The Impact of Demographic Factors and The Policy of Biomass Co-Firing as a New Kind of Renewable Energy on Spatial Planning in Indonesia

Cindy Yosiana
Faculty of Law, Universitas Sebelas Maret, Surakarta, Indonesia
Ir. Sutami Street, No. 36 Kentingan, Jebres, Surakarta, Jawa Tengah, Indonesia 57126
yosianacindy211@student.uns.ac.id

I Gusti Ayu Ketut Rachmi Handayani
Faculty of Law, Universitas Sebelas Maret, Surakarta, Indonesia
Ir. Sutami Street, No. 36 Kentingan, Jebres, Surakarta, Jawa Tengah, Indonesia 57126
Ayu_igk@staff.uns.ac.id

Mohd Rizal Palil
Faculty of Economic and Business, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia
Lingkungan Ilmu, Bangi, Selangor, Malaysia 43600
mr_palil@ukm.edu.my

***Abstract*—Renewable energy plays an integral part in addressing climate and environmental challenges by decreasing reliance on traditional energy sources and fossil fuels. The government continues to promote the use of renewable energy. A practical method involves augmenting biomass waste as a fuel blend in Steam Power Plants (PLTU). The demographic factors in Indonesia significantly impact energy consumption, including the projected increase in energy demand due to population growth, urbanization, and population dispersion. This research uses the normative juridical technique to examine the laws and regulations in Indonesia about demography, biomass co-firing policies as a form of new renewable energy, and spatial planning. Utilizing biomass as a sustainable energy source may mitigate our reliance on non-renewable fossil fuels and diminish carbon emissions. Nevertheless, the circular economy's principles align with the exploitation of industrial and agricultural waste facilitated by biomass co-firing. Implementing a circular economy strategy for biomass co-firing in Indonesia necessitates meticulously examining geographical and legal factors. Implementing a circular economy strategy in biomass co-firing affects spatial planning in Indonesia.**

***Keywords*—Biomass Co-Firing Policy; Demography; Spatial Planning.**

I. INTRODUCTION

Renewable energy is generated from nature's resources, which can regenerate organically over time. A period pertinent to human activities is characterized by natural processes' perpetual renewal of these natural resources.[1] Consequently, this energy is unlimited and can be utilized in a way that guarantees its long-term sustainability.[2] Reducing dependence on traditional energy sources and fossil fuels is a critical aspect of mitigating climate and environmental issues via renewable energy.[3] Solar, biomass, ocean waves, geothermal, and water are among the renewable energy sources that are currently being implemented.[4] Complying with regulations and adhering to international trends are not the only components of the transition to renewable energy. Moreover, it involves actively engaging in global initiatives to promote sustainability, preserve the environment, and guarantee uninterrupted corporate operations. For corporations, communities, and the environment, renewable energy utilization is a strategic measure that has the potential to yield long-term benefits. Renewable energy is a critical component of the climate crisis and is essential for its effective resolution.

From the production of energy through fossil fuels, most of the greenhouse gases that envelop the Earth and retain the sun's heat originated. Fossil fuels, such as gas, oil, and coal, now account for about 75% of global greenhouse gas emissions and almost 90% of all carbon dioxide emissions.[5] It is evident that to mitigate the most severe consequences of climate change, it is imperative to reduce emissions by about 50% by 2030 and achieve a state of net-zero emissions by 2050. In order to do this, we must cease our dependence on fossil fuels and allocate resources toward renewable energy sources that possess the qualities of dependability, environmental friendliness, affordability, sustainability, and accessibility.[6] Despite the emergence of new eco-friendly energy sources, fossil fuels still dominate global energy production, accounting for over 80%. Renewable resources account for around 29% of global energy consumption. The government continues to promote the use of renewable

A. K. Jaelani et al. (eds.), *Proceedings of the International Conference on Cultural Policy and Sustainable Development (ICPSD 2024)*,
Advances in Social Science, Education and Humanities Research 869,
https://doi.org/10.2991/978-2-38476-315-3_74

energy. An approach to consider is the augmentation of biomass waste utilization as a fuel blend in Steam Power Plants (PLTU). This approach is anticipated to expedite the energy transition process in Indonesia. The co-firing method involves using biomass as a partial replacement for coal in the power plant boiler.

Furthermore, this biomass may be derived from various sources, including forest, plantation, or agricultural waste. Utilizing biomass waste helps mitigate methane emissions resulting from the decomposition of biomass waste.[7] The use of biomass co-firing aligns with the principles of the three pillars of energy transformation discussed at the G20 Presidency meeting. Indonesia's resolve to expedite the Net Zero Emission (NZE) objective by 2060 should be highlighted via co-firing technology, mainly due to the significant contribution of CO_2 emissions from PLTU.

Demographic analysis is not just a factor, but a crucial tool in understanding and planning for renewable energy demands. By examining population growth, dispersion, and urbanization, we can determine the renewable energy requirements and make informed decisions about our energy future.

Table 1. Demographic Analysis of Renewable Energy Needs

DEMOGRAPHIC ASPECTS	DETAIL	IMPACT ON ENERGY DEMAND
POPULATION GROWTH	The estimated population in 2021 is around 273 million. The annual growth rate is around 1.1%. The population comprises more than 25% individuals under 15 and 9% over 60.	Population expansion leads to an escalation in energy consumption for home necessities, transportation, and public services. The presence of a substantial and youthful population will result in a surge in energy requirements in the coming years as they enter the stage of their lives when they contribute to economic productivity.
POPULATION DISTRIBUTION	60% of Java's population lives there. Java's population density exceeds 1,100 individuals per square kilometer, but the population density in Papua is less than ten individuals per square kilometer.	Java's high population density increases energy consumption in power, transportation, and industry. Areas with low population density may exhibit reduced energy use, although they may also face more significant obstacles in terms of energy delivery.
URBANIZATION	In 2021, the urban population accounted for 56% of the total population. Major urban centers: Jakarta, Surabaya, Bandung, Medan	Urbanization amplifies the energy needs in urban infrastructure, including power, water, and transportation. Metropolitan areas with concentrated populations have elevated energy requirements for commercial buildings and residential and industrial sectors.
FACTORS THAT INFLUENCE	Family planning programs effectively mitigate population growth rates. Urbanization results from the movement of people from rural to urban locations. Urban economic expansion.	Family planning programs can mitigate the long-term growth of energy consumption. Urbanization leads to a rise in energy consumption in cities, particularly in transportation and housing. Urban economic expansion leads to increased energy use for industrial and service sectors.

The above table illustrates the impact of Indonesia's demographic factors on energy consumption, including the projected increase in energy demand due to population growth, urbanization, and population dispersion. Indonesia is dedicated to enhancing the use of sustainable energy sources via various regulations, such as biomass co-firing.[8] This strategy seeks to decrease reliance on coal by incorporating biomass into the combustion process in Thermal Power Station (PLTU).[9] As of 2021, Indonesia's population is around 273 million individuals, with an annual growth rate of 1.1%. This population expansion, therefore, leads to an increased need for energy.[10] Implementing biomass co-firing entails using biomass derived from agricultural wastes and waste generated by the wood industry and making necessary technological adjustments to the PLTU. Projects such as PLTU Paiton in East Java, which employs rice husks, and PLTU Tanjung Jati B in Central Java, which employs palm oil residue, have demonstrated their efficacy in reducing CO_2 emissions and bolstering the local economy.[11] The rapid process of urbanization, which has resulted in 56% of the population residing in urban areas, is also leading to an escalation in energy demands. [12] Spatial planning is a systematic process that regulates the use of space to facilitate equitable economic, social, and environmental progress. Spatial planning is crucial in promoting sustainable development, mitigating conflicts of interest, and ensuring effective regional governance. By determining the most suitable locations for constructing biomass power plants, solar panels, and wind turbines, spatial planning contributes to developing renewable energy infrastructure.

The government is maintaining this strategy by issuing regulations and offering incentives, like the Ministry of Energy and Mineral Resources Regulation and fiscal incentives, to encourage the development of renewable energy initiatives. A comprehensive spatial planning analysis is necessary to develop an optimum and productive spatial configuration that will enhance the feasibility of renewable energy provision in biomass co-firing initiatives, hence facilitating the implementation of biomass co-firing. However, challenges such as complex regulations, limited land availability, and logistical complexities must be overcome. This study evaluates the effectiveness of biomass co-firing policies as a renewable energy alternative in Indonesia. This report will assess the impact of legal policies, demographics, and spatial planning on implementing biomass co-firing. This study aims to evaluate the effectiveness of biomass co-firing regulations in facilitating local economic growth, mitigation of carbon emissions, and meeting sustainable energy needs via effective spatial planning.

II. LITERATURE REVIEW

A. Demographics and Energy Demand

The population of Indonesia is expanding at a rate of approximately 1.1% per year, with an estimated total of over 273 million individuals in 2021.[13] In addition, the urbanization trend is rising, with approximately 56% of the population residing in urban areas. Although Java Island is home to approximately 60% of the population, the unequal distribution of individuals has increased energy demands, particularly in metropolitan areas. According to research conducted by the Central Statistics Agency (BPS), the urbanization process in Indonesia has led to an increase in energy consumption, particularly in transportation and accommodation. A robust correlation between energy consumption and population growth was established by research conducted by the Asian Development Bank (ADB). As the population and urbanization rates increase, the energy demand also increases, particularly to meet the needs of the housing, commercial, and industrial sectors.[14] Due to the expanding utilization of electrical appliances and the infrastructure that supports metropolitan living, energy consumption in urban areas may increase annually by 1% to 2-3%. By 2035, Indonesia's population is anticipated to reach 295 million, with approximately 66% of the population residing in urban areas, per the United Nations.

According to pre-Malthusian theory, population growth is unaffected by technological and environmental factors, therefore new technological innovations and advances in the natural sciences would inevitably meet the needs of a growing population.[15] This chart shows that energy needs can be met without burning, as long as the number of people, technology, and renewable resources continue to increase. Alternatively, according to Malthusian theory, population growth will outpace crop production capacity, which in turn would mitigate imbalance and crisis.[15] Energy crisis, in which energy demand exceeds production capacity, may be caused by uncontrolled increases in demand for energy, according to this theory. Demographic theory illustrates the changing path of population growth from affluence to middle class as a result of economic and social development. This transition means that energy demand will first increase, but then stabilize as a result of population stabilization and improvements in energy efficiency. Economic growth also has a significant effect on energy consumption, especially in the industrial, commercial, and transportation sectors, since increasing activity in these areas requires a large amount of energy. In addition, increased energy consumption in the building, transportation, education, and healthcare sectors is affected by a growing population. Thus, there is a strong correlation between demographic factors and energy demand, and how this need is distributed will have a significant impact on energy production, technological innovation, and energy efficiency in the future.

A well-crafted energy policy is essential to address this increasing demand. The International Energy Agency (IEA) report emphasizes the necessity of co-firing biomass and other renewable energy sources to ensure a secure and sustained energy supply. There is a pressing need to reduce dependence on fossil fuels and reduce carbon emissions. National energy policy must be modified to accommodate these anticipated population growth rates.

B. Biomass Co-Firing Policy

In order to hinder EBT development, PLN proposed using co-firing at 52 PLTU. Co-firing is a burning process that aims to replace wood with biomass at a certain ratio. So far, PLN has conducted a co-firing experiment at 26 PLTU with a biomass percentage ranging from 1% to 5%. As part of its endeavors to reduce greenhouse gas emissions, Indonesia has implemented numerous regulations to encourage the use of renewable energy. By 2025, the General National Energy Plan (RUEN) is a primary policy that aims to obtain 23% of the energy composition from renewable energy sources.[16] Per Presidential Regulation Number 22 of 2017, the national energy policy is required to encourage using renewable energy sources, such as co-firing biomass. In order to encourage the utilization of biomass in PLTU, the Ministry of Energy and Mineral Resources (Kementrian ESDM) has implemented various laws and incentives. The successful implementation of co-firing biomass with rice husks as an auxiliary fuel at the Paiton PLTU in East Java is illustrated in the case study. Through this implementation, combustion efficacy has been significantly improved, significantly reducing carbon dioxide emissions.

Using biomass as a substitute for fuel in PLTU aligns with Indonesia's efforts towards achieving net zero emissions in the future and, in addition to enhancing the contribution of renewable energy to the na[17]tional energy mix, also cofiring positive impacts on the development of the local economy (circular economy) since it

may provide employment opportunities and business prospects in the biomass sector, particularly those based on waste and residues. Biomass for cofiring may be obtained from agricultural waste, wood processing industry waste, household waste, and energy crops grown on dry land or cultivated in Energy Plantation Forest areas such as Kaliandra, Gamal, and Lamtoro trees. As of June 2021, PT PLN (Persero) has successfully implemented cofiring, blending biomass with coal, at 17 steam power plants (PLTU). The cofiring project allows PLN to generate green energy with an equivalent power capacity of 189 Mega Watts (MW). Out of 17 commercial biomass power plants, about 12 are located in Java, and five are outside Java. Two PLN subsidiaries, PT Indonesia Power and PT Pembangunan Jawa Bali, manage the power plants. Indonesia Power generates green energy by co-firing at PLTU Suralaya 1-4, PLTU Suralaya 5-7, PLTU Sanggau, PLTU Jeranjang, PLTU Labuan, PLTU Lontar, PLTU Pelabuhan Ratu, PLTU Barru, and PLTU Adipala. Meanwhile, PJB generates green energy by co-firing Paiton Unit 1-2, Pacitan, Ketapang, Anggrek, Rembang, Paiton 9, Tanjung Awar-Awar, and Indramayu power plants. The acronym RAF stands for Royal Air Force.[17]

PLTU Tanjung Jati B in Central Java also employs palm oil residue as an additional fuel source. The usage of agricultural refuse has a beneficial effect on the local economy by reducing the reliance on coal. Technology adjustments to the PLTU and the distribution and accessibility of biomass are among the obstacles that must be overcome. However, there are opportunities to improve the economic well-being of the local community by creating employment opportunities and using an adequate amount of agricultural refuse. Research conducted by the International Renewable Energy Agency (IRENA) has demonstrated that the biomass co-firing strategy has substantial economic, social, and environmental results. Local farmers who market agricultural residues as biomass will experience significant economic benefits, such as reduced fuel expenses and increased revenue. Biomass gathering and processing businesses generate employment opportunities, which is their social impact. Some examples of environmental consequences are the enhancement of air quality and the reduction of CO2 emissions. In order to facilitate a sustainable transition to renewable energy sources and achieve reduced emissions objectives, this research underscores the significance of biomass co-firing legislation.

C. Spatial Planning and Renewable Energy

They are related to the tangible arrangement of objects or space. The Job Creation Law encourages significant and rapid economic growth and investment increase.[18] However, it fails to adequately address sustainable development, preserving natural functions and human safety.[19] The provisions of the Job Creation Law could have significant implications for spatial planning. Biomass co-firing necessitates sustainable biomass sources, such as well-managed forest plantations or agricultural refuse. However, eliminating the requirement for a minimum forest area of 30% and the weakened connection between the Strategic Environmental Assessment (KLHS) and Detailed Spatial Planning (RDTR) pose threats to forest ecosystems essential for biomass production.

The following nine initiatives aim to revise Law No. 26 of 2007 concerning Spatial Planning. The proposed modifications entail the following changes:

1. The removal of space utilization
2. The streamlining of the spatial planning system by eliminating provincial strategic areas, district strategic areas, and spatial planning of rural areas
3. The consolidation of permits and institutions
4. The weakening of the link between Strategic Environmental Studies (KLHS) and Detailed Spatial Planning (RDTR)
5. The resolution of conflicting spatial planning with permits and forest areas through a pragmatic approach (adjustment and even whitening) rather than relying on the precautionary principle
6. Amendment abolishes the need for a minimum forest area of 30%.
7. Revision stipulates that a "strategic change in national policy" must occur to carry out a spatial planning review within five years. These characteristics must be expressly expressed in legal legislation since they are changeable and distinct from the other criteria.
8. Concern is decreased chances for community involvement, particularly when accessing the judicial system.
9. The concept of criminal penalties has been revised, transitioning from procedural violations to substantive offenses. These modifications could disturb verifying and enforcing punishments for infractions and crimes related to spatial planning.

Furthermore, the licensing procedure for biomass co-firing projects has grown increasingly complex due to the consolidation of licenses and institutions. It necessitates collaboration across several sectors and levels of government. Limiting chances for community engagement may impede effective management and control of these programs and their possible negative impacts on the environment and nearby communities. The sustainability of biomass co-firing facilities in Indonesia under the Job Creation Law may be affected by changes in spatial planning. Hence, it is crucial to thoroughly assess and adjust spatial regulations according to the principles of sustainable development, which include ecological sustainability and human safety. It is necessary to guarantee the long-term viability and desired advantages of investments in biomass co-firing.

III. METHOD

This investigation employs normative juridical methodologies to investigate Indonesia's laws and regulations regarding demography, biomass co-firing policies as a form of renewable energy, and spatial planning.[20] Our study aims to thoroughly comprehend the effects of biomass and demographic co-firing laws on spatial planning in Indonesia. In addition, we will provide findings and suggestions based on solid facts, which may be used to influence future policy modifications. In order to acquire our data, we will systematically locate, assemble, and examine pertinent legal literature and records. It will include primary legal documents such as norms, jurisprudence, and statutory laws and secondary legal resources such as academic works, research, and literature. The data will undergo normative analysis, enabling us to examine the essence of laws, evaluate their coherence, and comprehend the legal consequences of biomass co-firing rules on spatial planning and demography.

IV. RESULT AND DISCUSSION

A. The Impact of Demographic Shifts on Energy and Spatial Planning Policies.

Demographic trends, including urbanization and population growth, are significantly impacted by Indonesia's spatial planning and energy policies.[21] According to Thomas Malthus's law of demography, the population tends to increase exponentially, whereas resources increase at a linear rate.[15] A severe shortage could result from the ineffective management of resources. As the population is expected to reach 295 million by 2035, there will be a consistent increase in the energy demand. To guarantee a sustainable and dependable energy supply, it is essential that we promptly implement energy policies that are both forward-thinking and adaptable.

According to projections, the urban population is anticipated to reach 66% by 2035, which will increase energy consumption for public services, transportation, and accommodation. According to the demographic transition theory, which explains the gradual decrease in population trends from high birth and mortality rates to lower levels in conjunction with economic and social advancements, this rapid urbanization will result in increased energy consumption and a reduction in the urban population. Urban regions frequently demonstrate an elevated demand for fossil fuels and electrical energy to preserve urban infrastructure and sustain economic activity. It is imperative to amend energy policy to incorporate renewable energy sources, such as co-firing biomass, into the overall national energy composition to address this need. Utilizing biomass as a sustainable energy source has the potential to reduce our dependence on non-renewable fossil fuels and reduce carbon emissions. In addition, biomass co-firing enables the utilization of industrial and agricultural waste, consistent with the circular economy's principles.

The introduction of circular economic strategies in biomass co-firing in Indonesia is a strategic measure consistent with numerous legal and geographical factors.[22] The renewable energy sector aligns perfectly with the principles of the circular economy, aiming to minimize waste and resource use by prolonging the life of products and promoting resource reuse, recycling, and recovery. The regulations governing biomass co-firing are based on Government Regulation Number 70 of 2009 requires actions to enhance energy efficiency and reduce greenhouse gas emissions, with a specific emphasis on implementing biomass co-firing technology in power facilities.[6] Additional policies that encourage the utilization of biomass co-firing include Minister of Energy and Mineral Resources Regulation No. 50 of 2017, which emphasizes the utilization of renewable energy sources for the supply of electric power. These regulations provide incentives and guidelines to promote the development and application of renewable energy. In addition, Presidential Regulation Number 97 of 2017, which preserves the National Policy and Strategy for Management of Household Waste and Similar Household Waste, underscores the concept of a circular economy by advocating for sustainable waste management practices, including the utilization of organic waste as a source of biomass for energy production. These policies establish a strong foundation for implementing circular economic strategies in biomass co-firing, thereby assuring the feasibility of our recommendations.

The circular economy policy in this project is carried out using a multifunctional business policy. The Paiton PLTU utilizes sawdust supplies from local collectors in the Probolinggo, Bondowoso, Jember, and Lumajang areas. PT PJB is also carrying out a pilot project by planting calliandra trees, which can be used as a source of biomass. For the incentive scheme, the Ministry of Energy and Mineral Resources supports PLN's efforts to seek opportunities for biomass utilization, and it is committed to collaborating with large biomass suppliers such as Perhutani and PTPN (PT Perkebunan Nusantara). The incentive scheme can take the form of efforts to maintain the sustainability of the supply of biomass raw materials while maintaining economic aspects so that electricity prices remain stable and affordable. The collaboration between PLN, Perhutani, and PTPN was marked by signing a Head of Agreement (HoA), which includes the provision and development of the biomass industry for co-firing. This program is expected to help reduce carbon emissions and open up new jobs and business opportunities in the biomass sector. The regulations and standardization that support this program are included in the national strategic direction and the new renewable energy (EBT) mix target of 23% by 2025. PLN has targeted the implementation of co-firing at 52 PLTU locations throughout Indonesia, with a biomass supply requirement of 9 million tons per

year by 2025. Collaboration with Perhutani and PTPN is carried out to ensure efficient biomass supply and increase economic value for the three BUMNs.

The policy of collecting and processing biomass in biomass co-firing projects involves many strategic steps. Firstly, incentives are provided to farmers and industries for the collection of biomass, namely plant residues and organic waste. at addition, a network of biomass collection centers is being established at strategic locations to facilitate this collection process. Investing in biomass processing technology for efficient fuel production is crucial in terms of processing. The development of local processing facilities is also carried out to reduce transportation costs and emissions generated.

The spatial planning implications and substantial benefits of adopting circular economy norms on biomass co-firing in Indonesia are significant.[23] Identifying optimal locations for these facilities is required due to the impact of land use for the collection, storage, and processing of biomass on spatial planning. It guarantees efficient distribution and reduces logistical expenditures. Additionally, the circular economy concept effectively mitigates waste accumulation in landfills by utilizing agricultural and industrial waste as biomass raw materials. This method could reduce the necessity for additional land for final disposal sites (TPA). The positive impact of circular economy regulations is underscored by the potential for efficient organic waste management in urban and rural areas to improve public health and environmental quality.

Infrastructure and technology are pivotal in supporting this policy. PLTU that adopt technological modifications for biomass co-firing will receive subsidies or fiscal incentives. We are continuously conducting research and development (R&D) to enhance the efficiency of biomass combustion. Optimizing the biomass supply chain through a circular approach helps to reduce distance and transportation costs. Additionally, the use of environmentally friendly vehicles supports more efficient biomass distribution. Regulations and incentives are crucial in ensuring the success of this policy.[24] We have implemented strict emission standards to ensure that biomass co-firing effectively reduces carbon emissions. Furthermore, certification and environmental audits are mandatory for companies involved in biomass co-firing. Economic incentives, such as tax credits, are provided to companies that use biomass as part of their fuel. Direct subsidies or soft financing are also available for projects that adopt biomass co-firing. Capacity building and education are integral components of this policy framework. We have organized a training program for the workforce in the energy sector to operate co-firing biomass technology. In addition, we are conducting a widespread campaign to raise public awareness about the economic benefits of the circular economy and biomass co-firing. We encourage the partnership between the government, private sector, and local communities to develop and execute biomass co-firing projects. International collaboration in biomass research and technology is also being strengthened. Strict monitoring and evaluation are conducted to measure the efficiency and environmental impact of biomass co-firing projects. We have implemented a strict monitoring system, and regular evaluations are conducted to assess the effectiveness of policies and make any necessary adjustments. Providing transparent reports to the public and stakeholders on the progress and challenges faced is also an important part of this policy. The social and economic impacts of this policy include the empowerment of the local economy and social sustainability. We aim to drive the development of the local economy by creating job opportunities in the biomass collection, processing, and distribution sector. Local industries are encouraged to participate in the biomass co-firing value chain. Moreover, this policy also aims to enhance the quality of life for the community by providing access to clean energy and ensuring economic stability.

The effective incorporation of renewable energy infrastructure, such as biomass co-firing facilities, into regional development plans is crucial for promoting sustainable growth. Efficient spatial planning plays a pivotal role in ensuring the seamless and long-term distribution of energy, thereby reducing transportation costs and mitigating environmental impacts. Moreover, embedding biomass co-firing within a circular economy framework can create job opportunities in the biomass industry, leading to enhanced local well-being and regional economic progress. It's important to prioritize the social and economic benefits of sustainable spatial design to ensure that surrounding communities also reap the rewards. Achieving synergy between the circular economy, energy policy, and spatial planning involves the development of a national roadmap, improved coordination among government agencies, community and industry stakeholder education, and providing incentives for renewable energy projects. Thoughtful spatial design is essential for efficient energy distribution and accommodating population growth, in line with human ecology theory, which emphasizes the connection between individuals and their environment for long-term sustainability. Efficient spatial planning has the potential to alleviate the adverse impacts of urbanization and enable equitable energy resource distribution.

The implementation of spatial planning policies involves a range of programs and initiatives aimed at enhancing energy infrastructure and promoting sustainability. One noteworthy example is the successful reduction of carbon emissions and improvement in energy efficiency achieved by integrating biomass co-firing technology into the construction of a PLTU. Factors such as the accessibility of electricity distribution networks and the availability of land for biomass storage are carefully taken into account during the project design phase. Efficient spatial planning plays a crucial role in seamlessly integrating renewable energy infrastructure, like biomass co-firing facilities, into regional development plans. This not only ensures long-term and effective energy distribution

but also minimizes transportation expenses and environmental impacts. Therefore, it is vital to integrate spatial planning policies with energy and demographic planning strategies to achieve sustainable development goals in Indonesia.

The Indonesian government has implemented numerous spatial planning regulations to meet the increasing energy demands and population growth.[25] The National Regional Spatial Planning Plan (RTRWN) is established by Government Regulation Number 26 of 2008 to ensure the sustainable use of space by considering economic, social, and environmental factors. Spatial planning policy is established by Law Number 26 of 2007, frequently referred to as the Spatial Planning Law.[23] This legislation requires that spatial planning maintain a fair and equitable distribution of resources while simultaneously achieving a harmonious balance between economic growth and environmental protection. Additionally, this regulation requires that the central and regional administrations work together to develop and implement spatial planning. Presidential Regulation Number 60 of 2020 on the National Strategic Area, Spatial Planning further emphasizes The necessity of integrating energy policy into the spatial planning process; legislation establishes criteria for developing critical regions across the country that promote the expansion of renewable energy sources, such as biomass co-firing.

B. Synergy between Demographic Planning, Energy Policy and Spatial Planning for Sustainability

Indonesia faces the crucial task of effectively managing its population growth, fulfilling its energy needs, and establishing sustainable spatial planning. The changes in population.[10] Indonesia should embrace the concept of sustainable development in order to effectively incorporate economic, social, and environmental aspects into spatial planning. The country is grappling with significant challenges from rapid population growth and extensive urbanization.

Attaining sustainable development goals hinges on integrating population planning, energy policy, and spatial planning. The country's energy mix needs to be revamped to meet the growing energy demands and include renewable sources like co-firing biomass.[22] In sustainable energy, biomass co-firing emerges as a vital solution, utilizing agricultural and industrial waste to generate electricity. It fulfills our energy needs and aligns with our efforts to decrease carbon emissions and promote a circular economy. However, the seamless execution of this initiative demands careful planning of physical infrastructure to ensure efficient energy distribution and the availability of biomass sources.

PT PLN, in partnership with Banyumas Regency Government (Pemkab) and PT Sinergi Energi Utama, is leading the charge in converting waste into biomass co-firing feedstock for PLTU. This collaboration, which exemplifies the harmonious efforts of different stakeholders, invites everyone to be part of Indonesia's energy transition. Converting waste into biomass presents an alternative use for the Integrated Waste Management Facility (TPST) in Banyumas, which currently transforms waste into valuable products like compost fertilizer, pavement, bricks, and plastic pellets. Beyond addressing urban waste issues, this transformation also contributes to emission reduction. This shift towards biomass aligns with the principles of a circular economy, where waste is repurposed into diverse products and transformed into clean energy resources. The President and Director of PLN EPI envision this collaboration as an effective integration of waste management and resource utilization, steering towards a sustainable biomass-based approach. Thus, this effort will support regional development, enhance community welfare, and preserve environmental sustainability. The President Director of PT Sinergi Energi Utama, is also committed to ensuring the success of this green collaboration. The party, acting as the waste offtaker in Banyumas, is ready to carry out further processing to ensure that the waste pulp meets the biomass requirements for co-firing in the power plant.[26]

A well-planned arrangement ensures the integration of renewable energy infrastructure, such as biomass co-firing facilities, into regional development plans. It is essential for equitable energy distribution and reducing logistical expenses and environmental damage. However, the Job Creation Law modifications present substantial challenges to Indonesia's spatial planning strategy. To expedite economic development and investment, the Job Creation Law significantly revised Law No. 26 of 2007 on Spatial Planning. The essential modifications include eradicating space utilization permits, restructuring the spatial planning framework, consolidating permissions and organizations, and obscuring the connection between Strategic Environmental Studies (KLHS) and Detailed Spatial Planning (RDTR). In addition, the Job Creation Law reduces the degree of community involvement in the spatial planning process and eliminates the requirement for a minimal forest area of 30%.[25] It's crucial to thoroughly review and adjust spatial planning laws in line with sustainable development principles to safeguard the sustainability and anticipated advantages of investments in biomass co-firing and other renewable energy projects. This involves evaluating ecological sustainability and human safety. However, the key to addressing the challenges posed by urbanization and population expansion in a more environmentally friendly and sustainable manner lies in the formulation of a comprehensive national roadmap. This roadmap should seamlessly integrate population planning, energy policy, and spatial planning, and it should be formulated by the government.

These modifications carry significant implications for physical space management and environmental preservation. Access to sustainable biomass sources, like agricultural waste or well-managed plantations, is vital for communal biomass burning. However, to ensure that spatial policies and planning effectively support the use

of renewable energy, it is crucial to improve cooperation between different government departments. Achieving sustainability requires providing financial aid, incentives for biomass co-firing projects, and education and training for industry players and the community. Indonesia has the potential to address the challenges posed by population growth and urbanization by coordinating demographic planning, energy policy, and spatial planning effectively. This approach will also help shift towards renewable energy sources and promote environmental sustainability. To ensure that the advantages of the circular economy and biomass co-burning reach all members of society and to support the principles of sustainable development, it is essential to assess and adjust the spatial planning changes brought about by the Job Creation Law.

However, removing the 30% forest area minimum requirement and weakening the connection between Strategic Environmental Assessments (SEAs) and Regional and Territorial Development Plans (RDTRs) have heightened the threats to forest ecosystems, which are crucial for biomass supply.[27] Moreover, the licensing process for communal biomass-burning projects, which necessitates coordination across various sectors and government levels, can be complex due to the concentration of licensees and agencies. More community involvement in spatial planning processes is necessary to ensure the efficient monitoring and administration of these initiatives. Community engagement is essential to mitigate adverse impacts on the environment and local populations. With the transition from procedural to substantive crimes and limited access to legal channels, enforcing spatial planning violations has become increasingly challenging, posing potential risks to the long-term sustainability of renewable energy initiatives. Indonesia can effectively tackle the challenges posed by urbanization and population expansion in a more environmentally friendly and sustainable way by implementing a comprehensive strategy that integrates demographic planning, energy policy, and spatial planning. Evaluating the impact of regulatory changes, such as those implemented by the Job Creation Law, is essential to ensure that the benefits of renewable energy are accessible to all members of society while safeguarding the environment.

V. CONCLUSION

Indonesia faces significant challenges as a result of rapid population growth and urbanization. This demographic shift profoundly impacts energy policy and spatial planning, increasing energy demand for public services, transportation, and accommodation. Efficient spatial planning is essential to support effective and efficient energy distribution and to reduce logistics costs, including identifying ideal locations for biomass co-burning facilities. Depending solely on unsustainable coal energy sources is not a feasible option. Hence, there is an urgent need to explore new, more sustainable energy alternatives, such as biomass co-firing. The successful adoption of biomass co-firing at PLTU Paiton, utilizing sawdust from local collectors and calliandra trees as biomass sources, exemplifies this strategic approach. The collaboration between PT PLN, Banyumas Regency Government, and PT Sinergi Energi Utama in converting waste into biomass fuel shows strong stakeholder synergy. However, changes to the Job Creation Law, which eliminates space utilization permits and reduces community involvement in spatial planning, pose new challenges. Effective waste management and community participation are essential to ensure the long-term sustainability of biomass co-burning initiatives. By adopting an integrated strategy involving demographic planning, energy policy, and spatial planning, Indonesia can address the challenges of urbanization and population growth in a more sustainable and environmentally friendly way. It will create jobs opportunities, improve regional welfare, and encourage regional economic development.

REFERENCES

[1] Y. Li, X. Wang, A. Imran, M. U. Aslam, and U. Mehmood, “Analyzing the contribution of renewable energy and natural resources for sustainability in G-20 countries: How gross capital formation impacts ecological footprints,” *Heliyon*, vol. 9, no. 8, p. e18882, 2023, doi: https://doi.org/10.1016/j.heliyon.2023.e18882.

[2] O. J. Olujobi, U. E. Okorie, E. S. Olarinde, and A. D. Aina-Pelemo, “Legal responses to energy security and sustainability in Nigeria’s power sector amidst fossil fuel disruptions and low carbon energy transition,” *Heliyon*, vol. 9, no. 7, p. e17912, 2023, doi: https://doi.org/10.1016/j.heliyon.2023.e17912.

[3] L. A. Attílio, J. R. Faria, and E. C. D. Silva, “Countervailing impacts of fossil fuel production and exports of electrical goods on energy transitions and climate change,” *J. Clean. Prod.*, vol. 464, p. 142797, 2024, doi: https://doi.org/10.1016/j.jclepro.2024.142797.

[4] L. Karjoko, J. Santosa, and I. G. A. K. R. Handayani, “Disfungsi Peraturan Perundang-Undangan Tanggung Jawab Sosial Dan Lingkungan Di Indonesia,” *J. Huk. Ius Quia Iustum*, vol. 26, no. 2, pp. 305–325, 2019.

[5] R. M. Andrew, “A comparison of estimates of global carbon dioxide emissions from fossil carbon sources,” *Earth Syst. Sci. Data*, vol. 12, no. 2, pp. 1437–1465, 2020.

[6] N. H. Widowati and I. G. A. K. R. Handayani, “POLITIK HUKUM KEHUTANAN DALAM MEWUJUDKAN PEMBANGUNAN yANG BERKELANJUTAN,” in *Seminar Nasional & Call for Papers 2020*, p. 50.

[7] N. F. Estiyantara, “PENGATURAN PEMANFAATAN JASA LINGKUNGAN PANAS BUMI YANG

BERKEADILAN DALAM UPAYA MEWUJUDKAN TARGET NATIONALLY DETERMINED CONTRIBUTION (NDC) INDONESIA," 2024.

[8] P. C. Ogugua, H. Su, and E. Wang, "Synergistic blending of biomass, sewage sludge, and coal for enhanced bioenergy production: Exploring residue combinations and optimizing thermal conversion parameters," *J. Environ. Manage.*, vol. 352, p. 120035, 2024, doi: https://doi.org/10.1016/j.jenvman.2024.120035.

[9] A. K. Jaelani, R. D. Luthviati, M. J. Hayat, R. O. Kusumaningtyas, and F. N. Aini, "Indonesia carbon tax policy: A key role in sustainable development goals," in *AIP Conference Proceedings*, R. R., K. H., and R. I.R., Eds., American Institute of Physics, 2024. doi: 10.1063/5.0202042.

[10] G. Kudrna, T. Le, and J. Piggott, "Demographics, Labour Force, and Older People in Indonesia," *J. Popul. Ageing*, no. April, pp. 1–43, 2021, [Online]. Available: http://events.development.asia/system/files/materials/2021/09/202109-demographics-labor-force-and-older-people-indonesia-final-paper.pdf

[11] W. Li, Y. Zhang, M. Li, and Y. Long, "Rethinking the country-level percentage of population residing in urban area with a global harmonized urban definition," *iScience*, vol. 27, no. 6, p. 110125, 2024, doi: https://doi.org/10.1016/j.isci.2024.110125.

[12] A. Hidayat, "Melihat Lebih Dekat Pembangkit Besar PLTU Tanjung Jati B," *Https://Web.Pln.Co.Id/*. 2019. [Online]. Available: https://web.pln.co.id/cms/media/siaran-pers/2019/12/melihat-lebih-dekat-pembangkit-besar-pltu-tanjung-jati-b/

[13] E. Rostiana and A. Rodesbi, "Transisi Demografi dan Pertumbuhan Ekonomi Indonesia," *J. Econ.*, vol. 16, no. 1, pp. 1–17, 2020.

[14] G. Gozgor, C. K. M. Lau, and Z. Lu, "Energy consumption and economic growth: New evidence from the OECD countries," *Energy*, vol. 153, pp. 27–34, 2018, doi: https://doi.org/10.1016/j.energy.2018.03.158.

[15] E. Unat, "A review of Malthusian theory of population under the scope of human capital," *FORCE Focus Res. Contemp. Econ.*, vol. 1, no. 2, pp. 132–147, 2020.

[16] Kementerian ESDM, "Kementerian ESDM RI - Publication - National Energy Plan (RUEN)." 2021. [Online]. Available: https://www.esdm.go.id/assets/media/content/content-rencana-umum-energi-nasional-ruen.pdf

[17] "Kementerian ESDM RI - Media Center - Arsip Berita - Kementerian ESDM Terbitkan HEESI 2022." [Online]. Available: https://www.esdm.go.id/id/media-center/arsip-berita/kementerian-esdm-terbitkan-heesi-2022

[18] Ştefan C. Gherghina, M. A. Botezatu, A. Hosszu, and L. N. Simionescu, "Small and medium-sized enterprises (SMEs): The engine of economic growth through investments and innovation," *Sustainability*, vol. 12, no. 1, p. 347, 2020.

[19] T. B. Dewinagara, I. G. A. K. R. Handayani, and H. Purwadi, "The Omnibus Law Concept in the Job Creation Law and the Legal Consequences for Limited Liability Companies," *Sasi*, vol. 28, no. 2, p. 323, 2022, doi: 10.47268/sasi.v28i2.963.

[20] M. Pardede *et al.*, "Perspectives of sustainable development vs. law enforcement on damage, pollution and environmental conservation management in Indonesia," *J. Water Clim. Chang.*, vol. 14, no. 10, pp. 3770 – 3790, 2023, doi: 10.2166/wcc.2023.417.

[21] I. F. U. Muzayanah, H. H. Lean, D. Hartono, K. D. Indraswari, and R. Partama, "Population density and energy consumption: A study in Indonesian provinces," *Heliyon*, vol. 8, no. 9, 2022.

[22] M. Hiloidhari, M. A. Sharno, D. C. Baruah, and A. N. Bezbaruah, "Green and sustainable biomass supply chain for environmental, social and economic benefits," *Biomass and Bioenergy*, vol. 175, p. 106893, 2023, doi: https://doi.org/10.1016/j.biombioe.2023.106893.

[23] A. Wibawa and L. Karjoko, "Realizing World-Standard's Spatial Planning and Land Management: The Urgency of Bureaucratic Reform," in *International Conference On Law, Economic & Good Governance (IC-LAW 2023)*, 2024, pp. 346–353.

[24] W. D. Febrian and A. Solihin, "Edukasi Ekonomi Sirkular: Solusi Pengelolaan Sampah Yang Ramah Lingkungan Dan Berdayaguna," *J. Pengabdi. Masy. Dan Penelit. Terap.*, vol. 2, no. 2, pp. 50–56, 2024.

[25] I. G. A. K. R. Handayani, L. Karjoko, and others, "Space Planning Oriented Toward the Realization of Sustainable Food Agriculture Land in Banyumas Regency," in *International Conference on Law, Economics and Health (ICLEH 2020)*, 2020, pp. 741–747.

[26] "PLN Gandeng Pemkab Banyumas Manfaatkan Sampah untuk Co-firing PLTU - Nasional Tempo."

[27] I. Rosidawati, "Kebijakan Penanganan Lingkungan Hidup Dalam Penyelenggaraan Tata Ruang Pasca Lahirnya Undang-Undang Nomor 11 Tahun 2020 Tentang Cipta Kerja," *Wacana Paramarta J. Ilmu Huk.*, vol. 21, no. 4, pp. 1–9, 2022.