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The Shaping of Future Sustainable Energy Policy in Management Areas of Indonesia's Energy Transition

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ABSTRACT

Modifications to energy management models have made them more adaptable and dynamic, with intelligent monitoring and control of energy production, distribution, storage, and consumption. However, the management paradigm has not yet been optimally implemented, given that fossil fuels account for 73% of all greenhouse gas (GHG) emissions in the energy sector. The purpose of this study was to find out the policy of management area in energy transition toward sustainable development. This was normative legal research employing the statutory approach, the fact approach, and the case approach. The results indicate that a global energy transition will have a positive effect on the future stability and development of economies worldwide. Therefore, the green investment promotion for Renewable energy has acquired prominence in recent years and is now at the forefront of global efforts to reform the energy sector. In addition, the harmonization of legislation and technical requirements is highlighted as a requirement for achieving this objective.

1. Introduction

Energy transition refers to the shift from traditional energy sources (i.e., fossil fuels) to a system dependent on renewable energy. Such a transition reduces reliance on conventional energy sources; consequently, it is crucial for climate resilience and long-term prosperity.[1] The term "energy transition" refers to the

[1] Sidhartha Harichandan and others, 'Energy Transition Research: A Bibliometric Mapping of Current Findings and Direction for Future Research', *Cleaner Production Letters*, 3 (2022), 100026 https://doi.org/10.1016/j.clpl.2022.100026

transition from fossil-based energy systems, such as coal, oil, and natural gas, to renewable-based energy systems, such as solar, wind, biodiesel, hydrogen, and others. Today, fossil fuels account for 73% of all greenhouse gas (GHG) emissions from the energy sector.[2] The empirical findings corroborate the significance of inter-regional trade among South Asian economies to increase the proportion and output of clean energy consumption, thereby confirming a sustainable ecological solution. Afshan et al. investigate the OECD economies in terms of the role of the energy transition, ecological innovations, and environmental policy in relation to European Financing Partners (EFP). The findings indicate that eco-innovation and energy transition promote ecological sustainability while reducing EFP.[3]

SDG7 is directly related to SDG13, which is concerned with climate action.[4] Similar to other regional economies, the European Union (EU)1 has outlined a vision for energy transition that prioritizes energy efficiency while transitioning to a clean energy system.[5] In addition, the necessity of the transition to a low-carbon economy is currently a fiercely debated topic in which numerous economies have a keen interest. Eliminating fossil fuels from energy production is one of the best methods to reduce environmental footprints and global emissions. Although the phrase global energy transition is in its infancy, renewable energy sources can contribute to 90% of the carbon reduction. Under the SDGs and COP26 agendas, the terms energy transition, technology, and low carbon emissions have become of great interest to governments and policymakers.[6]

Renewable energy technologies and decentralized systems were utilized to lessen the impact of traditional energy sources. Solar energy, river runoff hydroelectric, wind farms, and information technologies were able to steer industrialized nations toward a low-carbon economy.[7] Social, environmental, and

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[2] Qiwen Xia and others, 'Drivers of Global and National CO 2 Emissions Changes 2000–2017', *Climate Policy*, 21.5 (2021), 604–15 https://doi.org/10.1080/14693062.2020.1864267

[3] Sahar Afshan, Ilhan Ozturk, and Tanzeela Yaqoob, 'Facilitating Renewable Energy Transition, Ecological Innovations and Stringent Environmental Policies to Improve Ecological Sustainability: Evidence from MM-QR Method', *Renewable Energy*, 196 (2022), 151–60 https://doi.org/10.1016/j.renene.2022.06.125

[4] Rajvikram Madurai Elavarasan and others, 'Envisioning the UN Sustainable Development Goals (SDGs) through the Lens of Energy Sustainability (SDG 7) in the Post-COVID-19 World', *Applied Energy*, 292 (2021), 116665 https://doi.org/10.1016/j.apenergy.2021.116665

[5] Jie Chen, Shoujun Huang, and Hafiz Waqas Kamran, 'Empowering Sustainability Practices through Energy Transition for Sustainable Development Goal 7: The Role of Energy Patents and Natural Resources among European Union Economies through Advanced Panel', *Energy Policy*, 176 (2023), 113499 https://doi.org/10.1016/j.enpol.2023.113499

[6] Panayiotis Tzeremes, Eyup Dogan, and Nooshin Karimi Alavijeh, 'Analyzing the Nexus between Energy Transition, Environment and ICT: A Step towards COP26 Targets', *Journal of Environmental Management*, 326 (2023), 116598 https://doi.org/10.1016/j.jenvman.2022.116598

[7] Lanouar Charfeddine and Montassar Kahia, 'Do Information and Communication Technology and Renewable Energy Use Matter for Carbon Dioxide Emissions Reduction? Evidence from the Middle East and North Africa Region', *Journal of Cleaner Production*, 327 (2021), 129410 https://doi.org/10.1016/j.jclepro.2021.129410

economic dimensions serve as the foundation for defining sustainable development. As the world moves toward a liberalized and open market, numerous institutions have collaborated to advance energy democracy.

In contrast, scientific and higher education institutions are not at the forefront of production because they struggle to fathom the practical issues involved in the manufacturing process. As the majority of scientific institutions rely on funding from corporations and the government, they have a strong incentive to pursue earning and proficiency in addressing and resolving practical issues. In terms of solving practical ecological problems, therefore, the EPTs of such institutions have less value than those of scientific institutions and businesses. In addition, the existing literature has demonstrated a greater interest in investigating the role of renewable energy and technological innovations in environmental issues such as CEM.[8]

There are numerous mechanisms worldwide for promoting the energy transition (particularly for advancing the development of renewable energy). Since the issue of clean energy consumption has already been thoroughly accounted for in the design process of power markets, a number of experienced nations are optimistic about the electric power market design.[9] This issue presents the most recent findings in energy planning research and is a special issue from the 5th Annual Conference of the Portuguese Association of Energy Economics in 2021 and the 2020 Sustainable Development of Energy, Waste, and Environmental Systems conference series. This study investigates the effects of the European emissions trading system on innovation and the growth of the Chinese wind power industry. Women have a more positive attitude towards renewable energy technologies than males do, according to an analysis of university students in Portugal. Energy PLAN-based analyses of energy systems in Iran and Serbia are presented, and various indicators for energy system analyses in Mexico are discussed. The article discusses marine energy developments in Columbia, the United Kingdom, Canada, and Denmark with an emphasis on siting and obstacles. In addition, obstacles to the use of solar energy in Indonesia and obstacles to energy conservation in Nigeria are investigated.[10] The transition to renewable energy may be advantageous for one community and detrimental for another. Therefore, the policy devised for a

[8] Yi Su and Qi-ming Fan, 'Renewable Energy Technology Innovation, Industrial Structure Upgrading and Green Development from the Perspective of China's Provinces', *Technological Forecasting and Social Change*, 180 (2022), 121727 https://doi.org/10.1016/j.techfore.2022.121727
[9] Liu Pingkuo, Gao Pengbo, and Zhang Chen, 'How to Promote Energy Transition With Market Design: A Review on China's Electric Power Sector', *Frontiers in Energy Research*, 9 (2021) https://doi.org/10.3389/fenrg.2021.709272
[10] Duić N. Seixasa Júlia, Stergaardb Poul Alberg, Johannsenb Rasmus Magni, 'Energy Transition and Sustainability', *International Journal of Sustainable Energy Planning and Management*, 32 (2021), 1–4 https://doi.org/https://doi.org/10.5278/IJSEPM.6850

transition to a cleaner energy source must be equitable and justiciable for all social communities.[11]

However, successful implementation and a just energy transition require the combination of technological solutions with more open decision making based on solid analysis, engineering, and social science knowledge.[12] Researchers from various academic disciplines (social science, renewable energy, economics, political science, humanities, and public policy) have participated in energy transition research. Due to the multidisciplinary nature of energy transition, the term 'Big literature' was recently coined to emphasize the difficulties associated with assimilating and analyzing the literature on this topic. Traditional systematic evaluations have assimilated a substantial portion of the scientific literature when describing existing studies and have produced significant findings. 'Big Literature' poses a significant threat to conventional literary evaluations, as this literature has grown exponentially. To achieve its national clean energy production objectives, a nation may contemplate a combination of energy transition strategies. Transitioning any developing nation from its traditional techno-economic approach to "equity-inclusivity" necessitates paradigm shifts.[13]

2. Research Method

This study employs the statutory approach, the concept approach, the fact approach, and the case approach in order to conduct normative legal research. In an effort to accomplish sustainable development objectives, the legal approach is used to comprehend concepts related to energy transition policies. While the case study method is employed to investigate and resolve problems in real-world contexts. This investigation's findings are descriptive in nature. Primary data sources are secondary data sources derived from a literature review. The collected data was then analyzed qualitatively and descriptively.[14] We provide an overview of academic research on the various forms of energy transition based on past analytical findings. The objective is to map the emergent energy transition research trend. The fact that citations reflect the connections scientists have made between

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[11] William F Lamb and others, 'A Review of Trends and Drivers of Greenhouse Gas Emissions by Sector from 1990 to 2018', *Environmental Research Letters*, 16.7 (2021), 073005 https://doi.org/10.1088/1748-9326/abee4e

[12] Christina E. Hoicka and others, 'Implementing a Just Renewable Energy Transition: Policy Advice for Transposing the New European Rules for Renewable Energy Communities', *Energy Policy*, 156 (2021), 112435 https://doi.org/10.1016/j.enpol.2021.112435

[13] Alwin Long and others, 'Enhancing Sustainable Development via Low Carbon Energy Transition Approaches', *Journal of Cleaner Production*, 379 (2022), 134678 https://doi.org/10.1016/j.jclepro.2022.134678

[14] Abdul Kadir Jaelani and Resti Dian Luthviati, 'The Crime Of Damage After the Constitutional Court's Decision Number 76/PUU-XV/2017', *Journal of Human Rights, Culture and Legal System*, 1.1 (2021) https://doi.org/10.53955/jhcls.v1i1.5

their works inspired us to employ citation analysis.[15] By compiling a map of scholastic publications on energy transition, this study seeks to produce useful findings for the research community working on renewable and cleaner energy transition strategies.

3. Results and Discussion

The Shaping of Future Sustainable Energy Policy

The issue of rising global emissions compels policymakers to alter the pattern of economic expansion. This economic expansion is primarily fueled by the consumption of fossil fuel-based energy sources. The climate change is caused by the oxidation of fossil fuel-based energy solutions, which generate carbon dioxide and other greenhouse gas emissions. This global issue necessitates a radical shift in the economic growth drivers, particularly the pattern of energy consumption.[16] The International Energy Agency's premier report, Net Zero by 2050, discusses the benefits of embracing energy transition. During the COP26 Summit, the International Labor Organization also discussed the potential benefits of energy transition while discussing the Just Transition process. Therefore, it may be safe to infer that global policymakers must implement an energy transition in order to achieve the SDGs.

The energy sector is undergoing a technological transition towards the enormous incorporation of new computing technologies to assist with operational, management, and commercialization duties, thereby transforming into cloud-based energy environments or Energy Cloud (EC).[17] EC is a management trend that takes into account all energy-related activities.[18] It is now evident that both policymaking and planning must promote the energy transition by tying its spatial dimensions to the sustainable development of territories. Understanding the spatial and functional dimensions of urban and rural land-use is essential for shaping the energy transition, and should be the focal point of devising incremental and adaptable place-based policies for net-zero energy communities.[19]

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[15] Pedro Augusto Bertucci Lima and Enzo Barberio Mariano, 'Eudaimonia in the Relationship between Human and Nature: A Systematic Literature Review', *Cleaner Production Letters*, 2 (2022), 100007 https://doi.org/10.1016/j.clpl.2022.100007

[16] Avik Sinha and others, 'How Social Imbalance and Governance Quality Shape Policy Directives for Energy Transition in the OECD Countries?', *Energy Economics*, 120 (2023), 106642 https://doi.org/10.1016/j.eneco.2023.106642

[17] Jones Luís Schaefer and others, 'A Framework for Diagnosis and Management of Development and Implementation of Cloud-Based Energy Communities - Energy Cloud Communities', *Energy*, 276 (2023), 127420 https://doi.org/10.1016/j.energy.2023.127420

[18] Patrícia Stefan Carvalho and others, 'Proposal for a New Layer for Energy Cloud Management: The Regulatory Layer', *International Journal of Energy Research*, 45.7 (2021), 9780–99 https://doi.org/10.1002/er.6507

[19] Francesca Poggi, Ana Firmino, and Miguel Amado, 'Shaping Energy Transition at Municipal Scale: A Net-Zero Energy Scenario-Based Approach', *Land Use Policy*, 99 (2020), 104955 https://doi.org/10.1016/j.landusepol.2020.104955

Models of energy management have been modified to make them more adaptable and dynamic, with intelligent monitoring and control of production, distribution, storage, and energy consumption. This new approach to energy management combines energy systems with information and communication technology.[20] In this way, computational technologies such as Cloud Computing and the Internet of Things are currently being integrated to allow all production and energy consumption devices to be connected, thereby enhancing operational visibility and delivering real leverage at each stage of the energy flow, from generation to end-user.[21] Future energy business models can be developed in the form of peer-to-peer energy trading communities in which users can exchange energy. Thus, the evolution of digitization and decentralization of energy systems will occur via the establishment of decentralized service-oriented structures, cross-border interactions for profound flexibility, and a cooperative engagement of participants in a user-centric multi-level energy market[22]. Thus, these new energy business models can provide opportunities for businesses from a variety of industries, whether in the development and implementation of technological solutions or the provision of new and differentiated services across the complete energy sector logistics chain.[23]

However, the evolution of energy systems and the management of these systems presents a number of challenges; consequently, the utilization of data and information for decision-making becomes essential. Energy consumption, security issues, and interoperability and connectivity issues are the primary obstacles to the integration of smart solutions into energy management systems.[24] Derived from the conceptual framework, the framework for the diagnosis and management of the development and implementation of ECCs comprises the following levels: Framework Inputs, Evaluation of the Criticality Levels of ECCs Projects, and Evaluation of Performance Objectives.

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[20] Oussama Laayati, Mostafa Bouzi, and Ahmed Chebak, 'Smart Energy Management: Energy Consumption Metering, Monitoring and Prediction for Mining Industry', in *2020 IEEE 2nd International Conference on Electronics, Control, Optimization and Computer Science (ICECOCS)* (IEEE, 2020), pp. 1–5 https://doi.org/10.1109/ICECOCS50124.2020.9314532

[21] Tanveer Ahmad and Dongdong Zhang, 'Using the Internet of Things in Smart Energy Systems and Networks', *Sustainable Cities and Society*, 68 (2021), 102783 https://doi.org/10.1016/j.scs.2021.102783

[22] Mahdi Karami and Reinhard Madlener, 'Business Models for Peer-to-Peer Energy Trading in Germany Based on Households' Beliefs and Preferences', *Applied Energy*, 306 (2022), 118053 https://doi.org/10.1016/j.apenergy.2021.118053

[23] Ying Wu and others, 'Decentralized Transactive Energy Community in Edge Grid with Positive Buildings and Interactive Electric Vehicles', *International Journal of Electrical Power & Energy Systems*, 135 (2022), 107510 https://doi.org/10.1016/j.ijepes.2021.107510

[24] Michael Lanre Adekanbi, 'Optimization and Digitization of Wind Farms Using Internet of Things', *International Journal of Energy Research*, 45.11 (2021), 15832–38 https://doi.org/10.1002/er.6942

In the meantime, technological innovation as a form of knowledge promotes additional innovation, which is conducive to promoting the optimization of the regional economic structure and bolstering the vitality of regional green development.[25] The necessity of energy transition for achieving the Sustainable Development Goals can be discussed in light of SDGs 7 and 13. While energy transition can aid in achieving the goals of sustainable and affordable energy, the change in energy sources can aid in mitigating environmental degradation. The case for renewable energy has never been stronger as the topic of sustainable development continues to gain prominence in international affairs. Renewable energy, such as solar and wind, has the potential to be viewed as an optimal alternative to conventional (nonrenewable) energy sources in many climates if grid parity is taken into account. Numerous studies have been devoted to gaining an understanding of the concept.[26] Several countries have adopted Renewable Energy Frameworks to support both local and regional incentives for energy transition. The policy covered the variance between the market energy price and the renewable energy price and was available to companies and non-profit organizations producing renewable energy from biomass, geothermal energy, water, wind, or the solar.[27]

As the energy sector becomes increasingly intertwined with economic development, social priorities, and environmental requirements, it is necessary to integrate social processes with technical and economic analyses of energy systems. The results indicate that a global energy transition will have a positive effect on the future stability and development of economies worldwide. In addition to reducing the negative environmental impacts of the energy sector, renewable power generation technologies are creating new wealth and becoming key employment creators for the 21st century. Employment creation throughout the duration of the global energy transition is a crucial aspect to investigate, which could have global policy implications.[28]

The Role of Management Areas of Indonesia's Energy Transition

To combat environmental degradation, nations throughout the world are implementing policies such as renewable energy, eco-innovation, green financing, etc. Investment in renewable energy sources is essential for economic growth. A rise in investments in renewable energy within the development objectives has

[25] Su and Fan.
[26] Temitope M. Adeyemi-Kayode and others, 'A Bibliometric Review of Grid Parity, Energy Transition and Electricity Cost Research for Sustainable Development', *Heliyon*, 9.5 (2023), e15532 https://doi.org/10.1016/j.heliyon.2023.e15532
[27] Sol Maria Halleck Vega and Nienke van Twillert, 'Intra-Country Energy Community Developments: What Are Policy Implications for the Energy Transition?', *Energy Strategy Reviews*, 48 (2023), 101112 https://doi.org/10.1016/j.esr.2023.101112
[28] Manish Ram, Arman Aghahosseini, and Christian Breyer, 'Job Creation during the Global Energy Transition towards 100% Renewable Power System by 2050', *Technological Forecasting and Social Change*, 151 (2020), 119682 https://doi.org/10.1016/j.techfore.2019.06.008

become the primary concern of nations.[29] Investment in renewable energy is negatively correlated with the volatility of natural resources. However, economic performance, technological advancement, and energy efficiency have a positive effect on renewable energy investment. Therefore, the EU prioritizes renewable energy to accomplish sustainable development and mitigate the negative effects of climate change. Academics and policymakers have identified factors, such as environmental assurance, consumer compression, and cost reduction, that accelerate investment in renewable energy.[30] Currently, 15% of global energy production comes from renewable sources. Increasing investments in renewable energy is not limited to achieving a mid-term climate objective; rather, investments in renewable energy sources improve energy security.

The green investment promotion for Renewable energy has acquired prominence in recent years and is now at the forefront of global efforts to reform the energy sector. Renewable energy is a rapidly expanding and strategically vital industry in a new arena of global industrial competition. Adopting and utilizing renewable energy is one of the most effective methods to reduce pollution and protect the environment. Green finance development is essential for harmonizing economic growth and environmental protection. Global economies implement stringent environmental regulations to limit climate change, thereby fostering the transition to renewable energy by promoting green investment in response to improved public perception and rising consumer demand.[31] Government plays a crucial role in nurturing financing, and it has contributed to the expansion of green funding and forged connections between businesses. Environmental and ecological benefits accrue as financial institutions increasingly plan investments and financial transactions with ecological factors in mind. However, banks and federal organizations have implemented policies and practices to encourage the expansion of green economy concepts.[32] Particularly in the case of renewable energy, certain investments are initiated expressly to qualify for strategy subsidization.

Due to the significance of economic growth in economic literacy, governments and businesses will have more resources to invest in renewables funding and research to facilitate the transition. Mechanization is the primary method for achieving energy consumption and financial sector growth, and it frequently

[29] Riazullah Shinwari and others, 'What Drives Investment in Renewable Energy Resources? Evaluating the Role of Natural Resources Volatility and Economic Performance for China', *Resources Policy*, 77 (2022), 102712 https://doi.org/10.1016/j.resourpol.2022.102712

[30] Daniel Balsalobre-Lorente and others, 'The Environmental Kuznets Curve, Based on the Economic Complexity, and the Pollution Haven Hypothesis in PIIGS Countries', *Renewable Energy*, 185 (2022), 1441–55 https://doi.org/10.1016/j.renene.2021.10.059

[31] Shuzhi Zhang and Guangxiong Xie, 'Promoting Green Investment for Renewable Energy Sources in China: Case Study from Autoregressive Distributed Lagged in Error Correction Approach', *Renewable Energy*, 214 (2023), 359–68 https://doi.org/10.1016/j.renene.2023.05.131

[32] Hongda Liu and others, 'Research on the Peer Behavior of Local Government Green Governance Based on SECI Expansion Model', *Land*, 10.5 (2021), 472 https://doi.org/10.3390/land10050472

coincides with economic expansion.[33] Switching to renewable energy sources is one of the most important and innovative steps toward a green and pollution-free planet. Therefore, we can say that technological advances, transformation, and economic development are intertwined in nations. The effect of policy changes regarding renewable energy on the long-term viability of energy companies and non-energy companies, respectively.

It is widely acknowledged that for an environmental policy to be effective, it must provide the eco-industry with strong incentives to reduce pollution and natural resource consumption by investing in E-R&D.[34] The climate change policies facilitate enormous support from both the public and private sectors, which contributes to the growth of low carbon sectors by introducing investments in green financial instruments, innovation, diffusion, and technological innovation.[35]

As one of the world's most ambitious and comprehensive national energy transition initiatives, the German Energiewende is receiving enormous attention from policymakers and researchers. The national framework for the Energiewende consists of the Renewable Energy Act (REA) and the Federal Energy Concept. These two documents state that Germany's nuclear power plants will be phased out within the next ten years and that its current energy system - which still relies heavily on nuclear power, oil, and coal - will be transformed into an energy system heavily dependent on renewable energies by 2050. Undoubtedly, the REA, as a pillar of the Energiewende, has successfully increased the proportion of renewable energies in the power mix. Renewable energies have flourished mainly in the electricity sector, with their share of gross power consumption increasing to nearly 33 percent in 2015. Since 2010, O2 emissions have decreased slightly, but a consistent downward trend is not imminent. Even though the use of coal for electricity generation has decreased in absolute terms (-14 TWh), it remains at a high level overall. For small-scale private energy entrepreneurs, e REA has provided a massive business incentive. By 2014, private individuals, energy cooperatives, and farmers produced nearly half of Germany's renewable energy. Establishing renewable energy capacities (plant/component production, installation, maintenance, etc.) has had significant direct and indirect gross employment effects. Gross employment in renewables increased from 160 thousand in 2004 to approximately 370 thousand in 2013. Unquestionably,

[33] Denny Irawan and Tatsuyoshi Okimoto, 'Conditional Capital Surplus and Shortfall across Renewable and Non-Renewable Resource Firms', *Energy Economics*, 112 (2022), 106092 https://doi.org/10.1016/j.eneco.2022.106092

[34] Weihua Pan, Hang Cao, and Ying Liu, '"Green" Innovation, Privacy Regulation and Environmental Policy', *Renewable Energy*, 203 (2023), 245–54 https://doi.org/10.1016/j.renene.2022.12.025

[35] Shaiara Husain, Kazi Sohag, and Yanrui Wu, 'The Response of Green Energy and Technology Investment to Climate Policy Uncertainty: An Application of Twin Transitions Strategy', *Technology in Society*, 71 (2022), 102132 https://doi.org/10.1016/j.techsoc.2022.102132

Energiewende has significantly increased electricity prices, particularly for private households and small and medium-sized businesses that do not qualify for special rebates. The cost of electricity for a three-person household has doubled since 2000. In particular, the proportion of taxes and levies has increased from less than 40% to more than 50%.[36]

Participatory governance has become a crucial strategy for the transition to sustainability. Success factors for the energy transition There are numerous opportunities for critical actors to influence participatory processes, such as deciding who can participate, implementing methods to give participants an "equal voice," disseminating information, and fostering trust-building. According to prior research, their actions impact participation processes' inclusiveness, fairness, legitimacy, and efficacy. Despite being a fundamental obstacle to participatory governance processes, Prior research identified the unwillingness of key actors to take participation and participants seriously and to learn as a significant obstacle to the democratic qualities of these processes.[37] Although there have been some objections to using renewable energy in the future, Thus, Energiewende fits the model of ecological modernization. As a result of this narrowing to questions about technology (promotion and acceptance), a negotiation regarding conflicting goals and competing Energiewende visions fall by the wayside, both in terms of the success of the Energiewende itself and its effects on the political culture. First, hazy objectives always risk resulting in ineffective, counterproductive, or costly measures, as previously illustrated with the coal phase-out. Second, there is an increase in conflicts at the level of specific projects as conflicts over Energiewende's objectives are fought out in disputes over its implementation. Third, related to this, some targets should be met, such as reducing greenhouse gas emissions.[38]

Germany's energy transition strategy Additionally, Denmark is implementing its policy. Denmark implements EU directives and decisions regarding global warming mitigation policies. Denmark established three agencies within the Ministry of the Environment, whose primary responsibility is to develop and implement measures to combat the threat of global warming. The Climate Change Act 2014 establishes an overarching strategic framework for implementing national climate policy and transitioning to a low-emission society. It also creates

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36 Leslie Quitzow and others, 'The German Energiewende – What's Happening? Introducing the Special Issue', *Utilities Policy*, 41 (2021), 163–71 https://doi.org/10.1016/j.jup.2016.03.002

37 Anna Ernst and Doris Fuchs, 'Power Dynamics, Shifting Roles, and Learning: Exploring Key Actors in Participation Processes in the German Energy Transformation (Energiewende)', *Energy Research and Social Science*, 85.March 2021 (2022), 102420 https://doi.org/10.1016/j.erss.2021.102420

38 Mario Kendziorski and others, 'Centralized and Decentral Approaches to Succeed the 100% Energiewende in Germany in the European Context – A Model-Based Analysis of Generation, Network, and Storage Investments', *Energy Policy*, 167.April (2022) https://doi.org/10.1016/j.enpol.2022.113039

transparency and public access to the status, direction, and progress of Denmark's climate policy and the Energy Agreement 2012–2020, a comprehensive agreement passed by a majority of parliament that addresses energy efficiency.[39]

Wind energy, wind power technologies, and wind farms are well known in Denmark, a small Nordic nation. In 2019, wind energy accounted for nearly 50 percent of the national total. His brief history of wind power in Denmark describes how the emergence and evolution of Danish wind energy technologies were supported by bottom-up innovation, cooperative values and culture, and top-down policy support. This demonstrates how government policy goals for energy independence and diversification, public anti-nuclear sentiments, and rising environmental awareness gradually translated into a focus on supporting renewable energy sources, primarily wind power[40]. In a case study of a Danish archipelago, Sams (Denmark) is examined. Energy transition policies are a vital component of the energy system transition, with implementation challenges arising from technical changes. In three island energy systems, both technology demonstration projects and scenarios are analyzed, and the requirements for policy alignment as part of a better incorporation of the social dimension are evaluated. Sams implements national regulations in Denmark. By addressing this issue through stakeholder engagement on three distinct European islands, barriers and solutions are identified, and potential development pathways and solutions are presented, indicating the need for a better alignment between local and island conditions and broader policy design.[41]

California can lead global efforts to adapt to and mitigate climate change by capitalizing on the state's history of innovation, economic growth, and science-based policymaking. State climate goals include carbon neutrality by 2045, 100 percent clean electricity by 2045, 25,000 megawatts (MW) of offshore wind by 2045, 100 percent ZEV new car sales by 2035, 7 million climate-friendly and climate-ready homes by 2035, and 6 million heat pumps in buildings by 2030. AB 32. The state's more recent SB 32 legislation requires CARB to adopt rules and regulations ensuring that statewide emissions are further reduced by at least 40% by 2030, and AB 1279 establishes a statewide goal of achieving carbon neutrality no later than 2045. Release of the Ini Scoping Plan in November 2022[42]

[39] Y Yiwananda and H S D Nugrahani, 'Realisasi Kebijakan Energi Terbarukan Uni Eropa (UE) Oleh Denmark Dalam Upaya Menghadapi Ancaman Pemanasan Global', *Intermestic: Journal of …*, 6.1 (2021), 121–46 https://doi.org/10.24198/intermestic.v6n1.7

[40] Katinka Johansen, 'Wind Energy in Denmark: A Short History', *IEEE Power and Energy Magazine*, 19.3 (2021), 94–102 https://doi.org/10.1109/MPE.2021.3057973

[41] Silver Sillak, 'All Talk, and (No) Action? Collaborative Implementation of the Renewable Energy Transition in Two Frontrunner Municipalities in Denmark', *Energy Strategy Reviews*, 45.November 2022 (2023), 101051 https://doi.org/10.1016/j.esr.2023.101051

[42] Kenneth C. Johnson, 'California's Ambitious Greenhouse Gas Policies: Are They Ambitious Enough?', *SSRN Electronic Journal*, 177.April (2022), 113545 https://doi.org/10.2139/ssrn.4189151

California's electricity system is carbon-free. The scenario that minimized solid construction materials mass exhibited near-minimal cost and land use, as well as middle-of-the-pack critical metals use, when 100% zero-carbon electricity systems were developed. This was a result of its use of materially-efficient and land-efficient resources (geothermal, nuclear when permitted) in addition to low-cost utility-solar and battery storage resources. Materially-efficient and land-efficient resources tended to be water-intensive, and the freshwater consumption of the various 100% zero-carbon electricity scenarios varied depending on whether or not such resources were chosen. On-intermittent zero-carbon resources, such as geothermal, hydropower, and nuclear, are land- and materially-efficient per unit of installed capacity. However, California's ability to utilize these resources is constrained by limited conventional geothermal potential, restrictions on hydropower expansion, and a de facto ban on new nuclear power plants. When constructing a 100 percent carbon-free electricity system, these benefits can be realized if one of these constraints is alleviated, either by lifting the ban on new nuclear power or by developing enhanced geothermal systems.[43]

Regarding zero carbon in an energy transition centered on renewable energy, electrical energy storage technologies play an increasingly vital role in California's decarbonization objectives. In the electricity sector, this is primarily due to the strong commitments established by procurement targets, financial subsidy programs, and the resolution of interconnection issues, as well as the added value of market participation resulting from reduced energy bills and financial subsidies. In terms of addressing the fundamental issues associated with the interconnection of energy storage resources and its market participation mechanisms, California is also significantly more advanced.[44]

Challenges and Opportunities in Energy Transition Policy

The transition from inefficient fossil-based energy systems to sustainable energy systems can encounter a number of lock-ins. Nonetheless, numerous routes are feasible. It is essential to have a solid grasp of the dynamic behavior of systems and to have the appropriate instruments to evaluate the outcomes of each selected path.[45] Energy transition, like any other transition, is challenging, and it is vital to understand the underlying structures that drive the behavior of transitions.

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[43] Brian Tarroja, Rebecca Peer, and Emily Grubert, 'Assessing How Non-Carbon Co-Priorities Affect Zero-Carbon Electricity System Development in California under Current Policies', *Journal of Cleaner Production*, 403.September 2022 (2023), 136833 https://doi.org/10.1016/j.jclepro.2023.136833

[44] Aravind Retna Kumar and Gireesh Shrimali, 'Role of Policy in the Development of Business Models for Battery Storage Deployment: The California Case Study', *Electricity Journal*, 34.9 (2021), 107024 https://doi.org/10.1016/j.tej.2021.107024

[45] Andra Blumberga, Armands Gravelsins, and Dagnija Blumberga, 'Deliberation Platform for Energy Transition Policies: How to Make Complex Things Simple', *Energies*, 15.1 (2021), 90 https://doi.org/10.3390/en15010090

Green growth and energy transition are crucial to attaining sustainable development goals (SDGs) and ensuring our planet's sustainable future.[46] The transition to renewable energy presents a multitude of challenges and prospective benefits that have a profound impact on the community. Therefore, it is crucial to increase inclusiveness, equity, and influence. Community-level obstacles, such as adequate and effective community engagement, appropriate renewable energy technology and system design, and dependable operation and maintenance, must continue to be considered in each new initiative for renewable energy supply to remote communities.[47] Energy autonomy is a political factor that corresponds well with the development of renewable energy. Despite the fact that economic factors cause power prices to fluctuate and that the price of electricity has a strong correlation with access to capital, transitioning to renewable energies may help to keep prices in check.[48]

Climate change and environmental degradation continue to be urgent global issues that must be addressed.[49] The current investigation determined that environmental policy rigor offers the most promising solution to the increasing environmental degradation in OECD economies. In addition to the imposition of taxes on numerous emissions and the introduction of emission certificates, governments are obligated to establish a regulatory body that imposes fines on organizations that cause additional harmful discharge while exhibiting policy rigor proportional to the fines. In addition, economies within the OECD should implement environmental strategies to reduce the ecological deficit. This can be accomplished through the imposition of fees to emphasize the scarcity of utilizing resources and the recovery of the costs of sustainable infrastructure and services.[50] In recent years, the price of wind and solar power has decreased substantially, making renewable energy increasingly competitive. According to a report by the IEA, the costs of wind and solar energy in the United States have decreased by 70% and 89%, respectively, by 2010. These trends indicate that economic growth and energy consumption are not mutually exclusive unless a proportion of renewable

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[46] Sami Ullah and others, 'Advancing Sustainable Growth and Energy Transition in the United States through the Lens of Green Energy Innovations, Natural Resources and Environmental Policy', *Resources Policy*, 85 (2023), 103848 https://doi.org/10.1016/j.resourpol.2023.103848

[47] Yao-Jen Hsiao, Jyun-Long Chen, and Cheng-Ting Huang, 'What Are the Challenges and Opportunities in Implementing Taiwan's Aquavoltaics Policy? A Roadmap for Achieving Symbiosis between Small-Scale Aquaculture and Photovoltaics', *Energy Policy*, 153 (2021), 112264 https://doi.org/10.1016/j.enpol.2021.112264

[48] Hongda Liu and Haifeng Zhao, 'Upgrading Models, Evolutionary Mechanisms and Vertical Cases of Service-Oriented Manufacturing in SVC Leading Enterprises: Product-Development and Service-Innovation for Industry 4.0', *Humanities and Social Sciences Communications*, 9.1 (2022), 387 https://doi.org/10.1057/s41599-022-01409-9

[49] Inese Zepa and Volker H. Hoffmann, 'Policy Mixes across Vertical Levels of Governance in the EU: The Case of the Sustainable Energy Transition in Latvia', *Environmental Innovation and Societal Transitions*, 47 (2023), 100699 https://doi.org/10.1016/j.eist.2023.100699

[50] Afshan, Ozturk, and Yaqoob.

energy sources is integrated into the energy matrix. Wind turbines, solar panels, and hydroelectric power are sustainable solutions to the world's energy demands. Clean energy also substantially reduces CO2 emissions, which improves the environment. Several obstacles must be overcome during the transition to renewable energy. Prior to the deployment of renewable energy initiatives, several financial barriers must be overcome, including the high cost of renewable energy infrastructure, initial cost, and operating cost. In the case of nonrenewable energy, these financial barriers are not an issue. To ensure acceptable price detection and financing, market liquidity, and risk management, a financially efficient and well-functioning structure is required.[51] In addition, governments have acknowledged infrastructure investment as a crucial driver of economic prosperity. One of the primary causes for the deterioration of the energy infrastructure is the absence of investment.

Energy and its supporting infrastructure are essential to the economic and social development of the globe. Energy and all of its associated infrastructure are the primary drivers of economic growth and employment creation. Due to the continued modernization of the energy sector, preconditions for the development of investments in the energy infrastructure can be created that are highly stimulating and profitable. However, providing the energy infrastructure with the capacity to meet the unmanaged growth in demand is ultimately unsustainable from an environmental and economic standpoint.[52] Recent forum in Political Geography titled 'Environmental Limits, Scarcity, and Degrowth' evokes age-old tensions between sustainable development and fundamental ecology. Environmental justice studies applied the concept of ecological distribution conflicts (EDC)[53] to investigate the quality of project design participation, local capacities to participate in planning, and the distribution of environmental 'costs' and 'benefits' across populations.[54] To everyone's knowledge, the only feasible method would be to actively halt industrial production. Reducing global energy consumption would facilitate a swift transition to renewable energy.[55] A competitive techno-economic foundation for low-carbon energy transitions and

[51] Naif Alsagr, 'Financial Efficiency and Its Impact on Renewable Energy Investment: Empirical Evidence from Advanced and Emerging Economies', *Journal of Cleaner Production*, 401 (2023), 136738 https://doi.org/10.1016/j.jclepro.2023.136738

[52] M.Yu. Shabalov and others, 'The Influence of Technological Changes in Energy Efficiency on the Infrastructure Deterioration in the Energy Sector', *Energy Reports*, 7 (2021), 2664–80 https://doi.org/10.1016/j.egyr.2021.05.001

[53] Arnim Scheidel and others, 'Environmental Conflicts and Defenders: A Global Overview', *Global Environmental Change*, 63 (2020), 102104 https://doi.org/10.1016/j.gloenvcha.2020.102104

[54] Mary Menton and others, 'Environmental Justice and the SDGs: From Synergies to Gaps and Contradictions', *Sustainability Science*, 15.6 (2020), 1621–36 https://doi.org/10.1007/s11625-020-00789-8

[55] Alexander Dunlap and Louis Laratte, 'European Green Deal Necropolitics: Exploring "Green" Energy Transition, Degrowth & Infrastructural Colonization', *Political Geography*, 97 (2022), 102640 https://doi.org/10.1016/j.polgeo.2022.102640

emergent Green Deals is accelerating the transformation of the energy infrastructure. Increasing research on sociotechnical transitions and energy justice, grouped under the term 'just transitions'.[56] To seize the new opportunities presented by the new round of scientific and technological revolution and industrial transformation, it is prudent to enhance the development of new infrastructure. New infrastructure is an infrastructure system driven by technological innovation, based on information networks, and tailored to the requirements of high-quality development.[57]

In addition, the harmonization of legislation and technical requirements is highlighted as a requirement for achieving this objective, as it would facilitate cross-border trade, increase efficiency through the shared use of resources, and encourage infrastructure investments.[58] When vertical dimensions are not well integrated, complex policymaking is susceptible to failure. The literature on sustainability transition has examined policy alignment using the concept of "policy mix," which refers to the combination of policy instruments and processes through which they emerged and interacted, focusing on a policy mix that spans multiple sectors or technologies at a single level of government, most often the state.[59] Given the uncertainty surrounding future technological, economic, and political developments, governance plays a vital role in context-dependent transition processes.

4. Conclusion

The influence of technological changes in energy efficiency on the infrastructure deterioration in the energy sector. Today, fossil fuels account for 73% of all greenhouse gas (GHG) emissions from the energy sector. Renewable energy technologies and decentralized systems were utilized to lessen the impact of traditional energy sources. Solar energy, river runoff hydroelectric, wind farms, and information technologies were able to steer industrialized nations toward a low-carbon economy. There are numerous mechanisms worldwide for promoting the energy transition (particularly for advancing the development of renewable energy). However, successful implementation and a just energy transition require

[56] Ingmar Lippert and Siddharth Sareen, 'Alleviation of Energy Poverty through Transitions to Low-Carbon Energy Infrastructure', *Energy Research & Social Science*, 100 (2023), 103087 https://doi.org/10.1016/j.erss.2023.103087

[57] Min Gong, Yidi Zeng, and Fan Zhang, 'New Infrastructure, Optimization of Resource Allocation and Upgrading of Industrial Structure', *Finance Research Letters*, 54 (2023), 103754 https://doi.org/10.1016/j.frl.2023.103754

[58] Stefan Borozan, Aleksandra Krkoleva Mateska, and Petar Krstevski, 'Progress of the Electricity Sectors in South East Europe: Challenges and Opportunities in Achieving Compliance with EU Energy Policy', *Energy Reports*, 7 (2021), 8730–41 https://doi.org/10.1016/j.egyr.2021.11.203

[59] Giliberto Capano and Michael Howlett, 'The Knowns and Unknowns of Policy Instrument Analysis: Policy Tools and the Current Research Agenda on Policy Mixes', *SAGE Open*, 10.1 (2020), 215824401990056 https://doi.org/10.1177/2158244019900568

the combination of technological solutions with more open decision making based on solid analysis, engineering, and social science knowledge. The energy sector is undergoing a technological transition towards the enormous incorporation of new computing technologies to assist with operational, management, and commercialization duties. Models of energy management have been modified to make them more adaptable and dynamic, with intelligent monitoring and control of production, distribution, storage, and energy consumption. The results indicate that a global energy transition will have a positive effect on the future stability and development of economies worldwide. Therefore, the green investment promotion for Renewable energy has acquired prominence in recent years and is now at the forefront of global efforts to reform the energy sector. The climate change policies facilitate enormous support from both the public and private sectors, which contributes to the growth of low carbon sectors by introducing investments in green financial instruments, innovation, diffusion, and technological innovation. The transition from inefficient fossil-based energy systems to sustainable energy systems can encounter a number of lock-ins. Therefore, it is crucial to increase inclusiveness, equity, and influence. Germany's Energiewende has achieved success in the energy transition by transitioning from non-renewable to renewable energy sources. This has resulted in an increase in the utilization of renewable energy over time. Denmark's energy transition policy has a positive effect on countries undergoing an energy transition, and according to its policy, Denmark is ranked first on the scale of the United Arab Emirates as a leader in the energy transition. California has a clean energy policy and a carbon reduction policy to 100 percent zero carbon, which is one of the battery manufacturing policies whose successful implementation can serve as a model for Indonesia. Energy and all of its associated infrastructure are the primary drivers of economic growth and employment creation. In addition, the harmonization of legislation and technical requirements is highlighted as a requirement for achieving this objective.

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