Materiality and Just Energy Transition in Indonesia

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Abstract. Climate change has driven the birth of the energy transition. However, several obstacles during the transition, such as high costs, technological limitations and societal resistance, result in big questions regarding how the energy transition should be carried out. The energy transition debate involves many issues, including governance, economic diversification, social dialogue, social protection, funding and skills development, which are essential aspects of a just energy transition. In the debate regarding a just energy transition, no one has considered the contribution of a country's domestic conditions, such as geography, network interconnection and energy mix. The research, which uses qualitative research methods based on documents and interviews, proposes the concept of energy materiality to see a just energy transition. Energy materiality requires consideration of transition through the Geographical Distribution of energy sources, Contribution to the National Energy Mix and Interconnection of Electricity Networks between islands.

Keywords: just energy transition, energy materiality, geography of energy sources, network interconnection, energy mix.

1 Introduction

The 2015 Paris Agreement is the first global sustainable development agreement considering environmental issues. Commitment to the Paris Agreement gave birth to an energy transition trend in three main directions: reducing the cost of renewable technology. If the costs of renewable technologies such as solar panels and wind turbines have fallen drastically, electricity from renewable energy sources has become cheaper than fossil-based electricity. The situation would be a more economical choice. Second, technology in the electricity sector. If electricity can be used more efficiently through advanced technology, many energy options can be explored and utilized efficiently. Third, the commitment to reduce global warming to 1.5°C by 2050 is the primary driver of a transition based on renewable energy sources and efficient technology.

Unfortunately, the energy transition brings consequences that are not always positive. Ocelík, Lehotský, and Černoch noted that as the energy transition continues, society's rejection of various energy developments is increasingly widespread for various reasons. Several studies have found that public objections to energy transition projects tend to be caused by land ownership issues [1], health problems [2], environmental problems [3],[4], financial problems [1], issues of public access and decision making [5] as well as problems of coordination between institutions [6].

Community mobilization, protest and social opposition are important not only because they reflect democratic ideals but also because they impact energy security, loss of income or violence. In Australia and the UK, for example, saboteurs have forced coal-fired power plants to shut down unexpectedly or forced the closure of coal and liquefied natural gas export terminals. In Brazil, hundreds of women occupied an industrial sugar factory to protest their

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position on gender and labor practices related to ethanol and biomass cogeneration, an action that resulted in the shutdown of operations for weeks; in China's Guangdong province, police killed as many as twenty people for protesting the lack of land compensation for a local wind power plant [7].

The problems and opposition that emerged towards the energy transition project led to a 'just energy transition' concept. The term 'just transition' was initially developed by trade unions in North America to discuss how to help workers deal with the change from a high-carbon to a low-carbon economy and climate change. This concept was first proposed by US labour and environmental activist Tony Mazzocchi, due to the American government's policy of closing several industries because they pollute the environment. The US government provided significant funds to clean up polluted areas but did not provide compensation funds for workers in closed industries. The union put forward a just transition proposal in which they agreed to factories being closed. However, the government provides funds for salaries, retraining former workers and developing alternative industries to replace the closed ones [8].

The 'Just transition' concept then developed, and the global community adopted the just transition principle into the global climate change mitigation agenda by reducing fossil energy, especially coal. At the global level, a just transition refers to sharing costs and losses arising from the energy transition between advanced industrial and developing countries. Mitigating climate change through decarbonization requires reducing fossil energy, especially oil and coal. At the domestic level, a just transition involves more complex aspects. Schröder argues that a just transition is vital from an ethical point of view and ensures the sustainability of the transition process itself. Indonesian civil society proposed that a just energy transition must fulfil the principles of accountability and participation, respect for human rights, environmental justice and transformative economics. Meanwhile KMPG [9]e proposed eight fundamental principles for a just energy transition. Three of them are (1) sustainable, consistent and ambitious; comprehensive, transparent and inclusive; (2) involving stakeholders; paying attention to environmental justice; and (3) access to justice, policy- making and information.

The study of the transition process places great emphasis on technical aspects. The shift from carbon-intensive to low-carbon energy is only seen as a technological change. Even though energy involves complex social, cultural, economic and political systems, implementing a just transition must consider the various barriers to transition that differ based on geographic, political and economic locality. Zinecker et al. emphasize the need for political and economic analysis to map the configuration of actors that support or reject the energy transition. A just transition process must consider the role of actors with the power to make energy policy. Apart from actors, the absence of a universal definition or framework regarding a just transition can also hinder the process of a just energy transition [10]. Sekaringtias, Verrier, and Cronin argue that conflicts of interest, constantly changing regulations, and low implementation capacity hinder a just energy transition process. Therefore, an independent energy institution and local participation are needed to drive an inclusive transition process.

[11] argue that a just energy transition must (1) be flexible to social complexity and change, (2) pay attention to access barriers for low-income groups, (3) pay attention to the rights of local communities. Community-based participatory approach, (4) Guarantee quality jobs and human resources through education and health; (5) Consistent, long-term collaboration between stakeholders, especially workers. Meanwhile, Mauger sees that a just energy transition must involve energy communities[12].

From studies regarding a just transition, differences in geographical conditions and state capabilities have yet to be considered. Meanwhile, these conditions sometimes differ for every country implementing an energy transition project. This article looks at a just transition by placing resource distribution, generator locations and energy supply networks as the foundation of a just energy transition [13].

2 Research Methods

This study uses Indonesia as a case study. The decarbonization policy through the plan to close coal plants by 2030 has a broad impact, considering the high dependence on coal plants. Three types of energy that can replace coal are solar power, geothermal power and large-scale hydropower [14]. Therefore, these three types of renewable energy will be used to analyze the influence of energy materiality on a just transition. Distribution of source locations, consumption and networks are two dimensions of materiality that influence just transitions. Meanwhile, fair access to cheap and affordable energy is the justice dimension of the transition process to be analyzed [15].

This study uses a qualitative approach. The relationship between materiality and just transition is analyzed descriptively. The explanation of materiality focuses on (1) the location of coal, hydro, geothermal, and solar energy sources. (3) The level of consumption reflected in the position of the three types of energy in the national energy mix; (3) The relationship aspect relates to the electricity connection infrastructure network between islands. Three dimensions of materiality are positioned as independent variables that influence the transition process in the future[16].

A combination of in-depth interviews and literature review is the data source for this study. Interviews were conducted with key staff at state-owned coal companies, energy experts from the National Research Agency, the Oil and Gas Daily Management Agency and the Directorate of New Energy and Energy Conservation of the Ministry of Energy and Mineral Resources of the Republic of Indonesia. Secondary sources come from literature reviews, government documents such as the strategic plan of the Ministry of Energy and Mineral Resources, studies by international institutions on Indonesia's energy conditions, national energy council reports, journal articles related to just transition, and print and online media news about energy transition. Indonesia.

2.1 Theoretical Framework.

Energy, defined as power that can move something else, is an abstract concept. Society uses this terminology to represent various types of primary and secondary energy that drive daily human activities. While the term energy abstracts various sources of energy, the concept of materiality designates the material dimensions of various types of energy.

In Bille ideas, Materiality is the relationship and process between humans and objects. Materiality is different from material culture. The second concerns the duality of understanding the material dimensions of culture and the cultural dimensions of material objects. Agricultural culture produces rice field patterns and the technology used. On the other hand, the type of technology and changes in its use produce different agricultural cultures. Meanwhile, according to Robert Preucel, Materiality is the social formation of oneself and society through various objects around [17]. Petroleum production installations are means of transportation that depend on petroleum, produce unique social structures and are formed by oil energy materials.

Energy materiality contains the physical dimensions of energy production, distribution and consumption and the social dimensions of these three aspects. The form can be the distribution of energy sources such as coal mines, oil wells, gas sources, rivers, reservoirs and hydropower plants. Another dimension is the transmission network and infrastructure. Modern energy systems have separated the physical dimensions of energy from human consciousness. In the past, the experience of consuming energy in the form of firewood, heat, fire, animal power or wind made humans closely related to physical forms of energy. Modern humans have lost physical awareness of energy because energy consumption is mediated by network infrastructure between energy sources and human users. The impact is a separation between the origin of energy and its final use in daily activities. This process causes energy to lose material dimensions and become more abstractly understood [18]. Therefore, Pierce and Paulos argue that material progress in the last century has brought consequences in the form of "*energy invisibility and energy unawareness*".

A cross-disciplinary study by Balmaceda et al. [19] found that energy materiality has four interrelated dimensions. The four are material location, energy use, relational characteristics and analytical function of energy materiality. Location aspects relate to energy sources, production infrastructure, distribution and energy consumption. In the use dimension, energy materiality includes access and barriers to use by whom, competing agendas and how various forms of political power operate within it. The relational dimension refers to a chain of energy objects related to each other spatially, temporally, historically, and discursively involving material and non-material aspects. The analytical aspect of materiality relates to whether energy materiality is a causal factor and, therefore, an independent variable, impact or a dependent variable, or is an intermediate variable in explaining a series of actions or energy policies.

In the analytical function, the materiality of energy can be both an obstacle and a supporter of specific actions. As materiality, Pierce and Paulos put energy as (1) "material of design". Humans design all aspects of energy that bring it into existence; (2) "material that designs". The production, distribution and consumption of energy strongly influences human civilization. According to them, energy materiality includes collecting energy through energy generation or production activities, storing and maintaining the existence of energy, sharing energy through delivery and distribution, and energy activation, namely how humans use or consume energy.

Energy materiality has a strong influence on a just energy transition process. In this study, materiality is an independent variable that can speed up or slow the transition process. Three dimensions of energy materiality influence a just transition: (1) distribution of locations of coal and renewable energy sources. Coal energy sources are abundant and easily accessible at low cost. This condition causes the government's preference to make coal fuel the primary support for Indonesia's energy security. On the other hand, renewable energy sources that can replace coal, namely hydropower, solar power and geothermal energy, are spread across various islands. (2) This preference locks the Indonesian energy system into a coal-dominated energy consumption pattern. The immense contribution of coal in electricity generation and consumption requires replacement generators with ample capacity to fill the supply gap. (3) Replacing coal plants with renewable energy plants is faced with low interconnection of electricity networks between islands, within islands and networks that integrate various renewable energy plants. Please consider these three aspects of materiality to ensure a just energy transition process in Indonesia.

3 Results and Discussion

3.1 Geographical distribution of energy resources

Indonesia is one of the largest coal-producing countries in the world. Regarding sources, Indonesia's energy materiality is manifested in coal mining locations, which are rich but spread across various islands. Coal mining is concentrated on the large islands, Java, Sumatra, Kalimantan, Sulawesi and a small part of Papua. The Ministry of Mineral Resources report shows that in 2018, Indonesia had surface coal resources of 164.46 billion tons, while surface coal reserves were 37.87 billion tons. The amount of coal below the surface is 43.43.08 billion tons. Mines are spread across 1369 locations. Two islands, namely Kalimantan and Sumatra, are the most significant contributors. Kalimantan has proven coal resources of 45.04 billion tons, while Sumatra has 23.14 billion tons.

Indonesia has approximately 75,000 Megawatts of hydro power potential. This data comes from a study conducted by the state electricity company 2003.The latest study in 2020 found that the potential for hydro power with a run off river system was 94,627 M, spread across 52,566 locations throughout Indonesia.

Another source of energy that can replace coal plants is geothermal plants. The rich potential and ability to produce large amounts of electrical power has encouraged the Government to develop geothermal energy. Indonesia holds around 40% of the world's geothermal energy reserve. In 2020, the Government estimated a geothermal potential of 23.7 GW originating from 251 locations in Java, Sumatra and Sulawesi. Other islands such as Sulawesi, contribute geothermal resources under three Megawatts. Flores in Eastern Indonesia has been a small island rich in geothermal energy potential in recent years.

Rumbayan, Abudureyimu, and Nagasaka have predicted solar radiation in Indonesia every year using the Artificial Neural Network (ANN) method for 30 cities in Indonesia from January to December. This research found that Indonesia has a enormous and stable solar energy potential throughout the year with a radiation intensity of no less than 4 kWh/m2. The potential for solar energy is spread throughout Indonesia. Ten provinces have the highest solar energy potential. In first place is East Kalimantan with 1120.5 GigaWatt Peak (GWp), followed by West Kalimantan with 998.7 GWp, Central Kalimantan with 605.8 GWp, Papua with 579.5 GWp, South Sumatra with 441.1 GWp, East Nusa Tenggara with 338.6 GWP. The provinces of North Sumatra, Riau, Jambi and the islands of Bangka and Belitung have solar energy potential of under 300 GWp. [20]

Let us look at the distribution of renewable energy potential, which includes micro-hydro, geothermal and solar energy. Equitable development of energy sources has not yet occurred. Microhydro is still concentrated in Java, and geothermal energy in East Nusa Tenggara. Solar is relatively spread between East Nusa Tenggara and Sumatra. Considering its uneven distribution, the government has quite a lot of homework to explore more renewable energy potential in every region in Indonesia. The condition of the country, which is an archipelagic country, does not make the distribution process easy. Therefore, the imbalance in the distribution of energy sources could be a potential source of energy injustice in Indonesia.

3.2 Energy mix dominated by coal fuel.

Rich coal resources make the development of coal-based electricity easy. Generation costs are cheap because the type developed is a mine-mouth generator [21]. However, on the contrary, easy access to sources has pushed the Indonesian energy system into being locked into a system dominated by coal plants. In the long term, the transition process becomes difficult due to the investment that has been made, the technological chain, the production of knowledge supporting coal mining studies and potent interest groups (Mikulska 2019; Peimani 2018; Sekaringtias, Verrier, and Cronin 2023; World Bank 2022).

Table 2 shows that the composition of coal in the primary energy supply in Indonesia continues to increase from 29.55% in 2016 to 42.38% in 2022. In the same period, the contribution of renewable energy increased very slowly. In 2022, the percentage of renewable energy will only reach 12.30%. The growth in coal supply shows the gap between the rhetoric about transition and the practice of energy use in Indonesia.

The percentage of coal in final energy consumption has also increased, while natural gas and petroleum have decreased. In 2017, coal's contribution to final energy consumption was 7.3%, then jumped to 26.8% in 2022. Meanwhile, in the same period, the percentage of natural gas decreased from 11.54% to 6.7%. Fuel oil reduced from 42.95% to 23.76%.(Mininistry of Energy and Mineral Resources Republic Indonesia, 2023) The industrial sector also depends on coal energy, which is reflected in this sector's high consumption level. The use of coal and briquettes increased sharply from 65.291 million tons to 86.587 million tons in 2022%.[22](Mininistry of Energy and Mineral Resources Republic Indonesia, 2023) Coal in Indonesia still dominates the energy mix in Indonesia. Until 2021, the total share of coal in the national energy mix is 65.93%. In the same year, coal's contribution to generating electrical energy reached 50% of the total national electrical energy production, or 36,967 MW. (Direktorat Jenderal Tenaga Kelistrikan Kementerian ESDM, 2022)[23][24] .

The State Electricity Company reports that by 2021, there will be 162 hydro power plants, 72 micro hydro power plants and 12 mini hydro power plants [25](Kusnandar 2022). Most of the hydropower plants, namely 95 units, are on the island of Java. The remaining 67 units are spread across various locations outside Java (Reza, 2023). From a geographical balance point of view, Java, which has a smaller area, has a more significant number and scale of hydropower plants. Meanwhile, areas outside Java with a broader geographical expanse have smaller hydro plants. The concentration of hydro plants in Java is due to the more significant number of rivers, the need for greater electricity consumption due to population density, and industrial and commercial activities.

Despite its great potential, the contribution of hydropower to electricity generation is still low. Of the 94,476 MW of hydro energy potential in 2016, the installed capacity was only 5.3% or the equivalent of 5,025 MW (National Energy Board, 2016)[26]. In 2021, hydro power and micro hydro plants will only contribute 2,877.6 MW of electricity out of 44,857.2 MW of electricity consumption in Java and Bali. At the national level, new hydroelectric power plants reached 6,412.8 MW of the total installed electricity capacity of 73,735.7 MW (Direktorat Jenderal Ketenagalistrikan 2022)[23]

Geothermal utilization in Indonesia is only 4.5%. The RUEN Presidential Decree states that Indonesia's total potential is 17,546 MW and targets 7,200 MW in 2025. Unfortunately, currently, it is challenging to achieve, considering that the realization in 2022 is only 2,280 MW. The biggest problem in geothermal development is the risk of exploration, even though geothermal energy is perfect for supporting the energy transition program because it is base load, environmentally friendly and clean. Indonesia's geothermal potential and utilization are number two in the world. PLTP construction to date is 2,280 MW installed and operating in Indonesia, with a target of 18,000 MW by 2035.

Another renewable energy that also has excellent potential for development is solar power. Solar power is also expected to be critical in Indonesia's decarbonization efforts. According to the decarbonization study, solar power is expected to account for 88% of electricity generation by 2050, with around 1,500 GW, mostly utility-scale solar installations (80%), coupled with energy storage systems, inter-island connections and solar power plants. In the third quarter of 2022, 76.8 MWp of utility-scale solar power projects were installed, representing approximately 40% of Indonesia's total installed solar power capacity. However, in terms of electricity generation, utility-scale solar power accounted for only 0.04% of total grid-tied electricity generation in 2021 (excluding off-grid generation). The condition is still far from the deep decarbonization scenario that requires 24% of electricity generation to use solar power by 2030.

3.3 Fragmented network connections

3.3.1 Interconnection of electricity networks between islands

The transition requires replacing coal plants with reliable EBT plants. Three of them are large- scale hydropower, solar plants and geothermal plants. The problem of fairness of access in the transition is related to how electricity infrastructure, especially generators and networks, must be interconnected to ensure continued access to affordable and stable electricity. Interconnection allows areas with large capacity and stable renewable energy generation but with low electricity consumption to support areas with high and low electricity production. Interconnection between islands is necessary when the Indonesian government wants to close coal plants in 2050. Network interconnection is also needed to ensure access to electrical energy for communities in disadvantaged, underdeveloped and isolated areas. Concerning fairness of access, interconnection relates to three elements: interconnection of generators and networks between islands, interconnection of networks within islands and interconnection between types of generators.

Indonesia's electricity system still needs an inter-island network, especially between large islands. The result is that regions with surplus electricity production cannot meet the needs of regions with unstable electricity systems. For example, several islands in East Nusa Tenggara with diesel-based generating systems often experience blackouts due to excessive loads or generator damage. In this condition, Bali's electricity system cannot meet its needs because there is no electricity network between the islands. In Press Release No. 991.PR/STH.00.01/XII/2022, the State Electricity Company stated that it would build a Java and Bali electricity network with a power of 500 kilovolts. The electricity transmission circuit called the Java Bali Connection is targeted to be operational in 2022, connecting the electricity systems of Probolinggo Regency in East Java and Tabanan Regency in Bali. This interconnection between islands makes it possible for excess electricity in East Java to meet the increasing electricity needs of Bali Island due to the growth of the tourism industry.

In addition, the government will build a network between large islands called the Nusantara super grid. In press release Number: 059.Pers/04/SJI/2023, the Ministry of Energy and Mineral Resources stated that the super grid connecting the electricity systems of Java, Sumatra, Kalimantan, Sulawesi and Papua will be based on submarine cables [27]**.** This super network allows various EBT generators to be connected. Large renewable energy plants with electricity needs, such as Papua, can supply the electricity needs of Java and Sumatra. This inter-island connection can guarantee supply stability and fair access to electricity after the closure of coal plants—super grid construction costs between US$ 100 billion – US$ 150 billion. Amid ballooning debt and subsidies, providing this giant budget has become a problem the government faces.

3.3.2 Interconnection within the Island

Interconnection integration within the island needs to be improved. The PLN intra-island electricity network map shows that only the islands in western Indonesia have a broad and deep intra-island electricity penetration. The map is reflected in the density of the electricity network between provinces, districts, cities and villages in Java, Bali, Sumatra and Sulawesi. In eastern Indonesia, isolated, disadvantaged and underdeveloped communities must be integrated into the state electricity company's primary power grid. Thus, they rely on solar generation, which needs to be more cohesive, sustainable and small-scale. Increasing intra-island inter- coordination is necessary if the transition process continues to meet equitable energy access.

In the study in Flores, for example, the community wanted their electricity to be integrated into the country's electricity grid in the long term because it was more stable, safe and robust. High- power electricity helps them drive home industry and other economic activities. The current solar power plant is too small, namely 20 Watt Peak. This type is only for lighting at night, while the community requires more electrical power for economic activities, such as processing agricultural products. The closure of coal has forced the government to refocus on providing renewable energy for urban areas with dense populations and high industrial activity.

3.3.3 Interconnection between types of renewable energy generation

Without replacement generation and an interconnected grid, the energy transition will lead to inequality in access to electrical energy. The situation could bring Indonesia back to the late to early 2000s when there were periodic power outages. An interconnection network between renewable energy generators can overcome the problem of supply instability due to the intermittent nature of some renewable energy. For example, wind and solar energy are intermittent due to changes in weather, wind direction or cloud density. This condition is generally experienced by tropical countries such as Indonesia, where the sun shines all year round but with varying radiation levels based on region, season and weather. Likewise, the strength of wind energy is different between coastal and mountainous areas.

The energy transition process requires integration between power plants, such as solar and hydro or hydropower and geothermal power. Until now, all electricity areas combine electricity from fossil generators and renewable energy. Geothermal, hydropower, and solar power are the most significant contributors of renewable energy electricity in Java-Bali, Sumatra, Kalimantan and Sulawesi. In Sumatra, the combination of the three renewable energy generators above and other renewable energy generators accounts for 4,485 Megawatts of the total installed electricity capacity of 14,921.3 Megawatts. In varying amounts, renewable energy generation also strengthens the electricity supply system in Java, Kalimantan and other large islands.

In 2021, Indonesia had 5258 diesel power plants, 193 gas engine plants, 162 hydropower plants, 150 wind power plants, 126 coal plants, 72 micro hydropower plants, 18 geothermal power plants, and five other power plants [25]. The stability of electricity access requires the interconnection of various renewable energy generators to integrate inter-island and intra-island connections. So far, some renewable energy generation has been integrated through the State Electricity Company's electricity network. In the future, strengthening a just transition requires using smart grids to integrate various renewable energy plants, renewable energy and gas plants, and inter-island interconnection networks if all coal plants are to be closed.

4 Conclusions

The ambition of decarbonizing development by 2050 encourages Indonesia to carry out an energy transition by closing coal plants. A just transition process must pay attention to the balance between development needs and environmental sustainability, the balance of electricity access between cities and villages, and between Java and outside Java. Transitional justice must also not increase inequality in access to electricity between social classes and communities. Aspects of energy materiality, namely the distribution of source locations, levels of energy mix and consumption and network interconnection, can facilitate or hinder a just energy transition process. For this reason, the Indonesian government's energy transition policy must pay attention to these three aspects of energy materiality.

References

[1] S. Gross, "Renewables, Land Use, And Local Opposition In The United States." 2020. [Online].Available:https://www.brookings.edu/wp-content/uploads/2020/01/FP_20200113_renewables_land_use_local_opposition_gross.pdf.
[2] D. Eller, "Neighbors in Eastern Iowa Fight to Bring down Turbines — and Win," *Des Moines Regist.*,2018,[Online].Available:https://www.desmoinesregister.com/story/money/business/2018/11/21/iowa-first-wind-developers-ordered-tear-down-turbines-land-use-lawsuit-supreme-court/1922334002/.
[3] J. Fenston, "Georgetown Solar Farm Blocked Over Concerns About Forest Loss." 2019.
[4] S. Haikola and J. Anshelm, "Power Production and Environmental Opinions: Environmentally Motivated Resistance to Wind Power in Sweden," *Renew. Sustain. Energy Rev.*, vol. 57, 2016.
[5] E. Grift and E. Cuppen, "Beyond the Public in Controversies: A Systematic Review on Social Opposition and Renewable Energy Actors," *Energy Res. Soc. Sci.*, vol. 91, no. 102749, 2022.
[6] R. Bridle, "Missing the 23 Per Cent Target: Roadblocks to the Development of Renewable Energy in Indonesia." 2018.
[7] K. Abramsky, *Sparking a Worldwide Energy Revolution: Social Struggles in the Transition to a Post-Petrol World*. California, USA: AK Press, 2010.
[8] D. A. Gambhir, F. Green, and P. J. G. Pearson, "Towards a Just and Equitable Low-Carbon Energy Transition." London, 2018.
[9] K.M.P.G., "The 8 Core Principles of a Just Energy Transformation," in *UNDP Sustainable EnergyHub,2018.[Online].Available:https://www.undp.org/sites/g/files/zskgke326/files/2023-01/8%20core%20principles%20of%20a%20Just%20Energy%20Transformation.pdf*, 2018.
[10] M. S. Henry, M. D. Bazilian, and C. Markuson, "Just Transitions: Histories and Futures in a Post-COVID World," *Energy Res. Soc. Sci.*, vol. 68, no. 101668, 2020.
[11] P. García-García, "Just Energy Transitions to Low Carbon Economies: A Review of the Concept and Its Effects on Labour and Income," *Energy Res. Soc. Sci.*, vol. 70, no. 101664, 2020.
[12] K. Eci, "Institute for Essential Services Reform," in *Indonesia Solar Energy Outlook 2023: The Emergence of Solar PV in Fueling Indonesia's Energy Transition*, Jakarta, 2022.
[13] O. Mariana and Geny, "Institute for Essential Services Reform and J." 2023. [Online]. Available: https://iesr.or.id/interkoneksi-listrik-antar-pulau-di-indonesia-adalah-keniscayaan.
[14] J. Nicholas, "International Renewable Energy Agency, World Energy Transition Outlook 1.5°C Pathway," *Abu Dhabi*, 2021.
[15] D. Hassan, "Performance Achievement of the Electricity Sub-Sector in 2021, DG Gatrik: Electrification Ratio Increases to 99.45%," *Energy Room*, vol. 11, 2022, [Online].Available: https://www.ruangenergi.com/capaian-kinerja-subsektor-ketenagalistrikan-tahun-2021-dirjen-gatrik-rasio-elektrifikasi-meningkat-jadi-99-45/.
[16] H. Lukman, M. Energy, and M. Resources, "Coal Reserves Still 38.84 Billion Tons, Clean

Technology Management Continues to be Encouraged.” 2021.
[17] M. Bille, “Material Culture Studies: Objectification, Agency, and Intangibility: Materiality,” in *The Palgrave Handbook of the Anthropology of Technology*, M. H. Bruun, Ed. Palgrave Macmillan, 2022.
[18] I. Bella, “Potential of Geothermal Energy in Indonesia,” *New Renew. Energy Inf.Invest.Serv.*,vol.11,2022,[Online].Available:https://ebtke.esdm.go.id/lintas/id/investasi-ebtke/sektor-panas-bumi/potensi.
[19] M. Balmaceda, “Energy Materiality: A Conceptual Review of Multi-Disciplinary Approaches,” *Energy Res. Soc. Sci.*, vol. 56, no. 101220, 2019.
[20] J. Geny, “Discussing Some Aspect of the Energy Transition.” 2023.
[21] J. Martin, “Distributed vs. Centralized Electricity Generation: Are We Witnessing a Change of Paradigm? An Introduction to Distributed Generation,” *HEC Paris*, 2009, [Online]. Available: https://www.vernimmen.net/ftp/An_introduction_to_distributed_generation.pdf.
[22] “Ministry of Energy and Mineral Resources Republic Indonesia, "Handbook of Energy and Economic Statistics of Indonesia 2022.” 2023.
[23] D. G. New, “Renewable Energy, and Energy Conservation, "Performance Achievement of 2021 and Work Plan 2022 for New, Renewable Energy and Energy Conservation Sub-Sector.” 2022.[Online].Available:https://ebtke.esdm.go.id/post/2022/01/17/3055/ini.capaian.kinerja.tahun.2021.dan.rencana.kerja.2022.subsektor.ebtke.
[24] D. G. Electricity, “Performance Achievements of 2021 and Plans for 2022 for the Electricity Sub-Sector.” 2022.
[25] V. B. Kusnandar, “These are the Types of PLN Power Plants with the Most in 2021,” *databoks*, vol. 11, 2022.
[26] Y. Dani and N. E. Council, “The Role of Geothermal in Energy Transition,” vol. 11. 2022.
[27] “Kementerian ESDM Sebut Potensi Energi Surya Capai 3.294 GWp,” *Kant. Ber. Antara*, vol. 11,p.3294,2021,[Online].Available:https://www.antaranews.com/berita/2543829/kementerian-esdm-