

THE ENERGY-CLIMATE NEXUS: AN INTEGRATED FRAMEWORK FOR SUSTAINABLE DEVELOPMENT IN EMERGING ECONOMIES

Dr. Yasir Arafat^{*1}, Mr. Suhrab Ahmad², Ms. Azra Amir³

^{*1}Lecturer, Department of Economics, University of Chitral, KP Pakistan

^{2,3}Lecturer, Department of Political Science, University of Chitral, KP Pakistan

^{*1}yasir.eco@uoch.edu.pk

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Corresponding Author: *

Dr. Yasir Arafat

Abstract

Developing nations are facing the enormous challenge of energy needs of all people in the regions and at the same time these countries are moving their energy sources to renewables and building energy resilience. The present study delves into one of the central aspects of the world map of fairness i.e. those countries that are responsible for less than 4% of total historic emissions of the atmosphere and are the most susceptible to energy infrastructure failure caused by climate impacts. The research is done through a multimodal approach which involves macroeconomic modeling, econometric analysis of 50 countries from 2000 to 2025, and three case studies of Pakistan, Vietnam, and Bangladesh for identifying the major structural barriers. The referred paper, among others, points to the insufficient climate financing and the trade tariffs which not only increase the transition costs but also make the change harder.

One of the core results is the strong, statistically significant negative correlation between climate vulnerability and energy security ($\beta = -0.32$, $p < 0.01$). The research strongly supports the implementation of efficient carbon pricing, stating that using its revenues for recycling could create a fiscal 'double dividend' for financing climate-resilient infrastructure. The research identifies a feasible concerted strategy with the help of three main components: risk-informed planning, market-based fiscal reforms, and the selective use of international aid to help disadvantaged countries that face the most profound inequities.

INTRODUCTION

Third World countries are a group of nations from the category of the developing countries. Such nations should make the first two achievements their main elements of the 21st-century development path that they would be using repeatedly later on: Besides that, these countries must first change their modernization processes completely in order to eradicate poverty, and secondly, they still need to recognize that the climate crisis is a global enemy, being their adversary. Still, energy is the core of development and can serve as the main example for the entire social system; however, on the contrary, it can be the primary cause

of a hospital revolution, but, at the same time, an industry headlight of the knowledge era with which we call clean and zero carbon technologies to be the ones that coexist as the complete solution for the necessary energization of the emerging market if we are willing to satisfy the global electricity demands and at the same time the debt and pollution reduction targets to co-exist. The situation is being managed with such great and seldom mentioned complexity, and the main factor of global distributive inequality is leading the operation. But, the majority of the pollutants that contribute to the air, and the gases that

are the main reason for the climate crisis, come from the industrialized countries, whereas the developing economies - notably the LDCs and SIDS - are only responsible for 4% of total global CO₂ emissions but at the same time they are the most impacted by climate change. Moreover, the main cause of SDG 7 arrears is the condition of 685 million people who live without power supply, which implies a huge challenge.

In most cases, energy access has been treated entirely separately from the climate change issue in conventional policy assessments. These analyses depict energy and climate as two distinct domains with no relationship or systemic trade-offs. This paper aims to dismantle the barrier by introducing and evaluating a shared policy that would be the most judicious dependence of the three interconnected pillars as its foundation.

Really, the researchers changed their viewpoint in numerous ways. Essentially, the research has been extremely "in the air" with macroeconomic modeling, more precisely the use of CGE models for climate change-related risk management and the use of DSGE models for sudden shocks, to become the most resilient framework for the policy evaluation. To be beyond the restrictions of just theory and to be near the practical analysis, they have employed panel data econometrics for 50 developing countries over the last 25 years (2000-2025) to study the interrelationships between climate vulnerability, quality of governance, and energy outputs.

The numbers in this paper are supported by the detailed comparative case studies of Pakistan, Vietnam and Bangladesh, which are the top examples of the changing role of institutional governance in the success of the transition. According to the article, the combined approach is presented as a just energy transition model that features properly risk-assessed planning, change of policy through market mechanisms, and changes in the governance structures at the local and global levels. The next chapters have the entire up-to-date literature review, research design, findings, and policy synthesis based on the evidence.

2. Literature Review

The energy-climate nexus research in third-world countries is an expansive research area with many interdisciplinary connections from economics and engineering to politics. The main analysis here surveys the indicators of the mentioned works that outline their major intuitive conceptions and informs them of the most significant gaps.

2.1. The Energy Poverty and Development Nexus

The first position in the discussion forum is titled "Energy as the primary driver of the socio-economic development of the Third World". In parallel to that, Goldenberg et al. (1985) conceptually explicated the underlying mechanism of how the extensive use of traditional biomass fuels leads into a vicious cycle of poverty and environmental degradation. Contemporary artists-have measurable parameters for this correlation that they identify through the variables linked with the educational outcome and also the global healthcare standard improvement, new venture funding getting access to reliable electricity demonstrates as one of the most marketable indicators (Bhattacharyya, 2019). The International Energy Agency (IEA) has played a role, among others, in monitoring and measuring progress. Their most recent reports state the aforementioned progress as "the pace of electrification in SSA and parts of Asia continues to lag with the targets for SDG 7 being difficult to meet". But the problem has changed character - from providing the light to the world to securing the adequate supply of industrial power as the process of industrialization is underway in many developing countries. "The changing demand and supply scenario requires that the amount of electricity generation projects in developing countries should increase more than double by 2035 if we want to have enough clean energy and electricity for all of the world's developing countries. The investments needed have to be overwhelmingly covered by private capital because public money is simply not enough; we have to be very smart in spinning off the balance of the capital"- said Fatih Birol, the executive director of the International Energy Agency (IEA).

2.2. Climate Vulnerability, Justice, and Historical Responsibility

There is a parallel and equally extensive body of literature that deals with the extreme vulnerability of developing countries to climate change. The Intergovernmental Panel on Climate Change (IPCC) reports have been very clear and consistent in highlighting the risks that these regions are exposed to because they have high exposure to these risks, are highly sensitive, and have low adaptive capacity. Hallegatte et al. (2016) showed that the poor are the ones most impacted, as they generally live in areas that are geographically vulnerable and have no financial resources to fall back on during a crisis. This has led to a major shift in the use of climate adaptation as the main instrument in development planning. From an ethical point of view, this vulnerability is described by the concept of "common but differentiated responsibilities and respective capabilities" (CBDR-RC), which is a part of the UNFCCC and is a principle that developed countries are obliged to provide financial and technological support. The limitations and challenges facing mitigation policy in developing economies because of minimal historical responsibility and acute development needs are at the core of the climate justice versus energy-driven growth debate.

2.3. Technological Pathways and Policy Instruments

Decentralized Renewable Energy (DRE) has been extensively praised in articles as a game-changer that can, at the same time, increase energy availability and make the system carbon-free. Several studies have revealed that off-grid and mini-grid solutions are usually the cheapest way to produce electricity for the remote population (Bhattacharyya, 2019). The dwindling costs of solar PV and wind power have been the main point in favor of the argument that they are becoming more and more competitive with fossil fuels. However, a great deal of literature warns that it is not enough by itself. The large-scale development of DRE requires a well-coordinated policy framework that goes beyond just Renewable Energy and Energy Efficiency Action Plans (NREAPs/NEEAPs) but also includes regulatory security and human capacity-building. Sovacool (2021) argues that the shift to a cleaner energy system can only be made by "socio-

technical" systems that handle the hardware as well as the institutions, the markets, and the user practices.

2.4. Financing Gaps and Structural Barriers in the Global Economy

Financing remains a major obstacle and is, among other things, widely mentioned in literature. Although international public climate finance flows to developing countries are increasing, the reports consistently call them insufficient and disproportionately advantageous to middle-income economies rather than to the most vulnerable LDCs and SIDS. There is a core contradiction between the "mobilizing" of private finance stressed by developed countries and the direct "provision" of concessional public finance requested by the developing countries, in accordance with the Paris Agreement. Besides, the trade and climate literature reveals that global trade policies put extra burdens on climate fighting. Just the tariffs imposed on intermediate goods for solar and wind technologies, accompanied by non-tariff measures, are enough to raise directly the costs of technology deployment and to bind developing nations in the position of raw material exporters, thus losing green industrialization and further value addition (UNCTAD, 2023). This situation is described as the "industrialization trap" that keeps the economic vulnerability cycle going.

Due to the vast body of literature advocating for Decentralized Renewable Energy (DRE), it is deemed a game-changer solution viable to open energy access and green the system at the same time. Several studies have revealed that off-grid and mini-grid solutions are most of the time the cheapest ways to provide electricity to far-off communities (Bhattacharyya, 2019). One of the main reasons for this kind of debate is the rapid cost reduction of the solar PV and wind power that has been pushing these two clean energy sources as a progressive choice against fossil fuels. The writing is, by and large, reserved, and frequently, a doubtful attitude is shown towards the idea that technology alone can lead the way. In order to implement a sizable off-grid renewable energy system, a sound and comprehensive policy framework is required, along with National Renewable Energy and Energy Efficiency Action Plans (NREAPs/NEEAPs), and also human capacity development. Sovacool (2021) points out that these great social-technical

transformations "need to engage not only vast amounts of hardware, but, at the same time,

institutions, markets, and user practices".

Table 1: Key Themes and Gaps in Energy-Climate Literature

Thematic Area	Key Consensus	Persisting Research/Practice Gaps
Energy Poverty & Development	Energy access is a prerequisite for meeting SDGs. Demand is surging in developing economies.	Financing gap for modern, reliable energy infrastructure. Effective models for public-private partnerships.
Climate Vulnerability	Developing economies are disproportionately affected. Hydropower is highly vulnerable to variability.	Quantitative, econometric evidence on the macroeconomic impact of climate shocks on energy systems.
Policy Solutions (DRE)	DRE is a critical tool for access and decarbonization.	Integration of DRE into national grids and financial sustainability of off-grid business models.
Finance & Trade	Climate finance is insufficient and inequitable. Trade barriers increase technology costs.	Mechanisms for equitable fund distribution and trade policy reform for local green industrialization.

Table 1: The table outlines the knowledge base with the main questions that are still unknown. It identifies the difference from only understanding the problems and applying solutions that are both working and scalable, hence the indication of the present study's extensive and empirical inquiry.

This investigation is a combined-method study which uses different methodologies to come up with one set of findings and to provide a complete overview of the energy-climate nexus. Although the different steps of the methodology are arranged sequentially, there is also a logical connection between them.

3.0. Methodology

This research is a combined-method study that employs multiple methods to produce one set of results and to give a comprehensive review of the energy-climate nexus. Even though the stages of the methodology are implemented in a stepwise manner, there is also a flow of ideas that binds them.

3.1. Macroeconomic Modeling for Policy Simulation

To show the economic effects of climate issues and the measures taken by the policy, this research employs two different but complementary

macroeconomic models. The leading instrument for the portrayal of climate change's persistent, systemic impact on the economy through various sectors is the in-depth sectoral disaggregated Computable General Equilibrium (CGE) models. Besides, CGE models facilitate the performance of an overall analysis of the socio-economic consequences of a large range of policies such as carbon pricing by the distribution of the sectoral allocation of economies. On the other hand, Dynamic Stochastic General Equilibrium (DSGE) models that are volatility-oriented are utilized in the study to cater for the macroeconomic impact of sudden climate shocks (e.g., hurricanes, very dry periods) on fiscal stability, inflation, and output, thus they become the source of short-term resilience and disaster response strategies.

3.2. Econometric Analysis

To test empirically, relationships between significant, observable variables, a panel data econometric model is made use of. Data for the 50 developing countries from the year 2000 to 2022 has been collected from the World Development Indicators, IEA, and the Notre Dame Global Adaptation Index. The base model is shown as below:

$$\text{EnergySecurity}_{it} = \beta_0 + \beta_1 \text{ClimateVulnerability}_{it} + \beta_2 \text{Governance}_{it} + \beta_3 \text{DREInvestment}_{it} + \beta_4 \text{TradeOpenness}_{it} + \alpha_i + \lambda_t + \epsilon_{it}$$

Where:

- **Energy Security:** Dependent variable, measured as electricity access (% of the population) and quality of supply (system losses).
- **Climate Vulnerability:** Main independent variable, indicated by an index of exposure to climate extremes.
- **Governance:** Worldwide Governance Indicators (e.g., regulatory quality, control of corruption) are used to measure the variable.
- **DRE Investment:** The investment flow that occurred in renewable decentralized projects.
- **Trade Openness:** The total of imports and exports as a percentage of the GDP.
- **α_i :** The country-fixed effects (to control for time-invariant country characteristics).
- **λ_t :** The year-fixed effects (to control global shocks).
- **ϵ_{it} :** The error term.

This model can estimate the effects of climate vulnerability and governance on energy security,

which is the main ceteris paribus assumption, thus, it allows for quantitative evidence to back up the modeling and case study approaches.

3.3. Comparative Case Study Analysis

To understand the "how" and "why" of policy success and failure, a comparison of Pakistan, Vietnam, and Bangladesh was carried out that is structured, focused, and detailed. This qualitative method looks at the influence of certain variables—policy coherence, regulatory certainty, and the rule of law—on energy-climate outcomes, offering context and causal mechanism to the numbers that go along with it.

3.4. Comparative Case Study Analysis

To understand the "how" and "why" of policy success and failure, a comparison of Senegal and Liberia was carried out that is structured, focused, and detailed. This qualitative method looks at the influence of certain variables—policy coherence, regulatory certainty, and the rule of law—on energy-climate outcomes, offering context and causal mechanism to the numbers that go along with it.

4. Empirical Analysis and Findings

4.1. Econometric Results: Quantifying Vulnerabilities and Leverage Points

Fixed-effects panel regression results serve as the main source of the paper's core arguments, providing the basis for those arguments with comprehensive statistical evidence.

Table 2: Econometric Results: Determinants of Energy Security in Developing Economies

Independent Variable	Coefficient (Dependent Variable: Electricity Access %)	Standard Error	P-value
Climate Vulnerability Index	-0.32**	0.09	0.001
Regulatory Quality	4.85***	1.12	0.000
DRE Investment (% of GDP)	1.21*	0.58	0.038
Trade Openness	0.05	0.04	0.210
Constant	67.50***	5.80	0.000
Observations	1,150		
R-squared (within)	0.41		
Country Fixed Effects	Yes		
Year Fixed Effects	Yes		

*Note: *p<0.05, **p<0.01,
***p<0.001

Table 2: Multiple factors are very likely to have an impact as confirmed by regression analysis. Among these is the negative effect of Climate Vulnerability that had a significant negative coefficient (-0.32), from which we can infer that raising the vulnerability index by one unit will result in a 0.32 percentage point reduction in electricity access if all other factors remain unchanged. This is just a number that shows that among other things climate change is the one which leads to energy security breakdown. Besides that, the very positive coefficient for the perfection of regulatory activities (4.85) points out the major issue which is the role of governance; the establishment of regulatory standards has an enormous, statistically significant, positive effect on electrification. A statistically positive and significant coefficient for DRE Investment greatly contributes to the increase in the investment in renewable energy as

a real solution. The non-significance of Trade Openness means that *nature* (e.g., green technology tariffs) might be a more critical factor than the amount of trade.

4.2. Macroeconomic and Policy Analysis

The CGE modeling experiments for a typical Sub-Saharan African economy illustrate that a \$40/ton carbon price, with revenues recycled to infrastructure investment, could result in emissions reduced by 18% over 15 years with the GDP increasing by 1.2% as a result of the public investment efficiency. A drought simulation utilizing the DSGE model indicates that GDP may fall by 3-5% in the following year, mainly because of the combined impact of agriculture and hydropower closures, the acute macroeconomic risks situation described.

Table 3: Projected Impacts of Climate Change on Key Energy Sources

Energy Source	Region	Primary Climate Risk	Projected Impact by 2050 (High Emission Scenario)
Hydropower	Southeast Asia, Zambezi Basin	Increased rainfall variability, droughts	Capacity reduction of 8-12%
Solar PV	Sub-Saharan Africa, South Asia	Increased ambient temperatures	Efficiency reduction of 3-5%
Thermal Power	Global South	Water scarcity for cooling, heat waves	Forced shutdowns, output reduction of 5-10%
Transmission Grid	Coastal Regions, Asia	Cyclones, flooding, sea-level rise	Increased outage frequency and infrastructure damage

Table 3: This table combines model forecasts with field research to show the diverse nature of the most significant physical risks for the energy mix of developing countries. The article goes deep into the different technologies that are exposed to risk and provides their detailed quantified risks instead of just putting these technologies in a group of broadly risky. This move demonstrates how significant the changes in the energy sector are, for example, the change from the extremely affected hydropower to the more stable coastal grid areas.

4.3. The Efficacy of Carbon Pricing and Revenue Recycling

This research points out that carbon pricing is not simply a primary means of reducing carbon emissions, and, in fact, one of the most important sources of state revenues. Considering that carbon prices are around six dollars per ton in developing regions, there is still quite a potential for carbon reduction. A very necessary recycling of carbon revenue is the intentional one. Our simulations indicate that the allocation of 50% for the development of infrastructure, 30% for transfers to households in the

form of money, and 20% for the deficit would not only be the most advantageous mixture of economic growth and social justice but also a source of the pro-poor "double dividend" effect."

5.0. Case Studies in Governance and Implementation

5.1. Vietnam: A Model of Policy Coherence and Rapid Transition

Vietnam is a trendsetter in the energy transition that has taken place in its surrounding region. This step has been largely a show of the huge impact that integrated planning and policy action by decision makers can have. The country's Power Development Plan VIII (PDP8) has been rated very high largely because of its daring targets to achieve, among other things, 50 percent of the power needs from renewable sources by 2030. A key success factor has been the implementation of a competitive Feed-in-Tariff (FiT) scheme, which was designed to unleash solar and wind power growth and to ensure that there would be regulatory stability that was attractive to private-sector (World Bank, 2023) investments that reached high levels. In this sense, the power purchase agreements (PPAs) of the government, which are simple and transparent, have greatly contributed to this. These agreements are a prime example of how strong institutions can make rapid operational changes and release the amount of money that is needed for a low-carbon future.

5.2. Pakistan: The Intersection of Acute Climate Vulnerability and Governance Challenges

On one side, Pakistan gives an interesting case of a country greatly suffering from severe climate-shocks, where the changes in the climate have a direct impact on the energy supply. The floods of 2022, which were the consequence of climate change and had terrible impacts, destroyed more than 880 power

distributing facilities, which outage led to millions of people who were without electricity and the estimated loss of the country's economy was more than \$30 billion (Asian Development Bank [ADB] & World Bank, 2022). Along with numerous other instances, this example unmistakably points towards the adverse linkage as our econometric studies have detected.

Even though the country does have policies such as the Alternative and Renewable Energy Policy (ARE) 2019, the execution of activities faces a lot of problems because of the governance issues that are stated as the circular debt in the power sector, political instability, and regulatory bottlenecks. The private investors are discouraged by these problems, who are the ones that forming the resilient energy transition the country is stuck in a situation of being vulnerable and them having to recover again.

5.3. Bangladesh: Progress on Access Marred by Fossil Fuel Dependence and Climate Risks

Bangladesh has made great strides in the extension of electricity availability that has been raised from 47% in 2009 to more than 97% in 2023, most of which was achieved through the fast growth of domestic natural gas and imported LNG capacity. This is, however, a picture of the trade-offs between instant access and the long-term sustainable use of resources. The high climate vulnerability of the country, especially to cyclones and floods, endangers the power supply infrastructure located in the coastal area. Even though the Solar Home Systems project used to be an innovative model for decentralization, the current policy framework appears to be biased in favor of large fossil projects leading to the establishment of a sort of path dependency that is difficult to change (IMF, 2023). The problems of governance, which include the subsidies for fossil fuels and the complicated regulatory environment for renewables are pushing the change to a clean and resilient grid very slowly.

Table 4: Comparative Case Study Analysis: Pakistan, Vietnam, and Bangladesh

Governance Factor	Vietnam (Positive Case)	Pakistan (Mixed/Vulnerable Case)	Bangladesh (Access Success, Climate Risk Case)	Impact on Energy-Climate Outcomes

Policy Coherence & Stability	High-quality PDP8; stable, long-term strategy.	Ambitious ARE policy but inconsistent implementation due to political volatility.	Successful access expansion but lack of clear long-term decarbonization roadmap.	Vietnam attracted massive RE investment; Pakistan experiences policy uncertainty; Bangladesh risks fossil fuel lock-in.
Regulatory Certainty	Clear FiT mechanisms; transparent PPA processes.	Opaque regulations: circular debt deters investors.	Complex regulations for renewables; subsidies distort the market.	Vietnam crowded in private capital; Pakistan and Bangladesh deterred investors for resilient, clean energy.
Rule of Law & Corruption Control	Relatively effective enforcement of contracts.	Pervasive corruption and governance issues in the power sector.	Challenges with contract enforcement and transparency.	Vietnam ensured project viability; Pakistan and Bangladesh suffered from misallocated resources and inefficiencies.
Climate Resilience Integration	Proactive grid planning for climate variability.	Reactive; infrastructure highly vulnerable and damaged by climate shocks.	Coastal infrastructure at high risk; adaptation planning is lagging.	Vietnam is building a more resilient system; Pakistan's system is frequently compromised; Bangladesh faces significant future risks.
Macroeconomic Impact	Increased renewable capacity and energy security.	Energy crises and climate disasters cost 4-6% of GDP annually (post-flood).	High import bills for fossil fuels strain foreign reserves.	Vietnam is on a low-carbon, secure path; Pakistan's fiscal stability is threatened; Bangladesh's economic model is exposed to risk.

Table 4: The table displays the fundamental features that differentiate the characteristics that portray the distinctions between the institutions that are successful and those that are not. One of the major factors that contributed to the organization's success during the transition phase was excellent management, as evidenced by the positive impact revealed through the regression analysis of the Regulatory Quality variable. The various circumstances in Vietnam, Pakistan, and Bangladesh provide a more nuanced relationship between the energy-climate nexus in developing countries.

6. Conclusion

The voice of the research is loud and clear that the combination of climate change and energy are the top severe and deepest problems that nations must solve. Several kinds of data, like econometric evidence, macroeconomic modeling, and case studies, all contribute to the main thesis that the gap between the easiest access to clean energy and the most affected by climate change is very large. It reflects the main messages of the study as follows:

In a way, as climate risks are systemic in nature, the idea of integrated, risk-informed planning as a new

default *modus operandi* was the proposal put forward. The strongest indication from which this is very clear is the close inverse relationship between climate vulnerability and energy security, a connection that can sadly be seen very clearly in the flood-related energy breakdown in Pakistan. After that, a point is that a well carbon pricing instrument together with revenue recycling if used efficiently and implemented properly could not only be the main fiscal lever for the reduction of emissions but also the vehicle for getting the development goals as shown by the potential of countries like Vietnam. Next, the climate finance system is stuffed with numerous structural obstructions which not only slow down the flow of climate finance but are also incompatible with trade barriers that raise the transition costs. Examining Pakistan, Vietnam, and Bangladesh situations, we can find the illustrations that most explicitly address these concerns besides econometric analysis, good governance, and institutional capacity that are the key factors for a nation's success. Hence, the process of converting a dual economy into a sustainable and productive one is mostly dependent on a comprehensive, multi-scale, coordinated strategy implementation that goes beyond the indelible resilient infrastructure planning, sound fiscal policy, and ceaseless institutional reform and is also endorsed by the global pledge to just finance and fair trade.

7. Policy Recommendations

Integrated analysis has been instrumental in uncovering the following recommendations, which are based on scientific evidence:

For National Governments

- **Mainstream Climate Risk into Energy Planning:** Energy planning at only a local level is insufficient. A detailed comprehension of energy systems under harsh weather conditions to remove dependence on climate-sensitive energy sources like large hydropower, such procedures as CGE/DSGE modeling ought to be implemented.
- **Implement Phased Carbon Pricing with Pro-Poor Revenue Recycling:** Carbon taxes need to be implemented primarily to help climate-resistant infrastructure (which is going to take up one-half of the revenue) and give money to poor households (that

will receive 30% of the revenue) so that the two concepts of fairness and kindness become feasible.

- **Strengthen Regulatory Frameworks for Distributed Renewable Energy:** The administration needs to create well-defined and consistent policies that are backed by tax incentives to draw in private investors who would invest in renewable decentralized mini-grids and off-grid systems.
- **Prioritize Anti-Corruption and Governance:** Pushed the law to action and opened up the transparency of how contracts are executed as well as ensuring the technical capacity of the institutions in the energy sector for the proper distribution of resources.

For the International Community

- **Fulfill and Scale Up Climate Finance:** In addition to raising climate finance for the supply of grant funds and low-interest loans on concessional terms to LDCs and SIDS, as well as making access procedures very simple for users.
- **Remove Renewable Energy-related Trade Barriers:** Through the elimination of tariffs as well as other obstacles to the trade in intermediate products for renewable energy technologies by the WTO, carbon-neutral domestic industrialization can be enabled, which is an eco-friendly technology's output.
- **Support Capacity and Technology Transfer:** Innovative modeling tools, green technology, and technical skills that local institutional capacity can be empowered by to deliver a practical energy transition can be adopted.

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