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Addressing Regional Disparities in South Africa's Just Energy Transition: A Case for Green Infrastructure Planning

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1 ABSTRACT

Amidst the global push for decarbonization, solar and wind energy are rapidly gaining acceptance due to their minimal environmental impact and low carbon footprint. This global shift towards green energy transition presents both opportunities and challenges, particularly in addressing regional disparities in infrastructure investment. Using South Africa as a case study, this study employs a mixed-methods research approach, drawing on both primary and secondary data sources. It examines the historical context, governance, and regulatory framework influencing the Just Energy Transition in South Africa. The findings highlight significant spatial disparities in green infrastructure development, with limited investment observed in regions like Mpumalanga and Limpopo, which remain heavily reliant on fossil fuels. The study concludes by recommending indicators to identify priority areas for green infrastructure planning, thereby supporting a more equitable energy transition.

Keywords: Green infrastructure, regional disparities, fossil fuels, Just Energy Transition, South Africa

2 INTRODUCTION

South Africa is the largest carbon emitter in Africa, accounting for 40% of the continent's total emissions. It is also one of the most carbon-intensive developing economies in the world (Salahuddin et al. 2019; Udeagha and Breitenbach, 2023). According to World Bank (2021) South Africa is the continent's largest contributor to climate change and the world's 15th-largest producer of CO2 (making up 1.09% of global emissions). One of the most unequal countries in the world is South Africa, where the wealthiest 10 percent of the population own 86% of the nation's total wealth, over 30% of workers are unemployed, with youth unemployment exceeding 65%, and 55% of people live in poverty (IRENA, 2023). South Africa is now confronted with the urgent need to transition to cleaner power sources as a nation historically reliant on coal for its energy needs.

Globally to fight the global climate crisis, the European Union has committed to reducing its greenhouse gas emissions to net zero by 2050 (Pacesila et al., 2016). A fundamental step on that road is phasing out coal-based industry as coal has been outlined as a highly polluting energy source. In 2019, the European Commission unveiled its new development strategy, the European Green Deal (EGD), that seeks to reduce GHG emissions to net-zero and a decoupling of economic growth from resource use by 2050. The aim of this strategy was to conserve and enhance the EU's natural capital while protecting the health and well-being of its citizens from environment-related risks and impacts (Potrč et al., 2021). The EGD also stressed the need for a just and inclusive transition and presented a set of policy measures in key areas such as energy, industry, construction, transportation, agriculture, ecosystems, and pollution control. Moreover, it highlighted the need to strengthen cooperation between key stakeholders, to jointly promote just transition policies that "leave no one behind" (Musiał, et al., 2021; Brodny et al., 2021).

Germany's transition away from coal has not result in the abandonment of traditional coal industries. Rather, a focus on strengthening or upgrading these industries to make them more sustainable (Maliszewska-Nienartowicz, 2024). This process involved upgrading equipment and technology, reducing production, and adjusting product portfolios to enhance competitiveness. To facilitate this transition, Germany has implemented a targeted industrial policy that created a favourable institutional framework and market environment for industrial development (Ozkan, et al., 2024). This included providing financial subsidies and reducing land costs where necessary. The aim is to incentivize SME development, thus promoting vitality through the redevelopment. Additionally, policies aimed at improving the local investment environment attracted a significant number of emerging companies. Statistics show that during the transition

period, the fast-growing services sector absorbed 40% of the workers leaving traditional coal industries (Pata et al., 2023).

Poland's coal sector has been in a gradual but steady decline since 1990. Annual production in Poland was reduced by 50% between 1988 and 2019. This was driven by policy-led strategies aimed at reductions in hard coal. The number of operating coal mines declined from 70 in 1990 to 24 in 2021, and more are scheduled for closure in 2024 (Sokołowski et al., 2022). The Poland energy transition has been slow due to financial stresses. The industry continues to suffer from weak market conditions and elevated production costs, partly due to surplus labour, and partly due to the low quality of coal produced. In the past years, employment in the coal sector has reduced. The construction, manufacturing, and energy sectors have the highest potential to replace the coal sector jobs. These industries provide relatively good wages, are similar in terms of the required skills and competencies and are also in line with regional specializations.

One potential solution to repurpose the site would be the installation of a solar power facility (solar farm). The transitioning from a power plant to a different kind of renewable power source upon decommissioning may be perceived by the public as less risky than transitioning to a non-energy use (Idoko et al., 2024). With respect to coal-based communities, community members have expressed a desire to preserve their way of life, which had been enabled by and formed around the coal power plant (Pata, 2021). Because of this, a transition between two kinds of energy generation may feel like a natural pathway for the host community. Additionally, many former plant sites have retained critical electric power infrastructure that could make the transition to solar easier (Nakhli et al., 2022). There is already a precedent for siting large-scale solar operations on formerly contaminated sites through a process called "RE-powering" (Lin et al., 2021; King et al., 2021). A solar farm may also appeal to a utility that needs to manage risk because, apart from installation, solar farms require significantly less maintenance, which means less need for worker access to the site (Borowski, 2022). While fewer onsite workers may be seen as an advantage by the utility, it does mean that a solar farm would likely do little to mitigate the loss of skilled jobs after nuclear power plant closure.

To address climate risks, the South African government has created and is still creating extensive institutional, regulatory, policy, and governance frameworks in collaboration with important social groups (see Figure 1). Together, they provide the frameworks that make climate-related investments in adaptation, mitigation, and the just transition possible (Mirzania et al., 2023; Streimikiene et al., 2021; Heffron, 2022). They also show that South Africa is committed to fundamentally reshaping the electricity industry to address energy poverty and competitiveness, guarantee fair and inexpensive access to clean energy, and develop the human capital necessary for a new energy economy. The shift to cleaner energy sectors offers job opportunities as well (Musonda et al., 2025). The 2019 Integrated Resource Plan (IRP), the government's electricity plan, describes a strategy to diversify electricity production with a major emphasis on renewable energy sources. Twenty percent of the new capacity will come from grid-connected solar photovoltaics (PV), and about fifty percent will come from wind energy (Huang & Liu, 2021).

Nevertheless, many parts used in renewable energy are currently made outside of the country. Investing in the knowledge and equipment needed to produce these parts locally – like wind turbines – can generate long-term employment opportunities here at home and lead to more opportunities via export. It's critical to understand that jobs generated in the renewable energy sector do not always result in employment for those previously employed in coal plants (Chirisa et al., 2021). A reskilling plan is necessary for a just energy transition to guarantee that people have access to sufficient training.

Given South Africa has several power plants that are planned for decommissioning. The study assesses regional disparities in infrastructure investment using South Africa as case study. The shutting down of the old plant station will not significantly impact the national electricity grid as the remaining unit only contributed 121MW. Eskom has transferred the majority of employees from power station that have shut down to support and augment skills in other power stations and areas of the business in line with operational requirements. As of October 5, 2023, Eskom is considering delaying the decommissioning of some coal plants until 2030. This is due to appeals that could force Eskom to shut down some stations to meet minimum emissions standards. Several power plants have plans to repurpose the sites for renewable energy projects. The Komati power station had been operating at only 125 MW capacity since 2021. This will be replaced with a combination of 220 MW of renewable energy solutions (including 150 MW solar PV solar

and 70 MW wind) and 150 MW batteries, improving power supply and grid stability. The World bank funds this project to assist energy transition plans in South Africa.

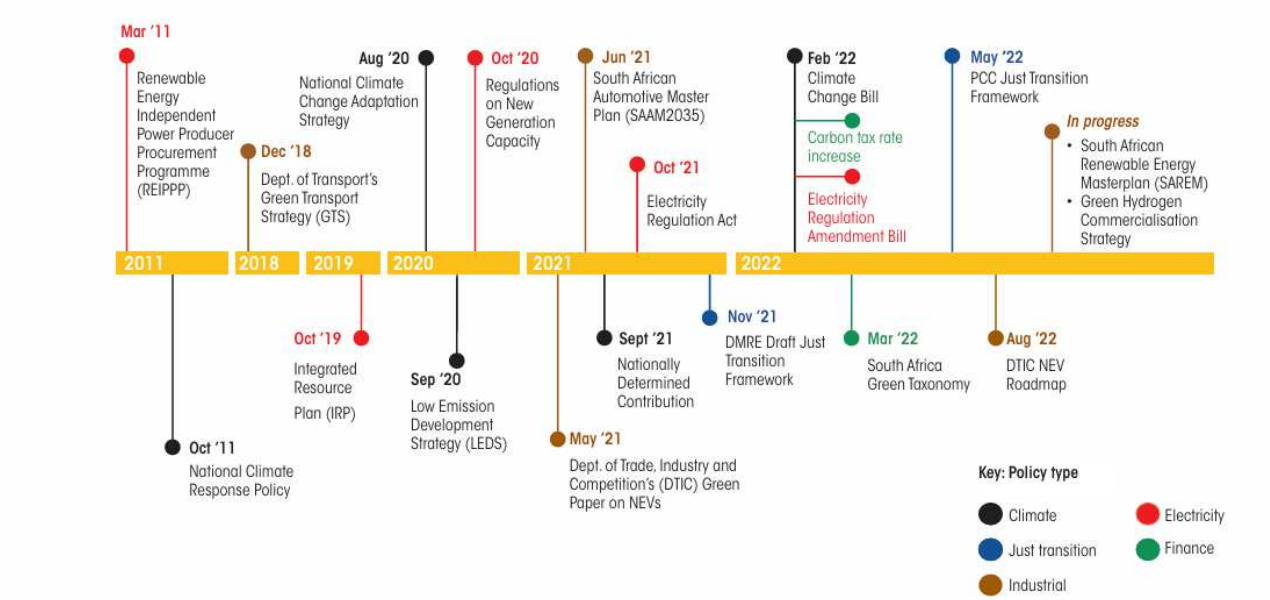

Figure 1: Key policies enabling energy transition in South Africa

3 METHODOLOGY

Using South Africa as a case study, this study employs a mixed-methods research approach, drawing on both primary and secondary data sources. Historical and current literature on governance, and regulatory framework influencing the Just Energy Transition in South Africa was reviewed. Additionally, Open source geographic information datasets were obtained from the Department of Agriculture, Land Reform and Rural Development (see table 1). The approach sheds light on the trade-offs between renewable energy plans and energy sector employment impact, while examining the distributional implications of these policy choices.

Format	Dataset
Shapefile	Location of power plants
Shapefile	Location of Green energy projects
Shapefile	Renewable Energy Development zones
Excel	Green energy projects

Table 1: Datasets

4 FINDINGS AND DISCUSSION

The corridors are important for planning the distribution and transmission of electricity infrastructure. In 2018, the Government published a notice that identifies five strategic transmission corridors and the procedures for applying for environmental authorization. There are currently five renewable energy zones which have been earmarked for the development of large-scale wind and solar projects (commonly known as RED Zones) (Figure 2).

Five existing power corridors support the RED Zones to develop large-scale electricity transmission and distribution infrastructure. These areas were chosen based on the findings of strategic environmental assessments: development is prioritised in specific geographic locations which have an abundance of resources (such as wind and sun), low environmental sensitivity, and where there is an increased need for socio-economic development, among other things. For example, the placement of RED Zones in mining areas aims to provide opportunities for rehabilitation, the re-use of existing infrastructure, and continued employment for local communities when the mines are eventually decommissioned.

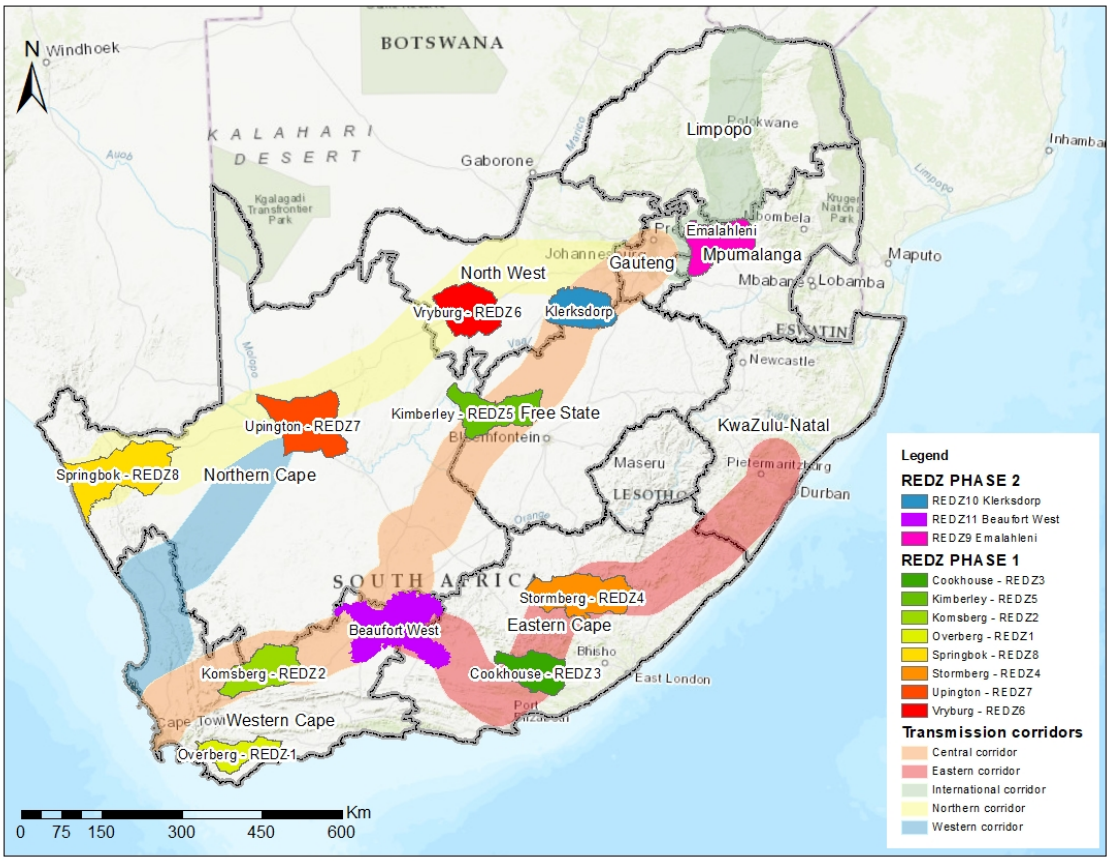

Figure 2: Renewable Energy Development zones.

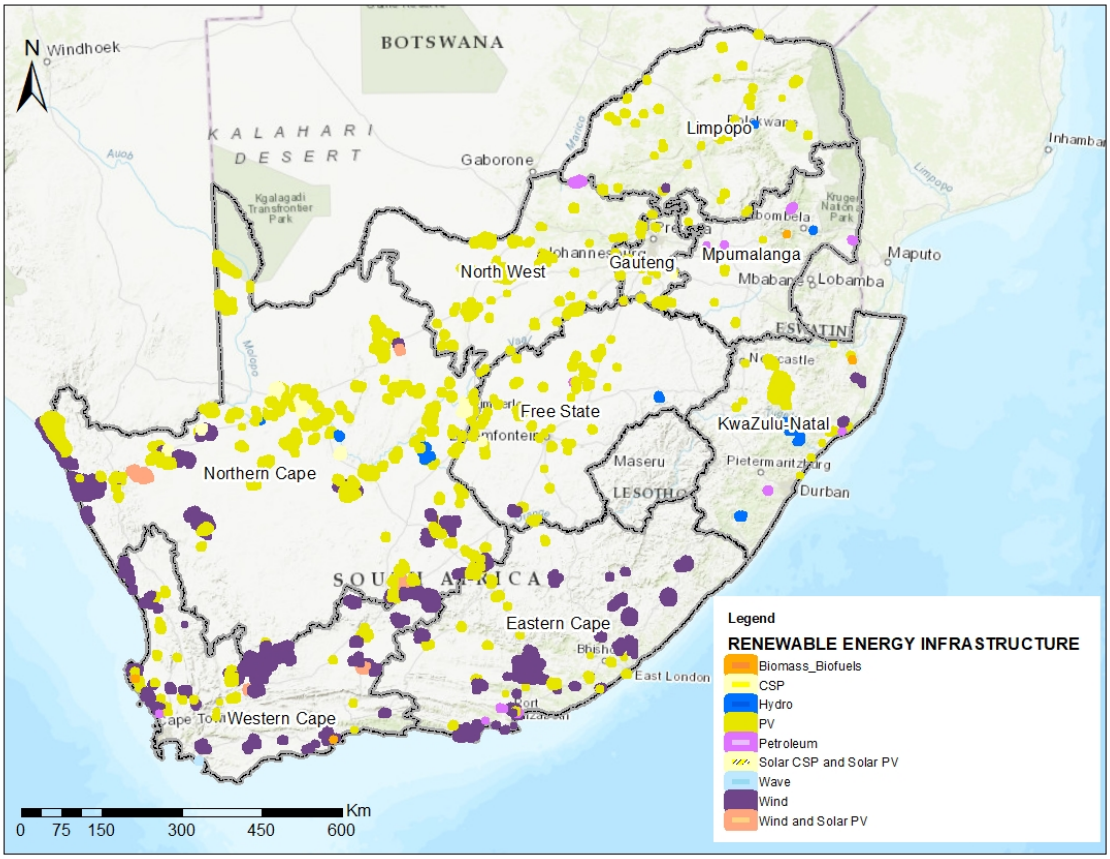

Figure 3: Spatial distribution of renewable energy projects.

The government has set goals to reduce emissions and increase the share of renewable energy in the national energy mix. To support this initiative several sites have been identified for clean energy projects, including solar, wind, and biomass (Figure 3). The South African Renewable Energy Masterplan informs these projects. Create and sustain decent employment across the value chain, from development and construction, to manufacturing and services, to operations and maintenance, to end-of-life management.

Expansion of the industrial capacity in the renewable energy and storage value chain should be supported with plans to develop the local industrial capabilities in the production of renewable energy and storage components, parts and systems to ensure the availability of supply for the domestic market as well as shield the local market from excessive price volatility.

1608 have been approved, 210 are under review, 29 projects were refused and 1 is currently under review (Figure 4). Renewable energy and battery value chains create a wide range of employment opportunities, particularly for skilled and semi-skilled workers. Over the first four bid windows, REIPPPP projects committed to the creation of 63 291 job-years (48 110 in construction and 15 182 in operations).[1] It is further estimated that about 20 000 people were directly employed in the solar energy value chain in South Africa in 2022.

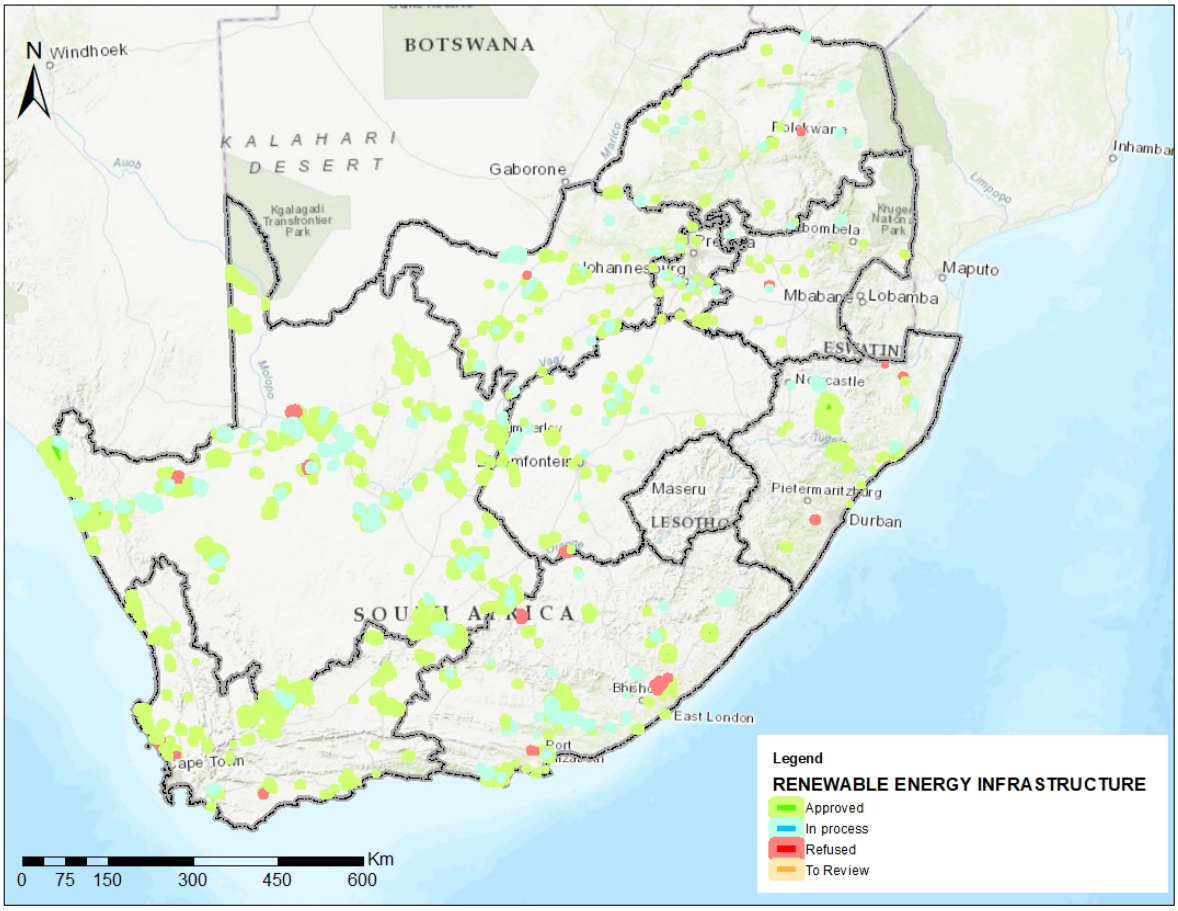

Figure 4: Status of projects.

5 LESSONS LEARNED AND IMPLICATIONS FOR POLICY

Overall, the case studies found that while many coals related jobs are at risk because of energy transition, there are available options retrain and upskill employees. Though the number of coal industry jobs is modest 4.7 million jobs globally and shrinking, the industry generates significant indirect jobs across economic sectors. Closing coal-based energy plants has implications for labour markets beyond the power plants

[1] IPPO, 2022. Independent Power Producers Procurement Programme (IPPPP): An Overview as at 31 December 2021. Independent Power Producer Office. Pretoria and Johannesburg: Department of Mineral Resources and Energy, Development Bank of Southern Africa and National Treasury.

workers. It negatively affects workers along the coal value chain, hurts local economies reliant on mine workers' earnings, fragments community well-being and social capital, and squeezes public finances.

In some communities, closing power plants can create a persistent, destabilizing demand shock as displaced workers struggle to transition to new jobs, because few alternatives are available, or workers are unwilling to accept lower-paying options or move to regions with greater labour demand. Given that coal production is concentrated in just a few countries, global coal phase-out targets could be achieved through ambitious action by a small number of key players. But, instead of phasing out, some countries are ramping up coal production for export.

Lessons from power plant closures illustrate the complexities and risks of inadequate planning, coordination and stakeholder consultation, insufficient investment, and poor policy design. A critical aspect to planning for coal transitions will be laying the foundations for attracting private investment and stimulating private-sector labour demand and business development. This calls for supportive infrastructure and institutions, education curricula aligned with the skill needs of emerging sectors, and a conducive regulatory environment. To address spatial misalignments related to employment, it was observered new jobs may be created in different communities, regions or countries than those where the principal job losses occur. This is particularly the case in locations that lack economic diversification. While sectoral misalignments rising from industries may draw more heavily on raw materials or intermediate inputs from sectors that are quite different from those that supply once prominent but now declining industries.

6 CONCLUSION

In conclusion the rise and decline of coal plant over the last century had the effect of building power-plant-dependent economies through coal-based employment, and then exposing these communities to severe negative shocks. Many of these relatively communities were already lagging in terms of socio-economic development; the sharp reduction in coal demand over the past several decades created further dislocation that undermined their economic sustainability. The magnitude of the impact across counties varies, as does the degree of economic resilience and capacity to transition to alternative industries. Some counties transitioned early, while others delayed the difficult and costly adjustment needed to diversify their local economies.

7 REFERENCES

Borowski, P.F., 2022. Mitigating climate change and the development of green energy versus a return to fossil fuels due to the energy crisis in 2022. Energies, 15(24), p.9289.

Brodny, J., Tutak, M. and Bindzár, P., 2021. Assessing the level of renewable energy development in the European Union member states. A 10-year perspective. Energies, 14(13), p.3765.

Chirisa, I., Gumbo, T., Gundu-Jakarasi, V.N., Zhakata, W., Karakadzai, T., Dipura, R. and Moyo, T., 2021. Interrogating climate adaptation financing in Zimbabwe: Proposed direction. Sustainability, 13(12), p.6517.

Heffron, R.J., 2022. Applying energy justice into the energy transition. Renewable and Sustainable Energy Reviews, 156, p.111936.

Huang, P. and Liu, Y., 2021. Toward just energy transitions in authoritarian regimes: indirect participation and adaptive governance. Journal of Environmental Planning and Management, 64(1), pp.1-21.

Idoko, I.P., Ijiga, O.M., Harry, K.D., Ezebuka, C.C., Ukatu, I.E. and Peace, A.E., 2024. Renewable energy policies: A comparative analysis of Nigeria and the USA. World Journal of Advanced Research and Reviews, 21(1), pp.888-913.

King, M., Jain, A., Bhakar, R., Mathur, J. and Wang, J., 2021. Overview of current compressed air energy storage projects and analysis of the potential underground storage capacity in India and the UK. Renewable and Sustainable Energy Reviews, 139, p.110705.

Lin, Y.L., Zheng, N.Y. and Lin, C.S., 2021. Repurposing Washingtonia filifera petiole and Sterculia foetida follicle waste biomass for renewable energy through torrefaction. Energy, 223, p.120101.

Maliszewska-Nienartowicz, J., 2024. Impact of Russia's invasion of Ukraine on renewable energy development in Germany and Italy. Utilities Policy, 87, p.101731.

Mirzania, P., Gordon, J.A., Balta-Ozkan, N., Sayan, R.C. and Marais, L., 2023. Barriers to powering past coal: Implications for a just energy transition in South Africa. Energy Research & Social Science, 101, p.103122.

Musiał, W., Zioło, M., Luty, L. and Musiał, K., 2021. Energy policy of European Union member states in the context of renewable energy sources development. Energies, 14(10), p.2864.

Musonda, I., Onososen, A. and Moyo, T., 2025. Digital Transitioning in the Built Environment of Developing Countries. Taylor & Francis.

Nakhli, M.S., Shahbaz, M., Jebli, M.B. and Wang, S., 2022. Nexus between economic policy uncertainty, renewable & non-renewable energy and carbon emissions: contextual evidence in carbon neutrality dream of USA. Renewable Energy, 185, pp.75-85.

Ozkan, Oktay, Babatunde Sunday Eweade, and Ojonugwa Usman. "Assessing the impact of resource efficiency, renewable energy R&D spending, and green technologies on environmental sustainability in Germany: evidence from a wavelet quantile-on-quantile regression." Journal of Cleaner Production 450 (2024): 141992.

Pacesila, M., Burcea, S.G. and Colesca, S.E., 2016. Analysis of renewable energies in European Union. Renewable and Sustainable Energy Reviews, 56, pp.156-170.

Pata, U.K., 2021. Do renewable energy and health expenditures improve load capacity factor in the USA and Japan? A new approach to environmental issues. The European Journal of Health Economics, 22(9), pp.1427-1439.

Pata, U.K., Erdogan, S. and Ozcan, B., 2023. Evaluating the role of the share and intensity of renewable energy for sustainable development in Germany. Journal of Cleaner Production, 421, p.138482.

Potrč, S., Čuček, L., Martin, M. and Kravanja, Z., 2021. Sustainable renewable energy supply networks optimization–The gradual transition to a renewable energy system within the European Union by 2050. Renewable and Sustainable Energy Reviews, 146, p.111186.

Salahuddin, M., Ali, M.I., Vink, N. and Gow, J., 2019. The effects of urbanization and globalization on CO 2 emissions: evidence from the Sub-Saharan Africa (SSA) countries. Environmental Science and Pollution Research, 26, pp.2699-2709.

Sokołowski, J., Frankowski, J., Mazurkiewicz, J. and Lewandowski, P., 2022. Hard coal phase-out and the labour market transition pathways: The case of Poland. Environmental Innovation and Societal Transitions, 43, pp.80-98.

Streimikiene, D., Kyriakopoulos, G.L., Lekavicius, V. and Siksnelyte-Butkiene, I., 2021. Energy poverty and low carbon just energy transition: comparative study in Lithuania and Greece. Social indicators research, 158(1), pp.319-371.

Udeagha, M.C. and Breitenbach, M.C., 2023. Exploring the moderating role of financial development in environmental Kuznets curve for South Africa: fresh evidence from the novel dynamic ARDL simulations approach. Financial Innovation, 9(1), p.5.

Wang, X. and Lo, K., 2021. Just transition: A conceptual review. Energy Research & Social Science, 82, p.102291.