Journal of Law and Legal Reform
Vol. 5 Issue 3 (2024) 1001–1028
DOI: https://doi.org/10.15294/jllr.v5i3.11838
Online since: October 31, 2024

Journal of Law & Legal Reform

journal.unnes.ac.id/journals/index.php/jllr/index

Paradox of Expanding Renewable Energy Resources: Legal Lag Behind the Advancement of Digital Technology

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Abstract

Advances in digital technology have brought transformative changes to various aspects of life, particularly in the management of natural resources for renewable energy. Digital technology has emerged as one of the most powerful drivers in achieving energy transition goals. Recognizing its potential, numerous government policies are currently being implemented to facilitate the expansion of renewable energy resources. At first glance, this expansion initiative appears well-conceived, as the shift to renewable energy promises significant benefits for environmental conservation, further supported by digitalization in energy management. However, a deeper analysis reveals a complex landscape, characterized by confusion from social, economic, and,

especially, legal perspectives, particularly at the regulatory level. The objective of this research is to explore the relationship between advancements in digital technology and the expansion of renewable energy, as well as to identify the legal barriers that hinder these efforts. Additionally, the research aims to examine the paradoxes inherent in this process. The study adopts an interdisciplinary approach, utilizing principles of law, regulatory synchronization, historical legal analysis, and comparative jurisprudential methods. The findings of this research reveal that digital technology, or digitization, plays a crucial role in enhancing the management of renewable energy, offering substantial benefits in terms of improving safety, optimizing production processes, increasing access, and promoting sustainable management practices. However, despite these advancements, the regulatory framework for renewable energy has not kept pace with the country's expansion efforts and potential. The research highlights significant legal, social, economic, and environmental conflicts that continue to hinder progress in this area.

Keywords *Energy, Legal, Paradox, Renewable, Technology*

Introduction

The rapid progress in digital technology has significantly transformed multiple facets of life,[1] particularly the management of natural resources. This includes the extraction of fossil fuels in addition to emerging renewable energy. The transition aim has been significantly propelled by the advent of digital technologies.[2] In this case, the government is enacting the increase of renewable energy as a means of conserving resources wisely and prioritizing environmental protection.

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1 Sreekanth Muktevi, "Digital Transformation in the Natural Resources Industry: Rethinking the Strategic Approaches," *The American Journal of Applied Sciences* 6, no. 6 (2024): 39–48.

2 Qian Zhao, et al. "Can artificial intelligence help accelerate the transition to renewable energy?." *Energy Economics* 134 (2024): 107584; Iwona Chomiak-Orsa, et al. "AI in Accelerating the Creation of Renewable Energy Sources. Bibliometric Analysis." *European Conference on Artificial Intelligence*. (Cham: Springer Nature Switzerland, 2023).

Prior research has explored the significance of advancements in digital technology in relation to the shift towards renewable energy. This includes investigations into regional conditions, comparisons with other nations, and analyses of energy policies in other countries.

As research conducted by Afif regarding the prospective sources of solar energy is enormous for power generation, as well as regulation and obstacles to solar power plant generation in Indonesia.[3] Regarding policy, in 2021 Savira has researched the development National Energy Policy and New Renewable Energy.[4] Comparative research with other countries was carried out by Apriliyanti in 2023, which examined Indonesia's new and renewable energy policies with a comparison of countries in the Nordic Region that were considered to have been able to utilize renewable energy optimally by considering efforts to reduce carbon, deforestation, and environmental impacts.[5]

On a global scale, research on renewable energy policies has begun to be carried out, including Wang's research in 2024 regarding the the progression of renewable energy legislation in China.[6] In 2024, Omri's research analyze the correlation between climate and the shift to renewable energy by financial and political sector involvement.[7]

According to the aforementioned five research, it has been determined that digital technology primarily functions as a facilitator for the energy transition, which is subsequently reinforced by energy policy. This transition is also a component of worldwide conservation

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[3] Faisal Afif and Awaludin Martin, "Tinjauan Potensi dan Kebijakan Energi Surya di Indonesia," *Jurnal Engine: Energi, Manufaktur, dan Material* 6, no. 1 (2022): 43-52.

[4] Savira Ayu Arsita, Guntur Eko Saputro, and Susanto Susanto, "Perkembangan Kebijakan Energi Nasional dan Energi Baru Terbarukan Indonesia," *Jurnal Syntax Transformation* 2, no. 12 (2021): 1779–88.

[5] Kiki Apriliyanti, and Darlin Rizki. "Kebijakan Energi Terbarukan: Studi Kasus Indonesia dan Norwegia dalam Pengelolaan Sumber Energi Berkelanjutan." *Jurnal Ilmu Pemerintahan Widya Praja* 49, no. 2 (2023): 186-209.

[6] Wenyu Ma, and Wenyu Wang. "Evolution of renewable energy laws and policies in China." *Heliyon* 10, no. 8 (2024): e29712.

[7] Anis Omri and Sami Ben Jabeur, "Climate Policies and Legislation for Renewable Energy Transition: The Roles of Financial Sector and Political Institutions," *Technological Forecasting and Social Change* 203 (2024): 123347.

initiatives aimed at mitigating climate change.[8] This research distinguishes itself from the aforementioned five studies by undertaking a comprehensive and in-depth analysis of the energy transition process, encompassing several dimensions such as social, economic, environmental, and particularly regulatory preparedness, with a specific focus on Indonesia.

Indonesia is renowned for being a haven of renewable energy.[9] Data based on Ministry of Energy and Mineral Resources (ESDM), shown that Indonesia, renowned as the ring of fire because of its abundant volcanoes, possesses almost 40% of the global geothermal energy reserves.[10] Depending on the data from the Center of Excellence for Energy Innovation and Technology Studies (CENITS), out of a total of 801.2 GW of potential renewable energy reserves, only 8.66 GW has been utilized. This utilization is a result of various sources including hydro and micro-hydro power plants, wind power, solar power, bioenergy, geothermal, and marine energy.[11] In this case, the government is enacting the expansion of renewable energy as a conservation strategy to responsibly manage resources and prioritize the preservation of the environment.

Recognizing the potential of these resources, several government programs are currently being implemented to promote their spread. The rules referenced include Statute No. 30 of 2007 regarding Energy and Republic of Indonesia Government Regulation Number 79 of 2014 on National Energy Policy. This rule establishes a goal to augment the ratio of newly generated renewable sources of energy in the nation's entire supply of energy. Specifically, the purpose is to achieve a 25% proportion of renewable energy by the year 2025, which is commonly

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[8] Odunayo Adewunmi Adelekan et al., "Energy Transition Policies: A Global Review of Shifts Towards Renewable Sources," *Engineering Science & Technology Journal* 5, no. 2 (2024): 272–87.

[9] Asif Raihan, "An Overview of the Energy Segment of Indonesia: Present Situation, Prospects, and Forthcoming Advancements in Renewable Energy Technology," *Journal of Technology Innovations and Energy* 2, no. 3 (2023): 37–63.

[10] Kementerian ESDM, "Pemerintah Optimistis EBT 23% Tahun 2025 Tercapai," https://www.esdm.go.id/id/media-center/arsip-berita/serasehan-ebt-untuk-mewujudkan-visi-energi-25-25, July 27, 2021.

[11] Herman Eman Khaeron, "Urgensi Undang-Undang Baru dan Terbarukan di Indonesia," https://pushep.or.id/wp-content/uploads/2020/04/Urgensi-UU-Energi-Baru-dan-Terbarukan-di-Indonesia-Kahmi.pdf, April 25, 2020.

referred to as "Energy Vision 25/25". In addition, there are now ongoing efforts to develop new and renewable energy legislation through the implementation of presidential decrees and ministerial decisions.

At first glance, this expansion drive seems to be a well-conceived and ideal strategy, the transition from fossil fuels to sources of renewable energy will greatly support environmental conservation efforts, aided by the implementation of digital technology in the energy production sector. From a comprehensive standpoint, there seems to be a certain level of perplexity arising from both social and economic viewpoints, and specifically from a legal aspect at the regulatory level.

Comparable to the extraction and utilization of minerals and fossil fuels, the effective management of renewable energy likewise requires a specific quantity of land. This encompasses the extraction of nickel for battery manufacturing, the exploration of hilly regions for geothermal mining, the utilization of vast plains for the installation of solar panels, and the utilization of forests for the generation of biomass energy. The utilization of this area unquestionably requires cooperation with other regulatory sectors in the fields of land, forestry, and environment, while also considering the possibility of social and economic disputes if the area is inhabited by a population.

Regulations pertaining to the expansion of renewable energy are currently limited to specific sectors and do not align with regulation in other sectors. In this scenario, the promotion of digital technology for controlling renewable energy sources persists. However, at the regulatory level, it is deemed inadequate and lagging behind advances in technology. Based on the aforementioned description, The primary objective of the present study is to investigate the relationship between advancements in digital technology and the expansion of renewable energy resources. Additionally, it aims to investigate the legal challenges that hinder efforts to expand renewable energy in the country, and to explore the significance of paradoxes in this process.

This legal normative study entails a thorough examination of relevant information on renewable energy, utilizing both physical and digital resources available in libraries. The first step is to identify and characterize the material. We subsequently categorized the acquired data into three distinct legal classifications: primary, secondary, and tarsier data. The primary legal resources consist of legislation and court

rulings, such as Law Number 21 of 2014 concerning Geothermal and Law Number 30 of 2007 concerning Energy and its derivative regulation, whereas the secondary legal materials relevant to this inquiry include case studies, books, journals, and other scholarly discoveries. Thirdly, legal tertiary materials are resources that provide direction and clarification on primary and secondary legal documents. The strategy employed integrates both a regulatory and a theoretical approach. The conceptual approach pertains to the convergence legal theory, which encompasses the conceptual and theoretical comprehension The convergence of economic, technological, and legal constraints on human-society ties in the digital information period.

Subsequently, the outcomes of both the statutory approach and the conceptual approach will be examined in further detail using the principles of law, synchronisation regulations, historical legal analysis, and comparative jurisprudential study.[12] The data is subsequently examined using the qualitative methodology[13] By employing deductive reasoning and thereafter providing a detailed account to get solutions to this study issue.

The Correlation Between Advancements in Technology Digital and the Expansion of Renewable Energy Resources

Indonesia is a geographically archipelagic nation, having a total of 17,001 islands according per the 2024 data from the National Statistics Agency.[14] These islands include both big islands and smaller ones, some of which have permanent residents while others are unoccupied. Out of this total, despite the fact that only approximately 30-35% of the islands

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[12] Theresia Anita Christiani, "Normative and Empirical Research Methods: Their Usefulness and Relevance in the Study of Law as an Object," *Procedia - Social and Behavioral Sciences* 219 (2016): 201–207.

[13] Ervina Dwi Indriati, Sary Ana, and Nunung Nugroho, "Philosophy of Law and the Development of Law as a Normative Legal Science," *International Journal of Educational Research & Social Sciences* 3, no. 1 (2022): 425–32.

[14] Badan Pusat Statistik, *Statistik Indonesia 2024*, vol. 52, https://www.bps.go.id/id/publication/2024/02/28/c1bacde03256343b2bf769b0/statistik-indonesia-2024.html, 2024.

are populated,[15] they nonetheless have significant energy requirements, particularly isolated islands that are distant from larger islands. Transporting electricity to this isolated island necessitates sufficient infrastructure and significant expenses.[16] Hence, digital technology serves a vital function in facilitating energy distribution in Indonesia.[17] Transporting electricity to this isolated island necessitates sufficient infrastructure and significant expenses,[18] particularly in establishing connections across power networks across different islands. *Smart Grid Technology* is a type of digitalization that is used. This network possesses the capability to link expansive islands by means of interconnection lines, allowing for increased flexibility in the provision of energy. A particular example is the Kamojang Geothermal Power Plant (PLTP) located in Bandung Regency. This power plant has been in operation since 1982 and provides electricity to the interconnected network of Java, Bali, and Madura.[19]

Presently, experts, academics, and researchers persist in supporting for diverse study endeavors targeted towards maximizing the usage of renewable energy resources in Indonesia, with the objective of fulfilling the electrification ratio requirements throughout different locations. The primary concern associated with the utilization of solar technology is its substantial upfront investment expenses. *Solar Photovoltaic Systems* utilize digital technologies to distribute solar power across different regions. This system is specifically engineered to provide solar power by utilizing photovoltaics, which consist of solar panels that capture and convert solar radiation into electrical energy. Photovoltaic solar power

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[15] Kumparan, "Jumlah Pulau Di Indonesia Berdasarkan Data Tahun 2024," https://kumparan.com/berita-terkini/jumlah-pulau-di-indonesia-berdasarkan-data-tahun-2024-22U4wj7ZFZA/full, April 8, 2024.

[16] Federico Succetti et al., "Challenges and Perspectives of Smart Grid Systems in Islands: A Real Case Study," *Energies* 16, no. 2 (2023): 583.

[17] D R Rachmadhani and Ilham, "Utilization of Technology and Digitalization to Bring Equality Energy Access for Remote Areas," *IOP Conference Series: Earth and Environmental Science* 997, no. 1 (2022): 012015.

[18] European Commission, "Digitalisation of the Energy System," https://energy.ec.europa.eu/topics/energy-systems-integration/digitalisation-energy-system_en, 2023.

[19] Aditya Putra Perdana, "Digitalisasi Berperan Krusial dalam Transisi Energi," https://www.kompas.id/baca/ekonomi/2022/12/01/digitalisasi-berperan-krusial-dalam-transisi-energi.

facilities have been constructed on various regions of Indonesia over the past ten years, and there is a possibility of expanding them to rural areas in Central Java.[20]

The energy sector implements digitalization through a smart system, a platform that enables real-time data collection and monitoring of energy utilization to determine energy management steps and strategies. Additionally, the government is implementing digitalization in the electricity system by preparing an integrated application for the Single Gateway for Public Electric Vehicle Charging Stations (SPKLU), which serves as an information center for users to locate electric vehicle charging locations.[21]

The influence of digitalization on energy from an international perspective is that it leads to a reduction in energy consumption, a decrease in energy intensity, and an optimization of energy structure. Nevertheless, Xu's research[22] indicates that digitalization mostly affects energy consumption in underdeveloped nations, whereas its impact is comparatively limited in developed nations. When implemented in Indonesia, a country classified as developing, these positive effects will naturally be subject to certain constraints.

Depending on the performance report from Directorate General of New and Renewable Energy Conservation (EBTKE) in 2023, in the last 5 (five) years, the augmentation of renewable energy capacity for production until 2023 was 3,322 MW, with an average increase of 6% per year.

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[20] Ramadoni Syahputra and Indah Soesanti, "Planning of Hybrid Micro-Hydro and Solar Photovoltaic Systems for Rural Areas of Central Java, Indonesia," *Journal of Electrical and Computer Engineering* 2020 (2020): 1–16.

[21] Kementerian Energi dan Sumber Daya Mineral, "Pemerintah Mendorong Transisi Energi Melalui Energi Baru Terbarukan dan Efisiensi Energi", *Online News,* November 26, 2020. Retrieved from https://www.esdm.go.id/id/berita-unit/direktorat-jenderal-ketenagalistrikan/pemerintah-mendorong-transisi-energi-melalui-energi-baru-terbarukan-dan-efisiensi-energi

[22] Qiong Xu, Meirui Zhong, and Xin Li, "How Does Digitalization Affect Energy? International Evidence," *Energy Economics* 107 (2022): 105879.

TABEL 1. The capacity of renewable energy generation

Renewable Energy Generators	Accumulated Installed Power Plant Capacity (MW)						
	2018	2019	2020	2021	2022	2023	2024 Goals
Wind	143,5	154,3	154,3	154,3	154,3	154,3	154,3
Solar	67,6	153,6	175,7	207,3	283,2	573,8	770,7
Bioenergy	1882,2	2101,2	2258,5	2296,7	3098,9	3.195,4	3.232,9
Geothermal	1948,3	2135,6	2135,6	2219,0	2360,3	2.417,7	2.474,7
Water	5791,5	5995,7	6140,7	6591,9	6689,2	6784,2	7.225.4
Coal gas	-	-	30,0	30,0	30,0	30,0	30,30

Source: Directorate General EBTKE, 2024

Based on the data above, the achievement of the share of renewable energy in the national energy portfolio for 2023 is 13.21%, an increase of 0.93 units compared to the achievement in 2022 of 12.28%.[23]

At the moment, the governmental entity possesses continued to improve the capacity of renewable energy generators consisting of as geothermal power generation facilities, solar energy facilities, wind energy facilities, and biofuel facilities. According to Law Number 30 of 2007, Indonesia's renewable energy sources include geothermal energy, wind power, bioenergy, solar, hydropower, and streams, alongside fluctuations in seabed temperatures. In this case, the geothermal and solar sectors continue to utilize digital technology. Research focused on developing prototypes of supporting technologies for renewable energy has only been evaluated in certain small-scale power facilities. Due to the lengthy process involved, there has been a lack of a substantial and all-encompassing initiative to introduce innovation to the local industry and market. The main cause of the slow digitalization in other renewable energy sectors is the absence of regulations that are able to accommodate the diverse use of technology in the renewable energy expansion process.

Legal Challenges in Expanding Renewable Energy Resource in Indonesia

Comparable to other natural resources that are regulated by the government to guarantee the utmost benefit for the on behalf of all people, the same applies for the utilisation renewable energy sources.

[23] Direktorat Jenderal Energi Baru, Terbarukan dan Konservasi Energi, "Laporan Kinerja DITJEN EBTKE," 2023.

According to Law No. 30 of 2007 regarding energy, which is the initial regulation for the usage of new and renewable energy, energy sources are defined as entities capable of generating power, Alternatively, by conversion method.

Energy sources are classified into two distinct categories: new and renewable energy sources.[24] Advanced technology has the capability to generate fresh energy sources Including renewable and non-renewable sources, encompassing nuclear power, the element hydrogen, coals bed methane, liquid coal, and gasified coals.[25] Alternatively, effectively controlled Energy generated from renewable sources such as geothermal, wind power, bioenergy, solar power, water, waterfalls, and fluctuations in seabed temperatures have the ability to generate renewable energy.[26]

The structure of regulation for the new, renewable energy and energy conservation sectors is divided into two main regulations, the first within the energy domain and the second in the geothermal sector. Geothermal is regulated through Law No. 21 of 2014 Regarding Geothermal Energy. The regulatory framework for energy encompasses bioenergy, various forms of renewable energy, conservation of energy, and new and renewable energy infrastructure.

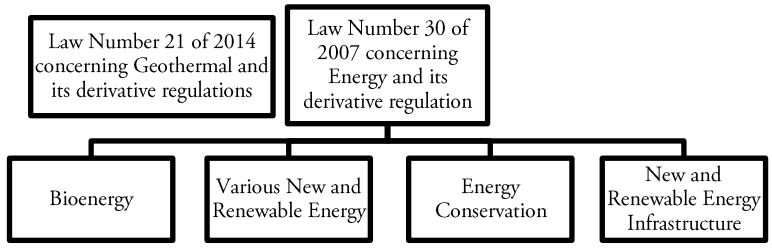

FIGURE 1. Regulatory Framework for the Energy Sector
Source: Author Analysis, 2024

[24] Ramkumar Alajingi and Marimuthu R, "Novel Classification of Energy Sources, with Implications for Carbon Emissions," *Energy Strategy Reviews* 49 (2023): 101146.

[25] Article 1 Paragraph 4 of Law Number 30 of 2007 concerning Energy.

[26] Article 1 Paragraph 6 of Law Number 30 of 2007 concerning Energy.

The regulatory framework of geothermal has been comprehensive enough to support the energy exploration process and the utilisation of digital technologies in the entire procedure. Some of them are The Regulation of the Minister of Energy and Mineral Resources Number 17 of 2014 on the Acquisition of Electricity from Geothermal Power Plants and Geothermal Steam for Geothermal Power Plants (PLTP) by PT Perusahaan Listrik Negara (PLN), Regulation of the Government of the Republic of Indonesia Number 7 of 2017 regarding Geothermal for Indirect Utilization, some of whose provisions have been revoked and replaced by Regulation of the Government of the Republic of Indonesia Number 25 of 2021 concerning the Implementation of the Energy and Mineral Resources Sector and Regulation of the Minister of Energy and Mineral Resources Number 7 of 2018 concerning the Management and Utilization of Geothermal information and data for indirect usage and numerous technical rules and regulations.

However, other renewable energy regulations are still not comprehensive enough when it comes to the use of digital technology. These regulations include Regulation of the Minister of Energy and Mineral Resources No. 32 of 2008 in conjunction with Regulation of the Minister of Energy and Mineral Resources No.12 of 2015 concerning the Provision of Utilisation and Trade of Biofuel as another Fuel, so in this case, the regulation for bioenergy is still at the initial stage of its use as an energy source.

For various new and renewable energy, the Regulation of the Minister of Energy and Mineral Resources No. 4 of 2020 regarding the second constitutional amendment to the Regulation of the Minister of Energy and Mineral Resources No. 50 of 2017 on the Use of Renewable Energy Sources for Electricity Generation. This regulation serves as the foundational basis for the expansion of new and renewable energy as a substitute power source. The latest regulation related to this is the Regulation of the Minister of Energy and Mineral Resources No. 2 of 2024 concerning Rooftop Solar Power Plants Linked to the Electricity Grid of Licensed Electricity Supply Businesses for Public Benefit (IUPLTU), which will be effective from January 31, 2024.

This rule addresses the evolving the study of forces and motion to expedite the deployment of photovoltaic systems installed on rooftops. The background of this solar sector continues to be pushed by the government because Indonesia possesses silica sand resources suitable

for the the solar energy industry. Consequently, the Rooftop project is anticipated to stimulate the expansion of the solar photovoltaic industry in Indonesia and bolster the proposed development of the integrated solar photovoltaic sector in central Java, on the city of Batam and Rempang Island.[27]

In the field of energy conservation, Government Regulation Number 7 of 2009 and has been revoked through Government Regulation N0. 33 of 2023 concerning Energy Conservation is the basis for the utilization of new and renewable energy, which must be increased by the national and regional authorities. The utilization Entities engaged in power plant of energy from new and renewable sources should receive facilities from governmental or regional authorities, in accordance with their jurisdiction, for a specified duration until the economic value is realised.

Referring to the regulatory framework above, it is clear that even though regulatory updates are continuously carried out, they have not been able to reach the resolution of all legal problems. The most crucial thing is the legal umbrella. From this framework, it is observable that new and renewable energy regulations are still sectoral, such as the geothermal sector and the energy sector. In the author's opinion, there should be one legal umbrella that oversees the energy sector, as currently the Draft Law on New and Renewable Energy has not received ratification by the government. This is also the reason regulations at the regional level in the form of regional regulations to not be able to accommodate the usage and development of new and renewable energy. In fact, there is a legal mandate regarding regional obligations to increase the use of renewable energy.

In this scenario, Draft on Law New and Renewable Energy is deemed inadequate in addressing legal concerns. One of the reasons is that the bill fails to meet the requirements of the energy trilemma, a concept introduced by the World Energy Council in 2010. According to this concept, an energy-producing country must achieve a balance between three key aspects: Energy Security, Energy Access, and

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[27] Sekretariat Kabinet Republik Indonesia, "Pemerintah Terbitkan Aturan Terbaru PLTS Atap, Kapasitas Pemasangan Tidak Dibatasi," https://setkab.go.id/pemerintah-terbitkan-aturan-terbaru-plts-atap-kapasitas-pemasangan-tidak-dibatasi/, 2024.

Environmental Sustainability. The Legislation Draft continues to exclusively prioritize the Energy Security paradigm which can be analyzed in Articles 20-26. [28]

Furthermore, there exists a lack of consistency in legislation pertaining to the determination of the price of sale of renewable energy. Specifically, Government Regulation No. 79 of 2014 employs the *feed-in tariff* method. According to the Regulation of the Minister of Energy and Mineral Resources No. 50 of 2017, and recently amended on Regulation of the Minister of Energy and Mineral Resources No. 4 of 2020, the cost at which electricity is bought from *Independent Power Producers* (IPP) is determined based on the *Cost of Provision* (BPP) of locally based electricity generation.[29]

Referring to the 2023 review of performance of the Directorate General of New, Renewable Energy and Energy Conservation that another obstacle is the fulfillment of the Domestic Component Level (TKDN) requirement in the field of industrial development, namely due to the limitation of current regulations that do not encompass all categories of power plants in the new and renewable energy sub-sector. The current standards have failed to adapt to the progress of technology and the growing new and renewable energy sector, which involves a wider range of components. The criteria in Indonesia are deemed unfair by international funders, resulting in some projects facing hurdles.

Presidential Regulation No. 112 of 2022 on the Advancement of Renewable Energy Production for Electricity Provision serve as a foundation for expediting the construction of power plants that utilize renewable energy sources. However, without a comprehensive legal framework that addresses issues pertaining to sectors such as land, forestry, environment, and coordination with local governments, the sectoral regulation on its own will not effectively support for the deployment of renewable energy.

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[28] Sahid Yudhakusuma Kalpikajati and Sapto Hermawan, "Hambatan Penerapan Kebijakan Energi Terbarukan di Indonesia," *Batulis Civil Law Review* 3, no. 2 (August 26, 2022): 187-2017.

[29] Vita Puji Lestari, *Ringkasan Permasalahan dan Tatangan Program Peningkatan Kontribusi Energi Baru dan Terbarukan dalam Bauran Energi Nasional* (Pusat Kajian Akuntabilitas Keuangan Negara Badan Keahlian Dewan DPR RI, 2021), https://berkas.dpr.go.id/pa3kn/analisis-tematik-akuntabilitas/public-file/analisis-ringkas-cepat-public-21.pdf.

Paradox in the Process of Expanding Renewable Energy Resources

Renewable energy sources offer benefits for society, enterprises, and governments, such as less emissions, lower energy expenses, and environmental sustainability[30] and it is undeniable that the utilisation of digital technology in the expansion of renewable energy sources would enhance the efficacy and efficiency of work procedures. Does it end there, nonetheless? Natural resources, such as renewable energy, ought to be utilised with the greatest the welfare of people. Of course, the objective of maximising people's prosperity still needs to be further scrutinised if there are people who suffer off consequently of the energy enlargement procedure.

This is in line with various global studies, Bainton asserts that if current transition only represents a transition to cleaner energy technology, lacking a significant emphasis on law and the societal and ecological ramifications of this transformation,[31] the motivations behind this expansion will be questioned. The expansion of renewable energy not only requires a comprehensive regulatory framework, but also depends on a country's financial strength, Omri asserts that the efficacy of green energy regulations in expediting the renewable energy transition is contingent upon a robust the financial services sector capable of implementing and enforcing these policies successfully.[32]

A study in Brazil found that integration of renewable solutions into mining activities, which can be seen as an important route to increase contribute to sustainability objectives. However, costs and even the lack of awareness are still major barriers that have limited renewables investments.[33] A different problem occurs in Ghana, while the

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30 Neli Ivanova and Palto Datta, "The Environmental Impact of Renewable Energy," *International Journal of Business & Economic Development* 11, no. 1 (2023): 85-103.

31 Nicholas Bainton et al., "The Energy-extractives Nexus and the Just Transition," *Sustainable Development* 29, no. 4 (2021): 624–34.

32 Anis Omri and Sami Ben Jabeur, "Climate Policies and Legislation for Renewable Energy Transition: The Roles of Financial Sector and Political Institutions," *Technological Forecasting and Social Change* 203 (2024): 123347.

33 Wellington Alves et al., "Renewable Energy for Sustainable Mining," *International Journal for Quality Research* 14, no. 2 (2020): 593–600.

renewable energy agenda is hindered by institutional weakness, ambiguous regulatory frameworks, and lack of proper planning, requiring legislative review.[34]

Each renewable energy source possesses both advantageous and detrimental effects. The beneficial effect is, undoubtedly, the utilization of renewable energy sources to mitigate climate change.[35] A comprehensive and balanced analysis, along with rigorous oversight of execution, is essential during the expansion of renewable resources to prevent adverse effects. The subsequent are the possible adverse effects of renewable energy proliferation.

Potential Impact on Social and Environmental

The adverse effects of renewable energy expansion manifest as potential issues, some of which have materialized as actual occurrences. It is classified as having a possible adverse effect due to the fact that certain forms of renewable energy have not been established, since they remain constrained by laws. Nonetheless, in Indonesia, the existing stringent laws for renewable energy have resulted in adverse effects, including ongoing social conflicts and resistance from the local community.

TABLE 2. Potential Negative Impacts of Renewable Energy

Types of Renewable Energy	Social	Environmental
Solar Energy	High cost of investment	Demands extensive land usage and, while operation, generates particulate pollutants that contribute to respiratory issues in humans and animals.
Bioenergy	High cost of investment	Operations still require Hydrogen generated by fossil fuel power stations.

[34] Raymond A. Atuguba and Francis Xavier Dery Tuokuu, "Ghana's Renewable Energy Agenda: Legislative Drafting in Search of Policy Paralysis," *Energy Research & Social Science* 64 (2020): 101453.

[35] Krishna Kumar Jaiswal et al., "Renewable and Sustainable Clean Energy Development and Impact on Social, Economic, and Environmental Health," *Energy Nexus* 7 (September 2022): 100118, https://doi.org/10.1016/j.nexus.2022.100118.

Types of Renewable Energy	Social	Environmental
Hydropower	Communities surrounding the construction site must be relocated to different areas.	For the construction of power plants, changes are made to natural water flows and wildlife movement routes around plants, thus changing the ecosystem.
Wind	Must be constructed at a considerable distance from residential zones	Wind turbin may affect bird population
Geothermal	Alterations in regional topography, community displacement, water quality, and noise disturbances	Unreintroduced pollution contributes to global warming, acid rain, and noxious smells

Source: Author's analysis[36]

Upon further examination, despite the commendable objectives of renewable energy expansion, it possesses inherent drawbacks, such as substantial initial expenses and investments necessitating significant financial resources,[37] in addition to the waste generated by geothermal energy generation. Both as solid waste manifested as sludge and as condensation water from Geothermal Power Plants, as well as brine that is not reinjected into the reservoir.[38] Particularly for bioenergy, which necessitates many forms of forestry, agriculture, and livestock as these are immediately burned, consequently demanding extensive land

[36] J. J. Strossmayer, "Positive and Negative Impacts of Renewable Energy Sources," *International Journal of Electrical and Computer Engineering Systems* 5, no. 2 (2014).

[37] Anisa Ayu Solikah and Bramastia Bramastia, "Systematic Literature Review: Kajian Potensi dan Pemanfaatan Sumber Daya Energi Baru dan Terbarukan di Indonesia," *Jurnal Energi Baru dan Terbarukan* 5, no. 1 (2024): 27–43.

[38] Dita Aprilia Istiqamah, Nugroho Adi Sasongko, and M. Sidik Boedoyo, "Analisis Dampak Lingkungan dan Life Cycle Cost Pembangkit Listrik Tenaga Panas Bumi," *E-Jurnal Ekonomi Sumberdaya Dan Lingkungan* 12, no. 1 (2023): 39–48.

expanses. Windmills and biofuel power facilities have a small ecological effect. Hence, their widespread implementation is warranted.[39]

The expansion of renewable energy, comparable to fossil fuel mining, necessitates the establishment of several new mines to supply the mineral resources required for renewable energy infrastructure. The expansion of renewable energy production will increase mining threats to biodiversity, potentially surpassing the benefits of climate change mitigation.[40] These mines can significantly affect society by generating new disparities, fostering social exclusion, or disrupting terrestrial natural resources. Neglecting to reconcile the social ramifications of climate change with prudent measures equates to exchanging one set of issues for another, rather than resolving them. Many are also situated on indigenous peoples' land. Dredging or mining operations will generate more mining by products or hazardous and toxic waste. Extensive mining operations also pose the danger of incurring post-mining losses. The energy transition's mineral mining influence is evident in Australia. Indigenous people in the McArthur River region persist in their opposition to lead and zinc mining in the Borroloola area due to its adverse effects on the environment and local inhabitants. This mining generates pollution from toxic substances and thermal rock waste.[41]

There is a perspective suggesting that global initiatives for sustainable energy adversely affect developing countries. The renewable energy transition is feared to exacerbate social inequalities. An instance in Indonesia pertains to the establishment of a substantial floating solar power plant (PLTS) in a regional reservoir in the Batam region. Based on the Batam Concession Agency website, the Rempang Ecocity project

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[39] Ahmed I. Osman et al., "Cost, Environmental Impact, and Resilience of Renewable Energy under a Changing Climate: A Review," *Environmental Chemistry Letters* 21, no. 2 (2023): 741–64. *See also* Adi Wijayanto, Hatta Acarya Wiraraja, and Siti Aminah Idris. "Forest Fire and Environmental Damage: The Indonesian Legal Policy and Law Enforcement." *Unnes Law Journal* 8, no. 1 (2022): 105-132.

[40] Laura J. Sonter et al., "Renewable Energy Production Will Exacerbate Mining Threats to Biodiversity," *Nature Communications* 11, no. 1 (2020): 4174.

[41] Nick Bainton and Deanna Kemp, "More Clean Energy Means More Mines – We Shouldn't Sacrifice Communities in the Name of Climate Action," *The Conversation,* November 4, 2021. Retrieved from https://theconversation.com/more-clean-energy-means-more-mines-we-shouldnt-sacrifice-communities-in-the-name-of-climate-action-170938

will take up 7,572 hectares of land on Rempang Island, or 45.89 percent of the total land on Rempang Island, which has an area of 16,500 hectares. The Rempang community opposes the relocation of the 16 ancient traditional law villages, which have inhabited the area for centuries.[42] Their residence will transform to substantial production of solar energy panels facility, a solar power producing farm, and the "Rempang Ecocity" initiative. Rempang island are rich in silica sand and the mineral quartz are vital raw materials for glass and solar panel manufacturing. Massive sand extraction is seen as a worldwide ecological catastrophe that frequently remains undetected.[43]

The results of Earlene's research show that the construction of Rempang Ecocity violates on human rights, specifically the traditional rights of local customary law communities, particularly regarding land rights. It also contravenes the right to security due to the criminalization of these communities by law enforcement officials, as well as their right to remain undisturbed on the land they have inhabited for generations.[44] Resistance to the progression of renewable energy power stations was also observed in Sinjai Regency, South Sulawesi. Activists and local communities oppose the proposal to construct a Geothermal Power Plant, due to its location in a forested area near the Balantieng River, which serves as a vital water source for residents and poses a risk of displacing agricultural and livestock land. The extensive utilization of forested areas contributes to deforestation, a significant factor in the climate catastrophe.[45]

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[42] Nabila Annisa Fuzain, "Konflik Sengketa Lahan Antara Masyarakat Adat Rempang dengan BP Batam Terhadap Pembangunan Rempang Eco City." *Jurnal Hukum dan HAM Wara Sains* 2, no. 11 (2023): 1081-1088.

[43] Nikita Sud, "This Indonesian Island Has Been 'Gifted' to China. They're Victims of Green Energy Boom," *ThePrint*, 2023, https://theprint.in/world/this-indonesian-island-has-been-gifted-to-china-theyre-victims-of-green-energy-boom/1822770/.

[44] Felishella Earlene and Tundjung Herning Sitabuana, "Tanggung Jawab Negara Terhadap Hak Masyarakat Hukum Adat di Pulau Rempang dalam Perspektif HAM," *Tunas Agraria* 7, no. 2 (2024): 144–61.

[45] Wahyu Chandra, "Dinilai Berisiko Tinggi Dan Timbulkan Konflik, Aktivis Tolak Rencana Pembangunan PLTP di Sinjai," *Mongabay*, https://www.mongabay.co.id/2024/01/17/dinilai-berisiko-tinggi-dan-timbulkan-konflik-aktivis-tolak-rencana-pembangunan-pltp-di-sinjai/.

The community opposes the expansion also happen in Ulumbu Geothermal Power Plant project in Manggarai, Flores Island, East Nusa Tenggara,[46] due to its demonstrated adverse effects on the community. The emission of gas into the environment results in the corrosion of zinc in buildings, the failure of perennial crops, water shortages, and public health issues, including acute respiratory diseases. Opposition was also manifested in Dieng, Banjarnegara, Central Java against the establishment of a Geothermal Power Plant (PLTP) by PT Geo Dipa Energi. The rejection stemmed from citizens' reluctance to coexist with a high-risk enterprise. In 2022, a gas leak during the drilling operation resulted in one death and eight individuals were hospitalized due to inhalation of poisonous gas.[47]

A number of rejections that have occurred in various regions of Indonesia, as well as the various impacts that have been caused, are indicators that there is a paradox in the noble ideals of developing renewable energy. In this process, digital technology intervention should be able to optimize the work system to help mitigate the adverse effects that may arise. However, in fact, the intervention of digital technology requires a legal basis, while the legal framework for the development of new and renewable energy is still partial, the draft law has not been approved, and the implementation of cross-sector regulations such as land in the rights of indigenous peoples, forestry if the mining location is in protected forests, and environment related to water and air quality standards.

Therefore, all stakeholders, especially the government, must ensure that the regulatory framework is well established and capable of effective implementation to attain the noble goal of expanding renewable energy. In this case, according to Heshan studies that stakeholders and the

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[46] Fransiskus Pati Herin, "Penolakan Warga Poco Leok dan Target Net Zero Emissions," *Kompas*, 2024, https://www.kompas.id/baca/nusantara/2024/03/30/penolakan-warga-poco-leok-dan-target-net-zero-emissions.

[47] Nurhadi Sucahyo, "Petani Dieng Gigih Menolak Proyek PLTP Geo Dipa Energi," *VOA Indonesia*, 2022, https://www.voaindonesia.com/a/petani-dieng-gigih-menolak-proyek-pltp-geo-dipa-energi/6805886.html. *See also and compare with* Riezka Eka Mayasari, and Yeni Haerani. "Review of Unlawful Acts of Livestock Owners Due to Crop Damage in Bombana Regency." *Sangia Nibandera Law Research* 1, no. 1 (2024): 19-25.

public have differing positions on renewable energy policy, which can hinder effective policymaking.[48] Based on Satya studies in renewable energy development in Indonesia based on stakeholder perspectives are that the barriers were actually expected as there is an evident contradiction between policy and business, particularly in the planning and implementation stages.[49]

Application of Convergence Legal Theory to Digital Technology Intervention in Renewable Energy Expansion

Convergence legal theory is a theories and concepts insight of the convergence of Technologically economical, and legal variables affecting humanity and societal relations in the digital information era, at national, regional, and globally scales. The creation of the concept of legal convergence aims to revitalize society in the context of information and communication technology convergence.[50] The argument for the convergence law idea is derived from the notion of 4C technology convergence, which consists of interaction, computations, material, and society.[51] The grandeur of the principal notion of legal convergence stems solely from its complex, multimodal, and flexible phenomenon.[52]

Through the prism of legal convergence, the mechanism of convergence of national legal systems with each other and with

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[48] Heshan Sameera Kankanam Pathiranage, "The Disjoint Between Stakeholders' and Voters' Positions on the Political Economy of Energy Policy." *Business and Economic Research* 12, no. 4 (2022): 183-210.

[49] Satya Widya Yudha, Benny Tjahjono, and Philip Longhurst. "Stakeholders' recount on the dynamics of Indonesia's renewable energy sector." *Energies* 14, no. 10 (2021): 2762.

[50] Danrivanto Budhijanto, *Teori Hukum Konvergensi* (Bandung: PT. Refika Aditama, 2014).

[51] Suyikno Suyikno et al., "Analysis Theory of the Law of Convergence in Regulation Licensing and Supervision Financial Technology (Fintech) in Indonesia," *Polit Journal: Scientific Journal of Politics* 2, no. 4 (2022): 226–38.

[52] Antonios E. Platsas, "The Concept of Legal Convergence," in *Are Legal Systems Converging or Diverging?* (Cham: Springer International Publishing, 2024), pp. 27–44.

international law can be revealed.[53] There exists a correlation among all variables in the domains of technology, economics, legislation, and human relations concerning the integration of digital technology in the expansion of renewable energy sources as shown on Figure 2.

The variables identified in Figure 2 are interrelated, highlighting a dynamic interaction between them. Harmonization and effective integration of these variables are indicative of legal reforms that align with contemporary developments. In contrast, disharmonization and disintegration signal the law's failure to adapt to emerging trends, as encapsulated by the adage: the law always lags behind societal progress. From the perspective of technological variables, digital technologies play a critical role in enhancing the performance of renewable energy systems, such as *Solar Photovoltaic Systems and Smart Grid Technologies*. However, these advancements require substantial financial investment and the establishment of appropriate regulatory frameworks. Such regulations are essential to ensure that the public can fully benefit from the expansion of renewable energy.

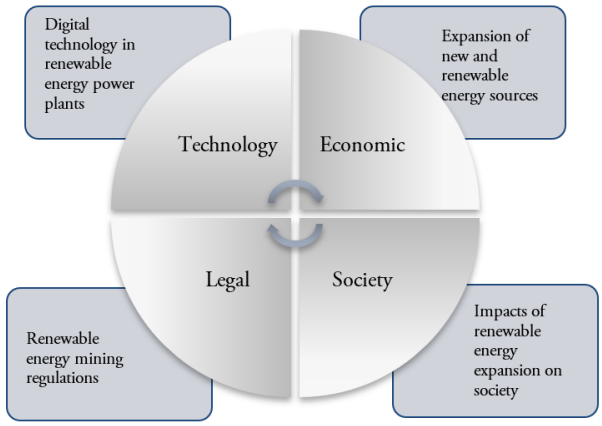

FIGURE 2. Correlation of Legal Convergence Theory
Source: Author's Analysis

Considering an economic standpoint, the proliferation of renewable energy will likely exert a substantial influence on economic

[53] Tatyana N. Kozhina and Alexander V. Petukhov, "To the Question of Forms, Methods, and Directions of the theory of Legal Convergence," *Oeconomia et Jus*, no. 2 (2024): 84–90.

and employment opportunities, Ula's research states that renewable energy consumption makes a positive contribution to economic growth, especially in ASEAN countries.[54] This is especially applicable in areas where power plants are being constructed. Nonetheless, rigorous oversight and surveillance can render all of this feasible. On the other hand, regulations play a crucial role, both as a legal basis and at the level of supervision and sanctions. Despite the establishment of a regulatory framework in the future, poor implementation will negate the impact of digital technology interventions.

Among all the variables, the primary goal of managing natural resources is to maximize public prosperity. However, if the process of expansion leads to significant harm to individuals—such as casualties, respiratory diseases, forced evictions, criminalization, loss of agricultural livelihoods, deterioration of water and air quality, or the disruptive effects of noise from power generation activities—this suggests that digital technology interventions have not been fully optimized and that regulatory frameworks remain inadequate. While economic benefits may be evident, the authors contend that these cannot justify the societal losses incurred. From a subjective standpoint, the well-being of society should not be compromised in pursuit of economic gain.

Conclusion

In conclusion, the findings of this study highlight the significant role of digital technology in improving power plant efficiency, particularly in the context of renewable energy expansion. However, a key issue identified is the lack of harmonization between the regulatory framework governing renewable energy sources and regional regulations, land use policies, environmental concerns, and social factors. This misalignment creates a paradox: while the objective of enhancing renewable energy across multiple sectors is commendable, it has unintentionally led to negative societal impacts. This situation exemplifies the legal lag in adapting to advancements in digital technology. To address this, it is imperative for the government to reassess existing regulations, accelerate the development of

[54] Tajul Ula, and Affandi Affandi. "Dampak Konsumsi Energi Terbarukan Terhadap Pertumbuhan Ekonomi: Studi di Asia Tenggara." *Journal of Economic Science (JECS)* 5, no. 2 (2019): 64-72.

comprehensive renewable energy legislation, and strengthen oversight of renewable energy extraction activities. Additionally, greater attention must be paid to the concerns of all stakeholders, particularly local communities near power plant infrastructure, to ensure that the benefits of renewable energy are equitably distributed and do not cause harm.

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Acknowledgment
None.

Funding Information
None.

Conflicting Interest Statement
There is no conflict of interest in the publication of this article.

Publishing Ethical and Originality Statement
All authors declared that this work is original and has never been published in any form and in any media, nor is it under consideration for publication in any journal, and all sources cited in this work refer to the basic standards of scientific citation.