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Article

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Evaluation and Modeling of Green Energy Consumption in North Sumatra, Indonesia

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ABSTRACT

This paper discusses the level of green energy consumption in North Sumatra from 2020 to 2022 using the entropy method, the breakpoint method, and the integrated method. These three methods are applied to determine the feasibility of using new renewable energy. The three methods will be compared to each other to determine accuracy and options for analyzing models in the future. The level of green energy users from 2020 to 2022 generally shows a relatively stable and sustainable upward trend. During the 3 years there were fluctuations caused by the large growth rate of total energy consumption in North Sumatra, which increased by 6.35% from the previous year, and the level of urban green energy consumption grew steadily, which provided a more stable increase in user levels green energy with a sharp increase in the previous year. However, there are significant gaps in green energy consumption levels between cities. The contribution of this research is to select a model that will be applied in North Sumatra and provide input for policymakers regarding future energy and can have a positive impact on technological innovation, industry, and financial support in particular.

Keywords: Methods of Analysis and Evaluation, Green Energy, Model Selection
JEL Classifications: C13, C22, C36, C93, L94, Q42

1. INTRODUCTION

In the last decade, the use of fossil energy has begun to shift to renewable energy for household, industrial, and other purposes (Zou et al., 2016). The development of new renewable energy in Asia has been supported by the development and construction of these plants (Wang et al., 2023). Major steps have been taken by several countries to reduce energy intensity. This is due to the determination of significant energy that can reduce about a third of energy use, but this energy use is still small. In general, clean and green energy is used throughout the world (Gielena et al., 2019), but there are difficulties in exploring this energy into commercial value.

Meanwhile, renewable energy increased very little and only contributed 16% of national electricity generation in 2019, slightly higher than in 2010. Although since 2020 Indonesia has been a biodiesel-producing country at 17% of the global total, followed by the United States and Brazil. In addition, Indonesia ranks second after the US for installed geothermal power generation capacity. The need for electrical energy in Indonesia has increased every year for various users. The increase in electricity expenses reaches around 5.81% annually. Electric energy consumption increased in 2011 by around 5.7% per year. The data is an approach for the next 10 years, Indonesia's electricity needs will increase by 6.42% per year (Fitrady et al., 2021).

The construction of fossil fuel power plants has resulted in environmental pollution, as a result of residential development patterns and the like, however, the use of new renewable energy is still low. To balance this pollution, the construction of new renewable generators can act as a catalyst for the impact of this pattern and can increase economic growth and human development (Kahia et al., 2021). Indonesia has achieved this target with a national renewable energy target of around 23% in 2025 and 31% in 2050. Indonesia is known to have all the potential for new and renewable energy (Langer et al., 2021), (Pasaribu et al., 2023).

Indonesia has developed new and renewable energy to improve this energy structure and can protect against the negative impacts of past energy use and protect against ecosystems, climate change, and others to achieve sustainable development (Napitupulu et al., 2018), (Raihan et al., 2023). The government has also increased the share of community development that saves energy and maintains a green and friendly environment. For this reason, laws regarding new renewable energy have been created to regulate the construction of these plants. Medium and long-term planning for the use of new renewable energy and the development of the Renewable Energy Industry by building environmentally friendly energy (Gielena et al., 2019), (Zambak et al., 2023).

Indonesia has great potential for the development of natural and renewable energy. Despite Indonesia's official statements and targets set in this regard, the development of renewable energy in Indonesia is still far from being a fire. According to the Secretary of the Directorate General of New, Renewable Energy and Energy Conservation, the potential for renewable energy (ET) in Indonesia is 3,600 gigawatts (GW), the utilization of which is only 11.15 GW or 3% of the total RE potential (Silalahi et al., 2021), (Suwarno and Zambak, 2021)

Furthermore, the Indonesian government plans to identify urban areas in North Sumatra as clean energy pilot projects that are environmentally friendly. City policies that use new and renewable energy are ideas from examples of new and renewable energy users that are important to encourage North Sumatra's progress to a better level and achieve sustainable development and as a model for strategic use of New Energy to be applied for sustainable development. The objective analysis and evaluation of the use of clean and green energy is a model for policies to build cities that are clean from pollution and contamination as a result of fossil energy. Many researchers have focused on new and renewable energy users (Lu et al., 2020), (Ang et al., 2022).

This policy regarding the use of new renewable energy towards energy production levels is the basis for the promotion and piloting of green energy in the future. This environmentally friendly energy pilot project in North Sumatra is very necessary to provide direction for energy use by improving quality and narrowing gaps in society. To regulate and promote green energy, an institution is needed that provides direction and regulation in the consumption and level of consumption of new renewable energy in North Sumatra from 2010 to 2023. Based on this data, with the help of the entropy, breakpoint, and different models, energy consumption can be achieved. green and explored extensively and accurately. The contribution to this research is an innovation, namely;

1. The results of this evaluation of energy consumption are compared with the total energy consumption.
2. Compared with the analysis and evaluation model of the three proposed models.

This paper provides contributions, namely, evaluation level of previous green energy consumption and provides input for policy making for the application of green energy.

Comprehensive systematic analysis to introduce the planning concept for a green city that has a low carbon and the impact of fossil fuels, policymakers play an important role in realizing this green city.

The main driver for the use of new, renewable energy is the key to the development and development of environmentally friendly cities as future green cities and governance, investment, political stability, and economic development (Tiba and Belaid, 2020). Reducing fossil energy consumption and changing to new and renewable energy is an important urbanization in energy use (Rahman, et al., 2022). The key to success in reducing climate change, acid rain, and water pollution as well as preventing soil erosion, the use of new and renewable energy is the key to success (Simionescu, 2022). Comprehensive efficiency must be taken by policymakers so that the need for new renewable energy is achieved (Tzeiranaki et al., 2023). The use of new, renewable energy implemented in Pintra City is very effective and conducive (Zhang et al., 2022). The implementation of energy policy requires the participation of various parties, and the city's new renewable energy policy takes this aspect into account. Fans et al., (Wang et al., 2022) show that the formation of the East Asia Summit (EAS) contributed significantly to GDP growth locally and had an impact on the policies implemented. Some researchers focus on new and renewable energy, as stated by Zheng (2022), that the development of smart cities will boost the economy and will have lower pollution, and increase human resources (Zheng et al., 2022). The use of land for new, renewable energy will have a positive impact on the development of surrounding green cities, due to the implementation of green city development. Empirical implementation of green city pilot projects will encourage significant economic growth and technological innovation to improve industrial structure (Zhang et al., 2022). The achievement of the formation of EAS is supported by a more efficient energy transformation because it involves many markets with the role of each component of society (Anna Ernest and Doris Fuchs., 2022). The development of science and technology can encourage the maximum development of EAS which has an impact on economic growth (Zhang et al., 2022). Technological developments and policies on the use of green energy will be significant in the production of new renewable energy (Zhao et al., 2022).

The spread of green energy development will have an impact on the quality of governance, and the stability of policies taken for global financial growth and investment supported by reducing carbon dioxide emissions and creating a safe and comfortable environment (Tiba and Belaid, 2020). Wise use of energy can narrow the gap in future green energy policies (Yuan Liu and Hongwei Liu., 2022). Efficient and economical improvement is a policy in using new, renewable energy and reducing carbon emissions (Maka and Alabid, 2022) and with green energy policies the impact of carbonization will be lower (Aleksel V Bogoviz, 2022), and can improve the quality of green energy production and require open information regarding the environment (Jaiswal et al., 2022).

The EAS planning aims to reduce the impact of environmental pollution and is a strategic plan for the development of power plants in urban areas in the future by utilizing environmentally friendly technology (Shabir et al., 2023).

The new renewable consumption rate will grow the economy regionally or nationally because negative impacts can be minimized (Purnomo et al., 2022). Indonesia in the development of green energy by improving efficiency in sustainable development (S Nugroho Agung Pambudi, 2023). The policies adopted by ASEAN will reduce distortions to energy use and strengthen institutions in protecting society from the effects of fossil energy and switching to new, renewable energy (Zhang et al., 2022). Policies to use new, renewable energy have also been implemented throughout the world to maintain a clean environment (Zhang et al., 2022), (Xu et al., 2022).

An important indicator in the use of new and renewable energy is policy in future energy consumption by taking into account economic and social factors involved directly or indirectly in the development of the green city (Chauhan et al., 2022). Green energy sources in an integrated, informative manner to reduce carbon emissions and encourage economic development with the development of green energy (Bank), 2020), and economical in environmental pollution due to emissions from fossil fuels (Olabi et al., 2023), (Nguyen et al., 2019). The use of new, renewable energy continues to increase as a form of community participation in protecting the environment (Ying et al., 2023), (Turedi and Turedi., 2021). The realization of efficiency and consumption of new, renewable energy will strengthen the economy (Ren et al., 2015), (Verma et al., 2019). Economic growth cannot be separated from the development of green energy so that it can be used economically proportionally (Li et al., 2020). The government by issuing a cheap credit policy for green energy users will encourage people to participate in protecting the environment (Shang and You, 2019). The process of evaluating and modeling new renewable energy consumption will have a positive impact on economic growth (Zhang et al., 2022). The two-way correlation between carbon emissions and energy efficiency for the use of green energy is increasingly of interest in the long term (Safi et al., 2022). El-Karimi and El-Houjjaji conducted a test on G7 countries to see the relationship between new renewable energy and GDP, they found a relationship to green energy consumption exceeding a certain threshold (El-Karimi and El-Houjjaji, 2022). In his research, Esquivias (2017) used developing Asian countries as research objects and verified the three channels in Kuznets' hypothesis, where green energy reaches a certain threshold, clean energy will begin to have a harmless interaction with economic growth (Padilla et al., 2017), (Padilla and Esquivias, 2018). It has been researched in many countries regarding carbon emissions and their impacts so that green energy and ICT can reduce environmental pollution (Hasanov et al., 2023), (Zhang, 2021).

There is a lack of research related to the EAS policy with the level of consumption of new and renewable energy, which is the largest energy consumer in the world. Indonesia is committed to making a transition to a low-carbon economy through various policies and targets. Further research on the impact of Indonesia's EAS policy on the energy consumption structure and level of green energy consumption will help policymakers to make maximum use of the impact of the policy to improve the energy structure and achieve harmonious economic and environmental development.

2. RESEARCH HYPOTHESIS

Several countries are already using new renewable energy, such as in Asia, Europe, and others. New renewable energy sources that have been utilized include wind, solar, geothermal energy, and biomass energy in the development of new renewable energy in urban areas. This is because new renewable energy can achieve a large utilization scale in energy consumption. IRENA has developed scenarios and strategies to convert technical and economic data on the energy system into information that is by policies for making decisions and has assisted the government in developing innovative strategies for the use of new renewable energy in the future. The important characteristics of the declaration are as follows:

1. Added value in the industry is that the energy consumption per unit is on a scale lower than the provincial average with the implementation of buildings that meet the requirements for energy consumption savings and comprehensive quantitative assessments.
2. Provinces must have a basis for the utilization of this energy so that energy consumption is not less than the provisions of the government to achieve this energy utilization standard.

Problems in urban development have been presented by the National Energy Administration (NEA), where supervision is not carried out adequately, so very few use renewable energy that does not meet the specified standards, How can initiatives in these cities use this energy optimally? Based on the problems above, the researcher made a hypothesis, namely;

H_1: Can the development of green cities on the use of new and renewable energy increase significantly?

H_2: Can the development of green cities from the use of new and renewable energy increase the consumption of new and renewable energy by taking advantage of the impact of technological innovation?

H_3: Can the development of green cities from the use of new energy increase green energy consumption by taking advantage of the structural effects of the industry?

H_4: Can the use of new renewable energy in urban areas increase green energy consumption through special fiscal support?

3. RESEARCH METHODS AND DATA SOURCE ACQUISITION

3.1. Research Methods

3.1.1. Entropy method model and comprehensive evaluation model

The Entropy Method is used to calculate the final entropy weight on each criterion. This method is used to find the best alternative, where in calculating the Entropy method, you must first determine the criteria and initial weight for each criterion. Giving standard weights and scores on the entropy method, measuring the level of energy consumption is important. This research is guided by Mitsuaki (Furukawa and Deng, 2019), which is the calculation of the level of green energy consumption. The values, units, and positive and negative aspects of the calculated indicators are evaluated. The recorded indicators obtained are standardized to determine the weight of each indicator using the entropy method, then eliminating these quantities using the normalization method. X_{ij} is the ith variable for the jth individual, for positive indicators such as economic indicators and sustainable development. This important indicator is used to identify energy consumption conditions in a region and is related to external factors including economic, policy, and social factors related to energy consumption.

$$X_{ij}' = X_{ij} - \min X_j \quad (1)$$

$\max X_j - \min X_j$

For negative indicators, there are:

$\max X_j - X_{ij}$

a prerequisite for reflecting the level of green energy consumption.

According to the results of several studies and other institutions, the index for the level of new renewable energy consumption is influenced by the economic and social growth of the area.

$$X_{ij}' = \max X_j - \min X_j \quad (2)$$

Equation (2) shows the relationship between several indicators, namely development, resource efficiency, environmental protection, and government policy support.

X_{ij}' is standard data and is to meet operational logarithms.

In the entropy weight method, normalized data needs to be shifted, $X_{ij}'' = X_{ij}, + \sigma$ in this study, $\sigma = 0.000001$.

With "n" being the number of individuals, the steps for carrying out operations using the entropy method are as follows.

X_{ij}'' where the value is based on analysis and reality, then identifying four level 1 indicators:

This shows that economic development, energy consumption, pollution emissions, and environmental protection are dependent on each other. This system plan is to measure the level of green energy consumption and the connotation of the level of green energy consumption, where this research shows that it explicitly builds a measurement system framework.

$$p_{ij} = N_i = 1, e = -1 \quad (3)$$

$$X_{ij}'' \sum p_{ij} \ln (p)_{ij} \quad (4)$$

1. A comprehensive representation of green energy consumption is designed to see the relationship between green energy consumption and the target value. That is;

$\ln(n)\ i = 1$

2. First level indicators. To better reflect the influence of various indicators on measuring the green economy, namely;

$$d_j = 1 - e_j \quad (5)$$

development in the green economy development process, namely;

$$d_{jj} = 1\ d_j \quad (6)$$

This paper has designed four first-level indicators, namely, economic development, energy consumption, pollution emissions, and environmental protection.

wj is based on the weight of each indicator, where each indicator is then added up to get a composite score for the level of green energy consumption.

3.1.2. The natural breakpoint method

This method functions to minimize a data variant that tends to fluctuate, so classification using natural breakpoints is required. Apart from that, to ensure data accuracy, this method can be divided into three classes. The high level of class value will depend on the area being analyzed.

3.1.3. Difference method

In this paper, we adopt a policy evaluation method to determine the right decision, because regression is generally difficult to solve for specific matters, such as the environment and the relationship between one variable and another (endogeneity). This research contributes to building an evaluation model with a different method for the value of the impact of developing an urban area using new and renewable energy and the level of green energy use, where urban areas that use green energy are the control group.

3.2. Selection of Data Sources

In this paper, the green economic development indicator measurement system is an indicator that has been determined as a benchmark. However, scientific concepts, completeness, operations, and a combination of quantitative and qualitative indicators are determined as requirements that cannot be released (as completeness requirements).

3.2.1. Green energy consumption indicator as a selection indicator

A reciprocal coordination of environmental protection and economic development is the achievement that will be aimed at in this research, taking into account the circular economy and second-level low-carbon indicators. Economic development is an indicator of economic development as a benchmark for the use of green energy in cities by maintaining vitality and basic levels of economic development. The income of the per-capita community is a reflection of the national economic potential in a country or region which is parameterized as X1, X2; Energy use is the main driving force for developing green energy consumption levels and choosing energy consumption indicators to measure resource utilization capacity in general. Considering the current conditions and situation, then the actual type of energy such as authenticity and data integrity, energy use which has an impact on clean energy at the level of green energy consumption. An indicator that has been determined in this research is energy consumption and net energy consumption for comprehensive analysis, with energy consumption as total energy consumption and other energy consumption. Total energy consumption is expressed as X3, which is considered a negative indicator, and for liquefied petroleum gas (LPG), electricity, and gas as a positive indicator, which is expressed as X4, X5, and X6. Three types of waste (industrial wastewater, industrial sulfur dioxide, and industrial soot), constitute a major pollution emission designated as X7, X8, and X9. Utilization of industrial waste, green environment, and development areas, the area of green area is expressed as X10.

3.2.2. Data source

This paper analyzes the data obtained from the North Sumatra province, which is a province with administrative divisions based on data from 2020 to 2022. The data in this paper comes from North Sumatra statistical data and other sources related to this research data and takes into account variable data, cities, and numbers. resident.

3.2.3. Level of new renewable energy consumption

The influence of the speed of development between cities is caused by variations in policy orientation, economic development, and differences in talent in each province in North Sumatra. In this paper, several cities in North Sumatra are selected for analysis, measuring the level of new and renewable energy consumption based on the method studied.

a. The chronology of the characteristics of the use of new renewable energy in several cities in North Sumatra generally shows a trend of continuing to increase, where the average value of green energy use from 0.387 in 2019 to 0.514 in 2022, this shows that the level of green energy use in North Sumatra is experiencing an increase in the level of development and utilization of good energy, where the level of urban green energy use is growing steadily, and the level of green energy use is growing steadily. These changes show that under the guidance of relevant national policies, energy technology has been improved, energy use structure has improved, clean energy use has continued to increase, the growth rate of total energy consumption has slowed down,
b. Spatial Characteristics of Green Energy Consumption Levels. In this paper, the problem is solved using the natural breakpoint method in visualizing the spatial patterns of green energy consumption levels in 25 districts and 8 cities under the Provincial Government.

The natural breakpoint grouping method uses statistical optimization methods to obtain cut points to minimize the amount of internal variance at each level and avoid the influence of subjectivity on grouping.

The effective development and utilization of new renewable energy sources can promote the use of green energy, optimize and adjust the economic structure, implement an innovation-driven development strategy, and comply with the development of the use of green energy (renewable energy). Has a great potential to increase the level of green energy consumption in rural cities or districts, which is the key to increasing the overall green energy consumption. Almost every city or district considers regional realities, learns from the development experiences of big cities, adapts to local conditions, improves their energy consumption structure, and increases the level of green energy consumption.

4. EMPIRICAL EVALUATION AND ANALYSIS

4.1. Variable Settings and Modeling

The variable setting model is a quasi-experiment, where this paper adopts the policy evaluation method commonly used today, namely the Difference-in-Differences (DID) method. Based on the thinking pattern of this method, we first group cities into treatment and control groups with a list of demonstration cities. Urban areas are demonstration areas consisting of district-level cities and administrative cities, so several missing data were excluded from this variable or the pilot area in the selection of treatment and control groups, thus producing the treatment group for this paper. The basic model is defined as follows; (Xin Huang, 2021).

$$green_{ct} = \beta_0 + \beta_1 D_1 D_{ct} + \beta_2 X_{ct} + \delta_c + \gamma_t + \varepsilon_{ct} \quad (7)$$

In this paper, the standard error is used for city-level grouping as the selected grouping variable, where green is a group of variables as a measure of the level of green energy consumption in cities. DIDct is the main explanatory variable group, where DIDct = Treatment (c)×Policy (t). In this case, where city "c" is designated as a pilot city for new renewable energy, Treat c = 1; if not met, then Treat c = 0; the policy shock variable is 1 after the policy is implemented and 0 before; the magnitude of c, t is a representative of each city and year. X_{ct} represents the control variable; t is a time-fixed effect; c is the city-fixed effect; εct is a random error. β_1 is a policy effect caused by urban users of new renewable energy. If the results of β_1 are significantly positive, then this proves that cities are users of new renewable energy and can increase the use of green energy. However, the impact of urban development using new renewable energy on city economic growth is a finding in this research, where districts and cities with large populations are a factor that influences the level of green energy use.

In this research paper excluding exogenous disturbances is used to estimate the net impact of the policy. The results of previous researchers were that the control variable chosen was per capita GDP to measure the impact of economic development; secondary industry share to measure the impact of industrial structure on energy consumption; regional public budget expenditure, a measure of fiscal income, especially tax income, which is structured in such a way as to maintain and improve people's livelihoods, encourage economic and social development, maintain national security, and support the operationalization of state institutions, etc. -other. Science, technology, and arts expenditures, used to develop and promote various research endeavors; level of government intervention, measured by the level of government spending minus science and technology spending as a proportion of total GDP; Green patents refer to inventions, utility models, and design patents that are based on environmentally friendly technologies such as resource conservation, energy efficiency, and pollution prevention and control. However, in the mechanism analysis, patent data is based on utility, invention, and design patent data published by the State Intellectual Property Office and a database that is a proxy variable for the effects of technological innovation. energy efficiency, and pollution prevention and control. However, in the mechanism analysis, patent data is based on utility, invention, and design patent data published by the State Intellectual Property Office and a database that is a proxy variable for the effects of technological innovation. energy efficiency, and pollution prevention and control. Mechanism analysis however, the patent data is based on utility, invention, and design patent data published by the State Intellectual Property Office and a database which is a proxy variable for the effects of technological innovation (Xiao et al., 2019), with the ratio of tertiary industry and secondary industry as a proxy variable for industrial structure (Shi et al., 2018) and special fiscal spending as a proxy variable. This variable influences financial support and differences in GDP per capita which is an expenditure of the regional public budget, and science and technology expenditures between cities. The variable is a logarithmic form so as not to affect the accuracy of the regression results.

4.2. Basic Regression Results

The regression results in this model show an urban effect of using new renewable energy on the level of green energy use in cities when no control variables are included. The coefficient is positive and significant at the 10% level; The resulting control variables are shown in the model and are positive and significant at the 5% level. The results of several applied models that do not take into account city and time effects are still positive and significant at the 1% level. The results above show that the development of cities using new renewable energy can increase green energy consumption, and H1 is acceptable (proven).

For the control variable, it has a positive value between GDP per capita and the level of green energy users. This is caused by the higher GDP per capita, the more advanced the economy, and the availability of financial and other support that can improve the structure of new renewable energy users and can increase energy efficiency, encourage the development and effective use of new energy sources, and gradually reduce the total energy users. As an obstacle to long-term energy users, the secondary industry reaches 5%. This is a result of the dominating use of fossil energy which makes it difficult for the development of new renewable energy to progress because the level of green energy users only absorbs expenditure funds of around 1%.

The budget used is the expenditure budget and fiscal revenues, including tax revenues, which are used to protect and improve people's livelihoods, encourage economic and social development, maintain national security, support the normal operations of state institutions, etc. The results of science and technology develop and encourage various scientific research. Some possible reasons for this are as follows.

First, the results of science and technology are used to develop new renewable energy and increase energy efficiency, but scientific research from the other side still provides a greater proportion of this expenditure.

Second, this research was carried out to produce conclusions and was implemented as a dynamic process and the positive effects of implementing green energy on short-term use, but for the long term. The government in this case is the main policy maker and is vital for the sustainability of this green use because the impact that can be felt is around 1% in the use of green energy.

4.3. Mechanism Analysis

Initial regression results show that the use of green energy in cities has increased quite a bit, this is shown in the policies that have been issued by the government regarding the use of new, renewable energy. The analysis mechanism provides policies that have an impact on economic development, the following equation is created (Zhang, 2023).

$$green_{ct} = \beta_0 + \beta_1 DID_{ct} + \beta_2 X_{ct} + \delta_c + \gamma_t + \varepsilon_{ct} \quad (8)$$

$$M_{ct} = \alpha_0 + \alpha_1 DID_{ct} + \alpha_2 X_{ct} + \delta_c + \gamma_t + \varepsilon_{ct} \quad (9)$$

$$green_{ct} = \mu_0 + \mu_1 DID_{ct} + \mu_2 M_{ct} + \mu_3 X_{ct} + \delta_c + \gamma_t + \varepsilon_{ct} \quad (10)$$

Mct is a mediator variable used in this research, where each variable represents the effect of technological innovation, the effect of industrial structure, and the effect of financial support. According to testing procedures (Shi et al., 2018) for the mediation effect, with regression, μ_1, μ_2 are significantly positive, and the coefficient μ_1 is smaller than before, then M_{ct} is a partial mediation variable, with regression, μ_1 is not significant and μ_2 is significantly positive, so M_{ct} is a full mediation variable. It can be concluded that the mechanism of city influence influences the use of new renewable energy on the level of green energy consumption. Several models show that urban areas are pilots of new renewable energy users that can encourage technological innovation. The regression coefficient of 0.913 is a significant value at the 1% level, while the model regression coefficient has a positive significant value at the 10% level, this shows that technological innovation has increased the level of green energy consumption, caused by local government enthusiasm to develop new renewable energy under the promotion of national new energy strategy. Under the policy guidelines, local governments and companies improve energy efficiency through technological innovation and thereby increase the level of use of such green energy. The regression coefficient in the model is 0.245, giving a significant positive value at the 5% level. This indicates that the urban development of new renewable energy users has encouraged the optimization of industrial structures with a significantly positive regression coefficient at the 1% level. local governments and companies improve energy efficiency through technological innovation and thereby increase the level of use of green energy. The regression coefficient in the model is 0.245, giving a significant positive value at the 5% level. This indicates that the urban development of new renewable energy users has encouraged the optimization of industrial structures with a significantly positive regression coefficient at the 1% level. local governments and companies improve energy efficiency through technological innovation and thereby increase the level of use of green energy. The regression coefficient in the model is 0.245, giving a significant positive value at the 5% level. This indicates that the urban development of new renewable energy users has encouraged the optimization of industrial structures with a significantly positive regression coefficient at the 1% level.

Improving the industrial structure can increase the level of green energy users regionally, this is because local governments have developed more new renewable energy industries, such as electric vehicles and photovoltaic industries, through city platforms that use new renewable energy and meanwhile traditional industries are Energy consumption has been reduced, thereby reducing pollution and increasing the level of green energy users. In the model, the regression coefficient is 0.508 and is significant at the 1% level, which shows that the development of cities using new renewable energy can increase financial support. A model with a significantly positive regression coefficient at the 1% level, shows that the development of new renewable energy pilot cities has increased specific financial support. Meanwhile, special fiscal support increases the level of green energy consumption in the regions, this appears to be because local governments provide more financial support to better implement green energy programs.

Policies guided by the national new energy strategy guidelines and support from local governments, all industries can build model cities for new renewable energy concepts that have been established by the government, to increase the level of green energy users. In this paper, we refer to Zhang (Zhang et al., 2022) and Chen (Chen, 2023) to select the nonparametric percentile Bootstrap method to validate and verify the above mediation transmission mechanism. In general, the coefficients of these three effects are significantly positive. This shows that these three effects have a significant positive impact on increasing green energy consumption. The total indirect effect refers to the amount of pilot city development utility in increasing the level of green energy consumption through the three mediation channels, which is 0.003. This shows that the selection of pilot city development through these three types of mediation effects is a valid and reliable result. Indirect effects from industrial structure effects provide the largest contribution to the total effect of around 11%,

4.4. Endurance Test

4.4.1. Parallel trend analysis

The important model of the difference-in-difference method is an assumption that parallel trends are met with no influence of exogenous policy shocks from urban green energy users so that the treated group and the untreated group have the same trend of change. This paper shows a graph of the trend in green energy consumption levels until 2020 and takes 2020 as the year of policy shocks due to the impact of COVID-19. In general, it is consistent between the two groups until 2020, thus showing that a prerequisite for the difference-in-difference method used can be met.

4.4.3. Placebo test

This paper is in line with studies such as Tong et al (Zhao et al., 2022), which advances the implementation of the policy for 2 years with the help of the placebo test idea, and if the coefficient of “Policy Treatment remains significant”, this provides evidence that the impact of the policy is not brought by urban development using new renewable energy, and on the contrary, proves that the policy “effective”.

The Treat×Policy coefficient is not significant, indicating that the increase in the level of green energy users caused by urban development of new energy users cannot be ignored.

4.4.4. Placebo test for a random sample

Based on a study conducted by Eggers et al (Eggers, 2023) using estimates with different matching methods. The regression analysis above with iteration to avoid events with a small probability that confound the estimation results, with the distribution of the estimated coefficients and “P” values corresponding to placebo test results taken randomly, it was obtained that most of the “P” values were greater than 0.05, and the existing coefficients largely fail to reject the null coefficient hypothesis, where the coefficient and value estimates from random sampling cannot exclude the initial assumption that the average value of the coefficient is equal to 0, by conducting an independent sample T-test on the regression coefficients carried out so that estimates are not too biased by the omission of that particular variable.

This research provides results that, the kernel density estimate of the core explanatory variable deviates significantly from the actual value several repetitions in random sampling, this shows that the effect of the core explanatory variable on the variable explained is not caused by other omitted variables, which proves the validity of policies that play a very big role in the implementation of new renewable energy users.

4.4.5. Matching method

This matching method is used to estimate the probability score in the form of a conditional probability of a sample of cities selected as urban users of new and renewable energy through a model to match cities that use new and renewable energy with cities that are non-users of energy as observed attributes and using the results from the successfully matched control group. as the counterfactual outcome of the treatment group to reduce possible bias and produce standard errors in parentheses of $P < 0.01$, $P < 0.05$, and $P < 0.1$. The results after data matching show that, the treatment group and the control group have a large area of overlap before and after matching, which meets the condition of general support.

The standard deviation of each variable in the matching model has a deviation with a value around the 0 line, which shows that the characteristics of the variables in the action and control groups are generally consistent. Using the matching model on radius 1 to 4 in the caliper shows that the mean value of the treatment effect is 0.00613 and is significantly positive at the 1% level. These results provide a positive treatment effect of urban development using new renewable energy on economic development which is consistent with the estimation results from the basic regression. As a result of testing the robustness of the results in the proposed model, additional matching methods are applied and if the results from other methods are robust, then the estimates are proven to be unbiased.

5. CONCLUSIONS

The level of green energy use in 33 cities/districts in the province of North Sumatra from 2020 to 2022 with the help of the entropy method and a comprehensive evaluation model is examined. The results of the natural breakpoint method are divided the data into three intervals, namely low level interval, medium level interval, and high-level intervals in exploring the spatial distribution patterns of green energy usage levels have been used. Second, this paper adopts the general policy evaluation method used and builds a different evaluation model, using urban areas using new renewable energy as a treatment group and non-using cities as a control group by providing an assessment of the impact of the formation of urban areas using new renewable energy on consumption levels green energy.

1. The level of green energy users from 2020 to 2022 generally shows a relatively stable and sustainable upward trend. During the 3 years there were fluctuations caused by the large growth rate of total energy consumption in North Sumatra, which increased by 6.35% from the previous year, and the level of urban green energy consumption grew steadily, which provided a more stable increase in user levels green energy with a sharp increase in the previous year. However, there are significant gaps in green energy consumption levels between cities.
2. Urban development of new energy users can significantly increase the level of green energy use.
3. GDP per capita and the level of green energy users have a positive correlation, so researchers provide recommendations, namely;
    a. The government must formulate appropriate policies according to local conditions, support clean industry, increase information exchange between cities, increase the use of sustainable energy resources, and increase the level of green energy consumption. Improve regional coordination, pay special attention to the potential for greening energy consumption in the region, and encourage active exploration of new industrial development models.
    b. Encourage the regular growth of urban uses of new renewable energy and provide policy supplies, where local governments must promote urban development of new renewable energy users in several cities to optimize the spatial layout of new energy cities.
    c. GDP per capita and the level of green energy users have a positive correlation and secondary industry influences and inhibits the level of green energy consumption.

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