interlinked. Wealthy countries are often more reliant on fossil fuels to power their economies, while underdeveloped countries will struggle to find cheap and reliable energy. Certain countries rely heavily on fossil fuel-based economies.

These economic changes have the potential to significantly impact income and employment, so these issues must be addressed equitably (Suriyanti et al., 2020).

This social justice impact is particularly pronounced in areas near fossil fuels, which necessitates the integration of fossil and renewable energy, which is heavily influenced by carbon emission mitigation. Reducing dependence on fossil energy sources that emit large amounts of carbon dioxide requires a number of procedures and methods that are part of the process of integrating renewable energy with carbon emission mitigation. The required step in the process of integrating renewable energy with carbon emission mitigation process is first energy efficiency, where improving energy efficiency is essential before switching to renewable energy sources. This means lowering overall energy use through the use of more energy-efficient technologies and procedures, and then we can transition fossil fuels to renewable energy, where the switch to renewable energy sources, such as biomass, hydropower, wind power, and solar power. Since renewable energy sources often have less environmental impact than fossil energy sources, investing in renewable energy infrastructure helps reduce carbon emissions. In addition, a region should conserve energy and increase energy storage capacity, and an effective plan to reduce carbon emissions should also include reducing energy use through conservation measures. This includes educating the public, using efficiency tools, and encouraging energy-saving behavior across industries, and the problems caused by frequent changes in renewable energy sources, such as wind and solar power, can be addressed by increasing energy storage capacity.

The best possible utilization of renewable energy sources is possible through energy storage technology. Certain regions can also undertake green infrastructure development and fossil energy use reduction, where reducing carbon emissions and incorporating renewable energy requires investment in green infrastructure, such as green buildings, sustainable transportation networks, and other green technologies, and reducing fossil fuel subsidies and putting a price on carbon are two examples of policies that can help reduce fossil fuel consumption and encourage a shift to more environmentally friendly energy sources. To implement the process of energy integration and carbon emission mitigation, adopting laws and regulations that regulate carbon emissions and encourage the use of renewable energy sources can encourage people to switch to more environmentally friendly energy sources (You et al., 2017). Although it is a difficult endeavor, integrating renewable energy with carbon emission reduction is essential to address climate change and achieve energy sustainability. The government, industry and society must work together in this process to reduce carbon footprint and improve energy security.

In carrying out the process of shifting fossil energy to renewable energy through carbon emission mitigation, comprehensive policies are needed, especially policies and business approaches through existing companies and previously producing renewable energy, where these companies have to carry out the integration process from fossil energy that destroys the world order because with increasing global warming faced with the destruction of the earth and the occurrence of natural disasters that can make a region experience severe damage (Karkour et al., 2020). This renewable energy integration process can be utilized well by several companies, especially by PT PLN which should be able to replace power plants in increasing the availability of electrical energy from coal power to renewable energy, such as water energy, ocean tidal energy and other energy that is environmentally friendly and able to mitigate carbon emissions to prevent global warming and climate change, where with this integration process it is hoped that electrical energy will become environmentally friendly and prevent the increase in carbon emissions that affect global warming which can damage the environment and also regions in Indonesia (Yudha et al., 2022).

The number of PT PLN customers during the 2022 period is 85,600,000 people, where most people are still not satisfied with PT PLN’s overall service due to the use of fossil-based energy which is proven to still not be able to serve 100% of electricity comprehensively. There are still many errors made, and the tendency of energy is wasteful and damaging to the environment, so that a renewable energy integration process is needed, where this integration process has not been fully carried out, so that it has not been able to be realized through a business approach that can be realized through the procurement of renewable energy projects, which has not been realized properly, it will affect the increase in the ability of the electricity sector in a sustainable manner, because coal power plants are easily depleted and very difficult to find a replacement, so that the application of fossil energy from coal will affect the quality of the electricity sector’s ability to sustain electrical energy with strong power and create high carbon emissions, thus affecting the process of mitigating carbon emissions in reducing carbon emissions to prevent global warming and climate change.

2. LITERATURE REVIEW

2.1. Renewable Energy Integration

Efforts to integrate renewable energy sources into the larger energy system are referred to as renewable energy integration (Vakulchuk et al., 2019). A comprehensive strategy that includes several stakeholders, including the government, the business world, the community, and the education sector, is needed to integrate renewable energy. (Rahmawati et al., 2023). Technological advances combined with renewable energy sources can help society achieve sustainability targets and reduce the impact of climate change (Wu et al., 2017). Here are some important aspects of renewable energy integration:

1. Renewable energy systems, which generate clean and sustainable electricity through grid integration of renewable energy sources including biomass, geothermal, hydro, solar and wind
2. Energy storage, which utilizes energy storage technologies to overcome variations in renewable energy production and ensure a stable energy supply, such as thermal storage, water pumps, and lithium-ion batteries
3. Energy efficiency and conservation is accomplished by reducing energy demand using energy-efficient technologies and practices in the commercial, industrial, and residential sectors
4. Renewable technology development is carried out by encouraging the development of renewable technologies to increase their effectiveness, reduce prices, and expand their application
5. Policies and regulations are carried out by implementing laws and regulations, such as carbon pricing, renewable energy goals, and tax breaks, to encourage the development and use of renewable energy (Hamzah et al., 2019).

The indicators of the renewable energy integration process are as follows:

1. The capacity of renewable energy installations in the form of the amount of renewable energy installation capacity built and operated
2. Reduction of carbon emissions by increasing the variety of greenhouse gas emissions caused by the utilization of renewable energy sources
3. Energy system efficiency is carried out by increasing the efficiency of energy supply and consumption through the use of renewable energy
4. Increasing energy storage is done by increasing the quantity of energy storage capacity increase or expansion in an energy system
5. Availability of finance and investment by increasing the availability of finance and investment levels for renewable energy initiatives
6. Technological innovation is carried out by increasing progress in the creation and use of new technologies in the field of renewable energy (Murshed et al., 2022).

2.2. Business Approach through Renewable Energy Integration

Corporate strategies that incorporate renewable energy can benefit from a number of factors, such as increased operational effectiveness, environmental sustainability, and possible long-term cost savings. (Umam et al., 2022) Business plans that incorporate renewable energy can reduce their negative impact on the environment while strengthening relationships with partners and customers and being a wise financial move. (Khalil et al., 2019). Addressing the issue of climate change and building a sustainable energy future requires multifaceted thinking and cross-sectoral cooperation (Seddiki and Bennadji, 2019). Some business strategies that can be carried out with the integration of renewable energy include the following:

1. Energy efficiency and cost reduction by reducing energy use and operating costs by implementing energy-saving technologies. This can involve utilizing renewable energy technologies, smart energy management systems, and LED lighting systems
2. The use of renewable energy at the production site is done by installing wind turbines or solar panels to generate renewable energy directly at the production site. This improves operational sustainability and reduces dependence on traditional energy sources
3. Partnerships with renewable energy suppliers are made by forming alliances with renewable energy suppliers to purchase renewable energy or contribute to renewable energy initiatives. This can reduce environmental impact and help achieve sustainability goals
4. Sustainable product development is done by creating goods or services with an emphasis on sustainability, such as “product for life” projects that promote circularity, environmentally

friendly goods, or sustainable packaging (Sambodo et al., 2022).

The indicators of the business approach through renewable energy integration are:
1. Renewable energy consumption through increasing the share of the organization's energy use that comes from renewable energy sources, including hydropower, wind, or solar energy
2. Reduce carbon emissions by lowering carbon emissions from energy use, transportation of goods, and other business processes
3. Energy efficiency by improving operational energy efficiency through the application of efficiency-focused technologies, astute energy management, and other techniques
4. Investment in renewable technologies by increasing the amount of money spent on the creation and implementation of renewable technologies across a business's infrastructure or supply chain
5. Sustainable product innovation by carrying out the process of creating sustainable goods or services or creating goods that have less impact on the environment (Mahidin et al., 2020).

2.3. Continuous Improvement of Electricity Sector Capability

In order to create a more efficient, clean and sustainable energy system, a number of actions and activities must be taken to increase the capacity of the electricity sector in a sustainable manner. (Mardhiah and Kazi, 2019). To increase the capacity of the power sector, innovation in energy storage is essential. It underscores the importance of creating more affordable and effective energy storage technologies (Martín-Pomares et al., 2017). Hydro, wind and solar energy are examples of renewable energy sources that can power the entire electricity industry. He emphasized the need to encourage legislation and infrastructure funding related to renewable energy (Simanjuntak et al., 2022). Here are some tactics to increase power sector capacity in an environmentally friendly way:
1. Renewable energy integration, where to reduce dependence on fossil fuels and reduce carbon emissions, include renewable energy sources such as biomass, solar, wind and hydropower in your energy mix
2. Development of energy development infrastructure, where purchasing energy storage technologies will help stabilize electricity supply and handle variations in renewable energy generation
3. Modernize the electricity grid by updating the grid infrastructure to facilitate the integration of renewable energy sources, improve distribution efficiency, and provide a more flexible electricity system
4. Energy efficiency programs are carried out by introducing energy efficiency programs to improve energy production and consumption in the electricity industry
5. Increasing resilience to climate change, where to ensure the resilience of the power sector to problems such as storms, floods, and extreme temperatures, identification and mitigation of climate change threats (Tambunan et al., 2021).

The indicators of sustainably improving the power sector's capabilities are:
1. This is done by reducing direct and indirect carbon emissions from energy production and use in the electricity industry. This shows the mitigation impact on climate change
2. Energy efficiency, which improves energy use, power distribution, and generation operating efficiency. Increased efficiency can reduce pollutants and the overall amount of energy required
3. Reducing carbon intensity is done by lowering carbon intensity, or the quantity of carbon emissions produced for each unit of energy produced. It is an effort to produce more energy while emitting less carbon emissions
4. Electricity supply reliability, where improvements in electricity supply reliability, such as increased quantity and efficiency of backup systems and faster recovery from power outages
5. The use of digital technology is done by making improvements to the administration and operation of the electric power sector with the use of digital technologies such as artificial intelligence (Pérez-Denicia et al., 2017).

2.4. Carbon Emissions Mitigation

The term "carbon emissions mitigation" refers to the collection of practices and tactics used to reduce or stop the release of greenhouse gases into the atmosphere, specifically carbon dioxide (CO_2) (Setyawati, 2020). The first step in addressing climate change and mitigating its adverse impacts is to reduce carbon emissions (Mustikaningsih et al., 2019). To meet emission reduction targets and save the environment worldwide, governments, businesses, communities, and international organizations must work together to mitigate carbon emissions (Dominković, 2017). Some tactics and actions to reduce carbon emissions are listed below:
1. Transition to renewable energy by reducing our dependence on fossil fuels by using renewable energy sources, such as biomass, hydropower, wind and solar energy
2. Energy efficiency is carried out by improving energy efficiency in various industries, such as buildings, transportation, and manufacturing, to reduce carbon emissions and energy use
3. The use of clean technology is done by adopting and developing clean technologies that can capture and reduce carbon emissions from major sources, such as carbon capture and storage (CCS) and carbon capture and utilization
4. Energy conservation is done by encouraging homes, companies, and industries to utilize energy more efficiently and save it
5. Climate change regulation and policy by adopting and implementing laws and policies to address climate change that drive emissions reductions and the advancement of sustainable innovation (Ogbonnaya et al., 2019).

Indicators of carbon emission mitigation are as follows:
1. Improved energy efficiency, where energy use decreases relative to output or economic activity, indicating improved energy efficiency
2. Carbon intensity reduction, which is a reduction in carbon emissions per economic activity or unit of production, meaning higher efficiency and lower emissions

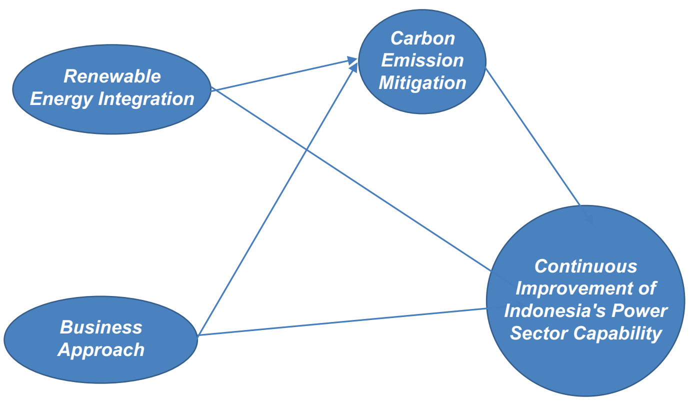
3. Use of clean technologies, where the uptake and implementation of clean technologies is a marker of mitigation success, such as CCS or renewable energy technologies
4. Green fuel use, where the portion of total fuel consumption that comes from environmentally friendly sources such as green hydrogen or biofuels.
5. Reduction of global carbon emissions, which shows a positive contribution to overall climate change (Lu, 2021).

Figure 1 Conceptual framework, which is a formula for determining the hypothesis listed below:

2.5. Hypothesis

1. Renewable energy integration has an effect on improving the ability of Indonesia's electricity sector in a sustainable manner
2. A business case for sustainably improving Indonesia's power sector capabilities
3. Renewable energy integration affects carbon emission mitigation
4. Business approach affects carbon emission mitigation
5. Mitigating carbon emissions has the effect of increasing the capacity of Indonesia's electricity sector in a sustainable manner
6. Carbon emission mitigation moderates the positive relationship between renewable energy integration and improving the sustainability of Indonesia's electricity sector
7. Carbon emission mitigation moderates the positive relationship between the business approach and sustainability improvements in Indonesia's power sector.

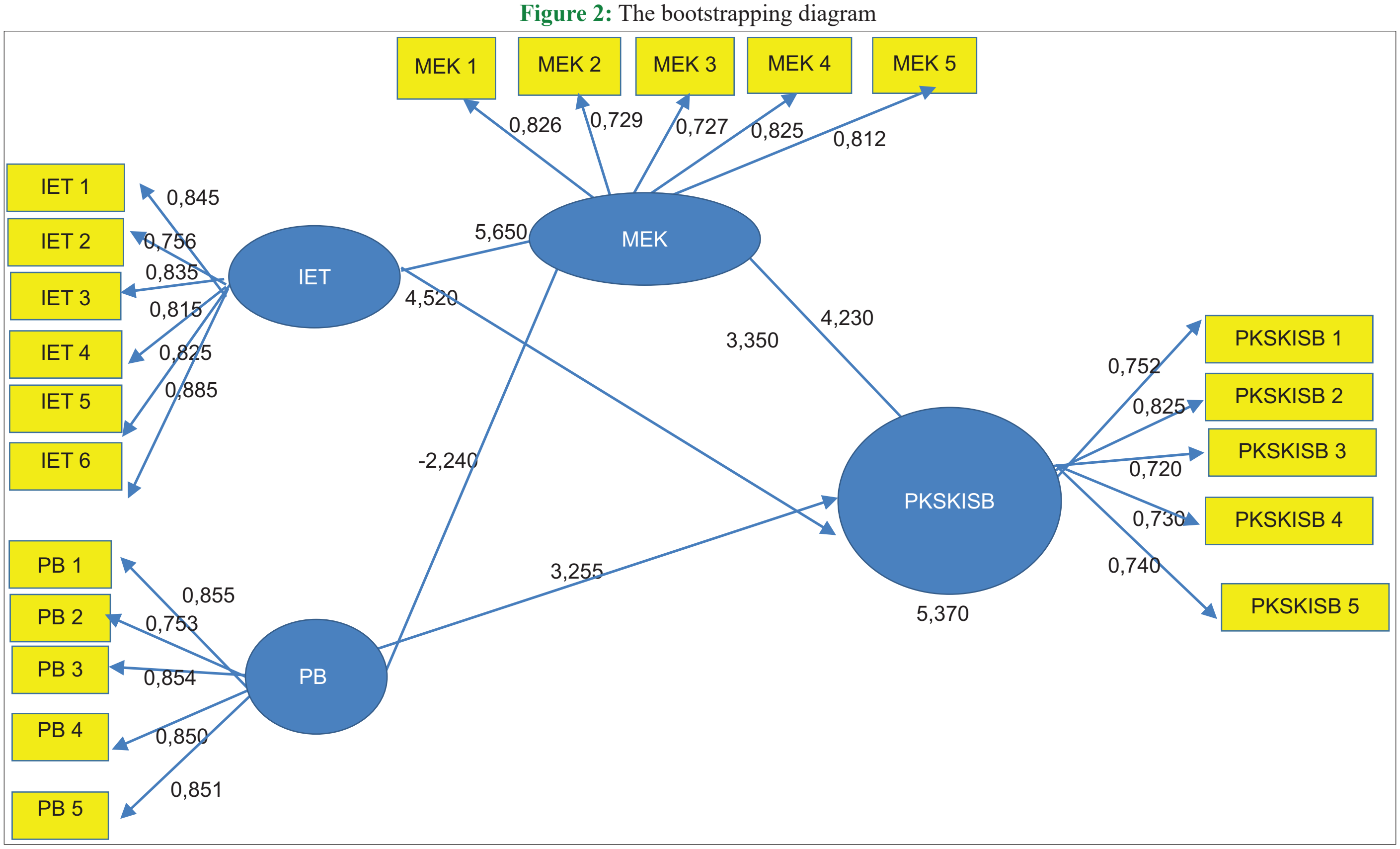
Figure 1: Conceptual framework



3. RESEARCH METHODS

The research method used is to use quantitative analysis by using data analysis with the structural equation model (SEM) method, where the results of data processing with the SEM method are carried out with the PLS application. (Franzese and Iuliano, 2018) quantitative methods with SEM analysis are quantitative techniques for evaluating and measuring the relationship between model construct variables. The complex relationship between latent (unmeasured) variables and measured variables can be assessed and modeled using SEM. The data collection technique in this study was carried out using observation and submission of questionnaires to respondents. The population in this study were 85,600,000 PT PLN customers, where the sampling method was

Figure 2: The bootstrapping diagram



Source: The Result data, 2024

carried out using the simple random sampling method, where (Franzese and Iuliano, 2018) the sampling method using simple random sampling is a sampling technique method that is often used in surveys and scientific research. The foundation of this approach is the idea that each component of the population has the same opportunity to be selected as a sample. The sampling can use the Slovin formula, where the number of samples is as follows:

$n = N/(1 + N e^2) = 85,600,000/(1 + 85,600,000 \times 0.05^2) = 399.99 = 400$ PT PLN customers who still use fossil energy so that the number of samples available is as many as 400 PT PLN customers who still use fossil energy. The data analysis carried out is by conducting descriptive analysis, convergent validity analysis, AVE analysis, R Square test and hypothesis testing.

4. RESEARCH RESULTS

4.1. Descriptive Analysis

4.1.1. Renewable energy integration variables

Table 1 explains that the distribution of data that most respondents answered for question 1 was agreed as many as 156 respondents (39%), for question 2 the most respondents answered agreed as many as 157 respondents (39.25%), for question 3 many respondents answered agreed as many as 158 respondents (39.5%), for question 4 respondents who answered agreed as many as 159 respondents (39.75%), question 5 respondents who answered agreed as many as 160 respondents (40%), and question 6 respondents who answered agreed as many as 162 respondents (40.5%).

4.1.2. Business approach variable

Table 2 explains that the distribution of data that most respondents answered for question 1 was agreed as many as 162 respondents (40.5%), for question 2 the most respondents answered agreed as many as 158 respondents (39.5%), for question 3 many respondents answered agreed as many as 159 respondents (39.75%), for question 4 respondents who answered agreed as many as 156 respondents (39%), question 5 respondents who answered agreed as many as 160 respondents (40%).

4.1.3. Carbon emissions mitigation variables

Table 3 explains that the distribution of data that most respondents answered for question 1 was agreed as many as 159 respondents (39.75%), for question 2 the most respondents answered agreed as many as 156 respondents (39%), for question 3 many respondents answered agreed as many as 160 respondents (40%), for question 4 respondents who answered agreed as many as 159 respondents (39.75%), question 5 respondents who answered agreed as many as 157 respondents (39.25%).

Table 1: Descriptive analysis of renewable energy integration variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	147	36.75	156	39	79	19.75	18	4.5	-	-
Q2	145	36.25	157	39.25	81	20.25	17	4.25	-	-
Q3	143	35.75	158	39.5	82	20.50	17	4.25	-	-
Q4	144	36	159	39.75	84	21	13	3.25	-	-
Q5	146	36,5	160	40	83	20.75	11	2.75	-	-
Q6	148	37	162	40.5	85	21.25	5	1.25	-	-

Source: The Result data, 2024

Table 2: Descriptive analysis of business approach variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	148	37	162	40.5	85	21.25	5	1.25	-	-
Q2	143	35.75	158	39.5	82	20.50	17	4.25	-	-
Q3	144	36	159	39.75	84	21	13	3.25	-	-
Q4	147	36.75	156	39	79	19.75	18	4.5	-	-
Q5	146	36.5	160	40	83	20.75	11	2.75	-	-

Source: The Result data, 2024

Table 3: Descriptive analysis of carbon emission mitigation variables

Question	Respondent answer score									
	SS (5)		S (4)		N (3)		TS (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	144	36	159	39.75	84	21	13	3.25	-	-
Q2	147	36.75	156	39	79	19.75	18	4.5	-	-
Q3	146	36.5	160	40	83	20.75	11	2.75	-	-
Q4	144	36	159	39.75	84	21	13	3.25	-	-
Q5	145	36.25	157	39.25	81	20.25	17	4.25	-	-

Source: The Result data, 2024

Table 4: Descriptive analysis of variables for improving the capability of indonesia's electricity sector sustainably

Question	respondent answer score									
	SS (5)		S (4)		N (3)		TD (2)		STS (1)	
	F	%	F	%	F	%	F	%	F	%
Q1	145	36.25	157	39.25	81	20.25	17	4.25	-	-
Q2	144	36	159	39.75	84	21	13	3.25	-	-
Q3	146	36.59	157	39.35	88	22.05	8	2	-	-
Q4	147	36.75	156	39	79	19.75	18	4,5	-	-
Q5	142	35,5	161	40,25	87	21,75	10	2,5	-	-

source: the result data, 2024

Table 5: Convergent validity test

Variables	Indicator	Outer Loading
Renewable Energy Integration $(X)_1$	IET 1	0.845
	IET 2	0.756
	IET 3	0.835
	IET 4	0.815
	IET 5	0.825
	IET 6	0.885
Business Approach $(X)_2$	PB 1	0.855
	PB 2	0.753
	PB 3	0.854
	PB 4	0.850
	PB 5	0.851
Carbon Emissions Mitigation (Z)	MEK 1	0.826
	MEK 2	0.729
	MEK 3	0.727
	MEK 4	0.825
	MEK 5	0.812
Sustainable Improvement of Indonesia's Electricity Sector Capability (Y)	PKSKISB 1	0.752
	PKSKISB 2	0.825
	PKSKISB 3	0.720
	PKSKISB 4	0.730
	PKSKISB 5	0.740

Source: The Result data, 2024

Table 6: AVE test

Variables	AVE
Renewable energy integration $(X)_1$	0.831
Business approach $(X)_2$	0.791
Carbon emissions mitigation (Z)	0.731
Sustainable improvement of Indonesia's electricity sector capability (Y)	0.771

Source: The Result data, 2024

4.1.4. Variables for continuous improvement of Indonesia's electricity sector capability

Table 4 explains that the distribution of data that most respondents answered for question 1 was agreed as many as 157 respondents (39.25%), for question 2 the most respondents answered agreed by 159 respondents (39.75%), for question 3 many respondents answered agreed by 157 respondents (39.35%), for question 4 respondents who answered agreed by 156 respondents (39%), question 5 respondents who answered agreed by 161 respondents (40.25%). The output results of the SEM test can be seen from the following *Bootstrapping* diagram:

Table 7: Composite reliability test

Variables	Composite reliability
Renewable energy integration $(X)_1$	0.748
Business approach $(X)_2$	0.828
Carbon emissions mitigation (Z)	0.858
Sustainable improvement of Indonesia's electricity sector capability (Y)	0.838

Source: The result data, 2024

Table 8: R square test

Variables	R square
Renewable Energy Integration $(X)_1$	0.850
Sustainable Improvement of Indonesia's electricity sector capability (Y)	0.717

Source: The result data, 2024

Table 9: R square test

Variables	R square
Business approach $(X)_2$	0.851
sustainable improvement of Indonesia's electricity sector capability (Y)	0.719

Source: The result data, 2024

Table 10: R square test

Variables	R square
Renewable energy integration $(X)_1$	0.853
Carbon emissions mitigation (Z)	0.711

Source: The result data, 2024

Table 11: R square test

Variables	R square
Business approach $(X)_2$	0.852
Carbon emissions mitigation (Z)	0.712

Source: The result data, 2024

Table 12: R square test

Variables	R square
Carbon emissions mitigation (Z)	0.757
Sustainable improvement of Indonesia's electricity sector capability (Y)	0.715

Source: The Result data, 2024

Figure 2, shows the Bootstrapping Diagram, which is the result of data processing on the SEM-Smart Pls Application, which is shown in the figure below:

Table 13: Hypothesis test

Hypothesis	Influence	T-statistics	P-value	Results
H1	Integration of renewable energy to sustainably improve Indonesia's power sector capability	4.520	0.001	Accepted
H2	A business approach to sustainably upgrading Indonesia's power sector capabilities	3.255	0.016	Accepted
H3	Integration of renewable energy towards carbon emission mitigation	5.650	0.003	Accepted
H4	A business approach to carbon emissions mitigation	−2.240	0.125	Rejected
H5	Carbon emission mitigation to sustainably improve Indonesia's power sector capability	4.230	0.018	Accepted
H6	Integration of renewable energy to increase the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable	3.350	0.003	Accepted
H7	A business approach to sustainably improving Indonesia's electricity sector capability through carbon emission mitigation as a moderating variable	5.370	0.001	Accepted

Source: The result data, 2024

4.1.5. Convergent validity analysis

Franzese and Iuliano (2018) stated that the convergent validity test in the SEM PLS test was carried out to assess the extent to which the latent construct under consideration could be said to be represented by the construct measured by the indicator variable. Indicator variables effectively measure latent constructs as indicated by convergent validity. convergent validity analysis is carried out by looking at the outer loading value.

Table 5 can explain that the test results of the outer loading value of the variables in this study, both exogenous, endogenous and moderator variables, are valid and suitable for hypothesis testing.

4.1.6. Average variant extracted (AVE) analysis

Franzese and Iuliano (2018) stated that the AVE test is a metric used in SEM studies to assess how well indicator variables in latent constructs are able to explain the variability of latent constructs. The results of the AVE test can be seen in Table 6.

Table 6 explains that the output results for the AVE test of the variables in this study are greater than the significance value of 0.5, where the existing data distribution is valid and suitable for further data testing.

4.1.7. Composite reliability test

Franzese and Iuliano (2018), Composite Reliability test is carried out to evaluate the level of reliability of indicator variables related to hidden constructs. When the indicator variables collectively contribute consistently and reliably to the measurement of the final construct, the CR value is high, where this data analysis can be seen in the following table:

Table 7 explains that the output results of the composite reliability test of the variables in this study are greater than the significance of 0.6, where the results of the data distribution of the data from the existing variables are appropriate and suitable and suitable for use.

4.1.8. Path coefficient test

As for the path coefficient (R square) test of each variable can be seen in Tables 8-12 below:

Table 8 explains that the R square value of the renewable energy integration variable of 85% can be explained by the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner and the rest will be explained by other variables that are not in this study by 15%.

Table 9 explains that the R square value of the business approach variable of 85.1% can be explained by the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner and the rest will be explained by other variables not in this study by 14.9%.

Table 10 explains that the R square value of the renewable energy integration variable of 85.3% can be explained by the carbon emission mitigation variable and the rest will be explained by other variables not in this study by 14.7%.

Table 11 explains that the R square value of the business approach variable of 85.2% can be explained by the carbon emission mitigation variable and the rest will be explained by other variables not in this study by 14.8%.

Table 12 explains that the R square value of the carbon emission mitigation variable of 75.7% can be explained by the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner and the rest will be explained by other variables not in this study by 24.3%.

4.1.9. Hypothesis test

The results of the hypothesis test are known through Table 13.

Table 13 explains that partially renewable energy integration variables and business approach variables affect the improvement of the ability of the Indonesian electricity sector in a sustainable manner and renewable energy integration variables affect carbon emission mitigation. Simultaneously, the variable of renewable energy integration and business approach affect the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable.

5. DISCUSSION AND CONCLUSION

The results state that the variable of renewable energy integration affects the improvement of the ability of the Indonesian electricity sector in a sustainable manner. This is in accordance with research Dagoumas and Koltsaklis (2019) which states that creating the integration of fossil energy into renewable energy can create the ability of the electricity sector to increase electrical power which produces cheap energy, strong energy and does not quickly damage the environment and surrounding conditions, so that this renewable energy can prevent the increase in carbon emissions that endanger humans. The results also state that the business approach variable has an effect on increasing the ability of the Indonesian electricity sector in a sustainable manner. This is in accordance with research (Raihan, 2023) which states that the integration of carbon energy through a business approach will create special benefits for the state, where these benefits will make the state increase the ability of electricity in a sustainable manner. the results of the study stated that the variable integration of renewable energy affects the mitigation of carbon emissions. This is in line with research (Purwanto et al., 2019) which explains that the integration of fossil energy into renewable energy will make the carbon emission mitigation process run smoothly and will be able to reduce carbon emissions established standards. This will tend to reduce the losses of the state and society both in material terms and in moral terms. The research results also state that the business approach variable has no effect on carbon emission mitigation which (Gasparatos et al., 2017) states that the business approach taken for renewable energy integration has not been able to increase carbon emission mitigation because the renewable energy integration process needs a large and expensive cost and needs serious efforts from state leaders to commit to reducing carbon emissions, as well as reducing global warming and climate change. The results showed that the variable of carbon emission mitigation has an effect on improving the ability of Indonesia's electricity sector in a sustainable manner. This is in accordance with research (Maghfuri, 2022) which states that the process of mitigating carbon emissions will increase the increase in energy for the community from the electricity system in Indonesia, so that the ability of the electricity sector will tend to continue. The results of the study state that the variable integration of renewable energy on increasing the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable.

This is in accordance with research (Dudin, 2019) which states that the ability to integrate renewable energy will improve the ability of the electricity sector to be better, so that the mitigation of carbon emissions that will be generated will tend to make carbon emissions go down and reduce global warming and climate change. The results of the study state that the business approach to improving the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable. This is in accordance with research (Umam et al., 2022) which states that a business approach to renewable energy integration can create environmentally friendly energy that can reduce carbon emissions in order to improve or increase the ability of electricity power in a sustainable manner. With the renewable energy integration process we can mitigate carbon emissions in accordance with existing standards, where declining carbon emissions will create the ability of the Indonesian electricity sector in a sustainable manner, where the utilization of the sustainability of the electricity sector's capabilities requires a business approach that can be reached by underprivileged people so that later it can create affordable prices and make people's purchasing power easier, and avoid community losses due to global warming and climate change.

From the results of this study, the conclusion obtained is that partially the renewable energy integration variable and the business approach variable affect the improvement of the ability of the Indonesian electricity sector in a sustainable manner and the renewable energy integration variable affects carbon emission mitigation. Simultaneously, the variable of renewable energy integration and business approach affect the variable of increasing the ability of the Indonesian electricity sector in a sustainable manner through carbon emission mitigation as a moderating variable.

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