Catalyzing Indonesia's Clean Energy Transition: Assessing the Best-Fit For Nusantara's Capital City Future Energy Needs and Social- Economy Prospects

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Abstract. Indonesia is constructing a new capital in the eastern part of Kalimantan. The new capital, Nusantara, will host almost two million inhabitants, leading to very high energy demands. Kalimantan is known for its big coal reserves that will be converted to become Indonesia's main energy supply, including Nusantara. The literature review explained that solar panel is the best fit for local renewable energy, estimating a 170.431 Megawatt peak in 340.864 hectares areas in the surrounding capital using AHP. Followed by Kayan Hydro- electric power that will reach up to 9000 Megawatt once the project is complete. Thus, this renewable energy supply will all Kalimantan. In conclusion, considering all socio and economic aspects such as accessibility and future investment, solar panels shows the most cantered community-renewable energy that could be implemented.

Keywords: Renewable Energy, Decarbonisation, Clean Energy, IKN, Social Impact, Economy Prospect.

1 Introduction

In 2022, Indonesia unveiled its plan to develop a new capital city, Nusantara, which will be located in East Kalimantan between the regencies of Kutai Kartanegara and North Penajam Paser also cities of Balikpapan and Samarinda. The new capital will span a total area of 256,142 hectares of land and 68,189 hectares of water and will transform the eastern part of Kalimantan into a megacity (Oentoeng Suria, 2022) [1]. Like developing a new area, the government must ensure the energy needs for the future megacity, Nusantara. Estimating 1,5 GW of the electric city needed for the new capital. A massive amount of energy has the consequence of developing a power plant to light up the new capital city. As we know, Indonesia, especially Kalimantan, has the biggest coal reserve in the world, and 61% of Indonesia’s energy supply comes from coal power plants, increasing until 2027 (Climate Action Tracker, 2020 [2].

In 2015, the United Nations held an international climate change conference in Paris. The conference resulted in an agreement signed by 195 state parties to tackle climate change through decarbonization (UNTC, 2015)[3]. Indonesia was among the signatories and committed to becoming a net zero emissions state party by 2060 or earlier.

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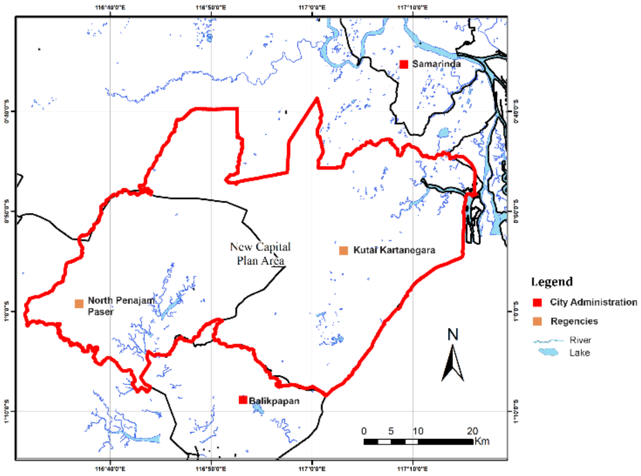

Fig. 1. Maps of the new capital area with surrounding cities and regencies (Basemap of administrative from RBI (tanahair.go.id).

As shown in **Figure 1**, the area of Nusatara is located in between an energy and non-renewable resource mining of Kalimantan, Indonesia. However, Indonesia is facing a major challenge in transitioning from coal energy to sustainable renewable energy due to the fact that most of its energy supply is still derived from coal. Indonesia has abundant renewable energy resources to support this mission: geothermal energy, hydropower, solar panels, wind energy, and biomass. These would become the biggest energy supply in decades to come. The new capital city has the potential to set an example for Indonesia's commitment to decarbonization, in line with the Paris 2015 agreement. However, the government must choose the most suitable local renewable energy sources to support this mission. In the future, it is essential that local renewable energy sources make up the majority of the energy supply.

The global transition to renewable energy sources represents a pivotal shift in our approach to energy production, one that extends far beyond the environmental benefits. The socio-economic implications of this transition have captured the attention of scholars and policymakers alike. At the heart of this transformation is the role of green investments, which play a critical role in propelling the renewable energy sector forward and shaping its impact on communities and economies. This paper delves into the intricate relationship between renewable energy and socio-economic development, particularly in the context of community-based initiatives, drawing on both empirical evidence and foundational theories that predate 2016.

The socio-economic implications of renewable energy deployment are multifaceted. The shift toward cleaner and more sustainable energy sources has the potential to create jobs, drive economic growth, and reduce income inequality. Scholars such as Jacobson and Delucchi (2011) in their ground-breaking work have argued that the widespread adoption of renewable energy can lead to a net increase in employment, stimulating local economies and providing employment opportunities in both urban and rural areas. Furthermore, the energy transition can enhance energy security, reduce energy-related health costs, and contribute to a more equitable distribution of resources [4]. These socio-economic aspects have drawn the attention of green investors, who recognize the financial potential in supporting renewable energy projects.

The role of green investments in community-based renewable energy projects is particularly noteworthy. Community renewable energy initiatives empower local residents to take an active part in the energy transition while benefiting economically. As outlined in the "Community-Based Energy Development: The Role of Green Investment" by Smith et al. (2015), green investments in community projects can lead to a more equitable distribution of renewable energy benefits. These investments are vital for overcoming the financial barriers that communities often face when attempting to establish renewable energy projects. This paper will explore how these investments enable communities to reduce their carbon footprint, lower energy costs, and stimulate economic growth, thus addressing socio-economic disparities at the local level.

2 Methodology

2.1 Literature Review

Sutistojo (2020), as cited by Vries and Schrey (2022)[5], estimates the energy needs of 1.5 million inhabitants in the new capital city to be 1,555 MW. This amount is nearly half of the geothermal energy utilized throughout Indonesia (Think Geo Energy, 2023). As part of the master plan for the new megacity, 80 percent of the energy requirements will be sourced from a mix of renewable energy (Isabela, 2023) [6].

The identification of suitable renewable energy sources surrounding the new capital city is initiated by comparing the output potential from previous studies, such as the work of Kresnawan et al. (2018), who assessed the renewable energy potential in East Kalimantan. In their research, Kresnawan et al. (2018) highlighted that solar panels represent the most promising energy source among all available renewable sources in East Kalimantan. This is consistent with the findings of Vries and Schrey (2022)[5], who emphasized that solar panels have more prospects compared to wind energy. Additionally, hydroelectric power, which is already in use in Indonesia, is being developed in the Kayan River in North Kalimantan. Four power plants are planned for the future, potentially supplying clean energy to the new capital.

Apart from solar panels, the new capital also plans to meet its energy needs through hydroelectric power sourced from the Kayan River in North Kalimantan Province. An estimated flow of 1,000 cubic meters of water is expected to yield a maximum output of 1,000 MW. The development of this ambitious project by PT. Kayan Hydro Energy (KHE) is divided into five phases, with a maximum output reaching 9,000 MW (Power Technology, 2023). However, this maximum output is not solely intended for supplying the new capital city but also the surrounding areas of the project and the entire Kalimantan region (Vayed, 2022)[7]. The total expected cost of the project is 17 billion USD (Nikkei Asia, 2022)[8]

2.2 Analytical Hierarchy Process (AHP)

Saaty (1999) describes making a decision using priorities from a few available criteria, and this process is then called by Analytical Hierarchy Process (AHP)[9]. It is essential to create specific criteria to make the best solution to an obstacle that some researchers face. In this paper, AHP will help to estimate the maximum solar panel prospects in the research area. To conduct the process, this paper uses the digital elevation model and land use data of Kutai Kartanegara

Regencies, North Penajam Paser Regencies, Balikpapan City, and Samarinda City from the Indonesia Geospatial Agency.

Three essential criteria are Slope using Karnawati (2006) classification, land use, and body of water[10]. After discussing with experts in the relevant field, the scoring is shown in Table 1.

Table 1: Scoring main criteria with slope is top priority followed by land use and body of water.

Criteria	Slope	Land use	Body of water
Slope	1,00	1,50	3,00
Land-use	0,67	1,00	2,00
Body of water	0,33	0,50	1,00
Total	2,00	3,00	6,00

After getting the scoring shown in Table 1, it has a consistency ratio of 0,0014 or acceptable. However, **Figure 2** shows land use in the surrounding new capital plan area, such as agriculture, urban areas, mining, and forest. As shown in Table 2, it has its sub-criteria with its own scoring and consistency ratio of 0,0476 or acceptable.

Table 2: Scoring land-use sub-criteria with agriculture is top priority followers by urban, mining, and forest.

Land-use	Agriculture	Urban	Mining	Forest
Agriculture	1,00	2,00	2,00	4,00
Urban	0,75	1,00	1,50	3,00
Mining	0,50	0,67	1,00	2,00
Forest	0,25	0,33	0,50	1,00
Total	2,50	4,00	5,00	10,00

In this research, the urban area does not distinguish between areas with constructed and area not constructed buildings. Thus, the limitations of this research is not use current data about how much a free area that is available for solar panels development.

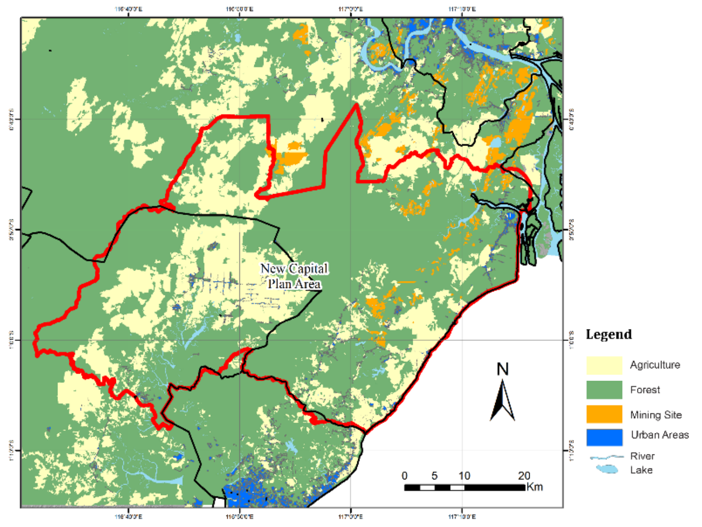

Fig. 2. Land-use in the surrounding capital with river and lakes (Basemap of land-use from RBI (tanahair.go.id).

Land use data that shown in **Figure 2** are based on Peta Rupa Bumi Indonesia by Indonesia Spatial Agency. As shown in Table 3, slope analysis using spatial analysis shown in **Figure 3** also had its scoring with a consistency ratio is 0,0014 or acceptable. As shown in Table 4, the body of water shown in **Figure 2**, including river and lake, also had its scoring without using AHP due to only two options, where a lake is the best place rather than a river.

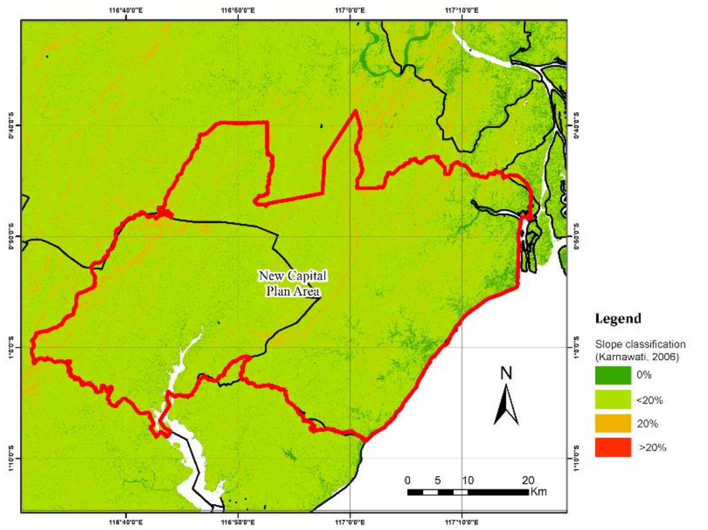

Fig. 3. slope in the surrounding capital (Karnawati, 2005) (Basemap of hillshade from DEMNAS (tanahair.go.id).

To find the result, all of the data that has already been processed to AHP, shown in **Figure 4** a final result using union spatial analysis method. Areas with the green mark are the high prospect for developing solar panels in the surrounding new capital. The area is reaching up to 170.431 ha.

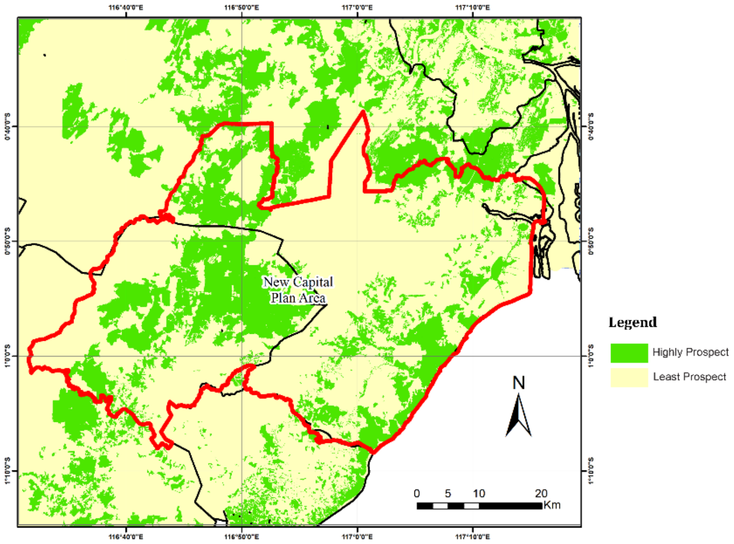

Fig. 4. Highly prospect area that shown in green mark that reaching up into 170.431 hectares.

2.3 Conversion Output & Capital Cost

Converting from solar panels areas prospect to maximum energy output is using open source application in Phovo Voltaic (photovoltaic-software.com). To measure maximum output is use a formula as shown below:

$$E = A.r.H.PR \tag{1}$$

With:

E = Maximum Energy Output (Kw)
A = Areas (meter square)
r = Solar pane yield (2% with disturbance from dusk, etc)
H = Annual irradiance not shading include (1900 kWh/meter square in Kalimantan)
PR = Performance Ratio (0,75 default)

As a result, estimated 340.864 megawatts peak (MwP) from 170.431 hectares highly prospect area in surround the new capital city. The capital cost for developing solar panels in Indonesia is higher than in Europe and China, ranging from 700 - 1200 USD per 90 Kw (IESR, 2019). In summary, the capital cost to develop solar panels in the surrounding new capital ranges from 2,6 Million - 4.5 Million USD.

3 Discussion

3.1 Local Renewable Energy Mix and Decarbonisation

Projected to be a megacity with 1.5 Million inhabitants, the new capital must ensure energy needs reach up to 1.555 Mw. As a grand master plan, 80 percent of the energy needs will come from a renewable energy mix. As an area that is located in the equator zone, solar panels are the best fit for renewable energy that has a 340.864 megawatts peak (MwP) from 170.431 hectares areas. Followed by hydroelectric power that came from Kayan Hydroenergy in North Kalimantan. The project will have maximum output in coming years, reaching 9.000 Megawatt, and this hydropower plant will become the main supply for the capital. Thus, it is also for the rest of Kalimantan.

Finding the best fit for renewable energy mix supply is the main action to show to the world that Indonesia will take serious action to commit to zero emissions by 2060 (IEA, 2022)[8]. Even with 20 percent energy needs came from coal that is already under carbon capture storage (CCS) and carbon capture utilization Storage (CCUS) policy based on Indonesia's Energy Secretary Policy (Peraturan Kementrian ESDM No, 2 Tahun 2023). Other action to support the 2060 mission is using an electrical vehicle to reduce more carbon emission.

3.2 Social Economic Impact

In the digital and industrial era, renewable energy is such a luxury thing for developing country such as Indonesia. The socio-economic aspects of renewable energy transcend the environmental realm and are crucial for understanding its overall impact. Renewable energy not only helps reduce greenhouse gas emissions but also has substantial socio-economic benefits. Central to this discussion is the role of green investments. Green investments are essential in propelling the renewable energy sector forward and play a pivotal role in shaping the socio-economic landscape of the communities involved. These investments facilitate the development of renewable energy projects, creating job opportunities and stimulating economic growth. A seminal work by Jacobson and Delucchi (2011) [4] underlines the potential net increase in employment as renewable energy is adopted on a broader scale. By referencing their findings, we can appreciate how green investments can be a driving force behind socio-economic growth.

Understanding the socio-economic impact of renewable energy necessitates the consideration of relevant social indicators. These indicators include factors such as job creation, income distribution, and access to clean energy. To assess income inequality, we will introduce the Gini index, a widely recognized tool. By analyzing the fluctuations of the Gini index in regions with renewable energy projects, we can gauge the effects on income distribution and equality. Empirical studies, such as those conducted by Smith et al. (2015) and Dincer and Acar (2011)[9], offer valuable insights into how the adoption of renewable energy can positively influence these social indicators. This section will provide a foundation for understanding the broader socio-economic context of renewable energy projects.

Turning our attention to regional conditions, we will explore the current state of renewable energy adoption in Borneo. Borneo's unique geographic and socio-economic conditions make it an interesting case study for understanding the challenges and opportunities of renewable energy projects. Additionally, we will consider the Afghanistan Journal's previous year's research, which offers a hypothesis on the potential for renewable energy, especially solar panels, to fulfill the energy needs of Afghanistan. Drawing on this research, we can evaluate the feasibility and socio-economic impact of solar panels projects in regions facing distinct challenges, further enriching our understanding of renewable energy's diverse applications.

Private equity and venture capital are playing increasingly significant roles in Indonesian renewable energy development. These investments have the potential to bridge the capital margins that often hinder the growth of the renewable energy sector. By examining case studies and financial data, we will gain insights into how private equity and venture capital contribute to the expansion of renewable energy projects. Reference to specific projects and their outcomes can illustrate the possibilities for further investments in the renewable energy landscape. This section will provide a clear picture of the financial side of socio-economic growth in renewable energy.

Understanding the evolving landscape of renewable energy investments in Indonesia is critical. Since 2016, there have been noticeable shifts in investment patterns within the renewable energy sector. This section will delve into these trends, identifying changes in funding sources and project types. Moreover, the investigation the allocation of funds for Community Renewable Energy (CRE) projects within the state budget (APBN) proven that the proportion of funding for CRE projects in the APBN provides an insight into the government's commitment to supporting community-based initiatives. By analyzing these trends and budget allocations, we can evaluate the trajectory of socio-economic development through renewable energy in Indonesia.

The research findings regarding the social and economic impacts of renewable energy-based rural electrification programs in Afganishtan provide valuable insights into the extent to which these initiatives improved recipient communities. At the community level, it becomes evident that Community Renewable Energy (CRE) projects led to "modest improvements" in various aspects, with significant variations in different areas.

Social benefits were notable, as approximately 45.5% of the survey participants acknowledged the development that CREs brought to their communities. Particularly noteworthy were improvements in social services, where 59% of participants agreed that health services saw a positive transformation. This outcome was primarily attributed to the provision of backup solar power stations in clinics, enhancing healthcare services and accessibility, which significantly contributed to the overall welfare of the communities. Furthermore, education services (57.5%) and government services (50%) also demonstrated notable enhancements, underscoring the role of renewable energy in improving access to essential public services (Shohib, 2022) [10].

In terms of economic indicators, the research identified areas where improvements were less pronounced. Job creation (38%) and the establishment of enterprises (32%) showed relatively lower levels of development. This was mainly due to the primary use of the electricity generated by renewable energy systems for lighting and household appliances. Importantly, the research revealed that none of the communities utilized this electricity for industrial purposes. The limited electricity production capacity and high household demand for electricity were identified as the main constraints on using electricity for productive activities, highlighting a key limitation of the CRE projects in enhancing economic benefits. This particular research findings by literature has been provide a projections about future social and economy impact for locals in IKN. There’s a lot of things that needed to be consider as our policy maker need to count to make a progressive energy transition for IKN in the future holds.

4 Conclusions

Best fit local renewable energy in the new capital region are solar panels and hydroelectric power. This clean energy could ensure the new capital needs in the near future and as an act of Indonesia 2060 net zero emission. In conclusion, economic models and growth projections will be referenced to show how solar panels and hydroelectric power maximize economic development. The adoption of solar panels not only reduces carbon emissions but also contributes to job creation and reduced energy costs. This section will provide a comprehensive understanding of how socio-economic benefits will be realized at the local community level and on a national scale through the widespread adoption of solar panels. The socio-economic development achieved through solar panel adoption will be a pivotal factor in fulfilling future energy needs as outlined in Indonesia's IKN. The absence of industrial applications and the inherent limitations in electricity production capacity have hindered the full realization of the economic potential of these renewable energy initiatives. These insights underscore the need for more comprehensive planning and strategies to maximize both social and economic benefits in future rural electrification programs.

Best fit local renewable energy in the new capital region are solar panels and hydroelectric power while economic models and growth projections will be referenced to show how solar panels and hydroelectric power maximize economic development.

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