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GEOPOLITICS OF ENERGY TRANSITION: UNITED STATES ASSISTANCE TO PAKISTAN

Shamaim Ali[1], Dr. Sameera Imran[2], Laila Rehman[3], Aliza Abrar[4], Sadia Manzoor[5]

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Affiliations:

[1] Visiting Lecturer,
Bahria University Islamabad,
Email: shamaimali.ghauri@gmail.com

[2] Associate Professor,
National Defence University, Islamabad,
Email: drsameeraimran@ndu.edu.pk

[3] PhD Scholar,
The Islamia University of Bahawalpur,
Email: rehmanlaila11@gmail.com

[4] M.Phil. Political Science Scholar,
Kinnaird Collage for Women, Lahore
Email: alizaibrar0@gmail.com

[5] BS International Relations,
International Islamic University,
Islamabad
Email: sadiahere085@gmail.com

Corresponding Author's Email:

[1] shamaimali.ghauri@gmail.com

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Abstract

This article provides a comprehensive examination of the United States' role in addressing Pakistan's pressing energy security challenges. As a nation heavily reliant on energy imports, Pakistan faces the critical task of securing substantial technological and economic assistance from major global powers to satisfy its domestic energy requirements. The United States, as an established global leader, not only possesses the advanced technological capabilities necessary to support Pakistan's legitimate energy needs but also holds a strategic position to influence the region's energy landscape. Simultaneously, China has emerged as a key player, demonstrating a robust and growing interest in providing energy assistance to Pakistan. This dual interest from two of the world's foremost powers creates a complex geopolitical environment, requiring Pakistan to perform a delicate diplomatic balancing act to maintain constructive relations with both Washington and Beijing without alienating either. Employing Power Transition Theory as its central theoretical framework, this paper offers a critical and nuanced evaluation of the rationale underpinning U.S.-Pakistan green energy collaboration, explicitly juxtaposing it with the nature and scope of Chinese involvement in Pakistan's energy sector. The study utilizes a qualitative methodology, incorporating a mixed-methods approach to analyse a diverse array of primary and secondary data sources, including policy documents, bilateral agreements, and scholarly discourse. The central argument posits that the U.S. approach to facilitating a green energy transition in Pakistan is predominantly motivated by its own strategic security interests within the South Asian region, rather than purely developmental or environmental concerns. The analysis further concludes that in the face of intensifying strategic competition from China, the United States must accelerate and substantiate its energy cooperation efforts to remain a relevant and influential partner. Conversely, the findings suggest that Pakistan would benefit most from a diversified and pragmatic strategy, leveraging multiple energy partnerships to maximize its technological, economic, and political gains while navigating the complexities of great-power rivalry.

Keywords: US-Pakistan Green Alliance, Power Transition Theory, Geopolitics of Energy, US-China Rivalry, Renewable Energy Cooperation.

Introduction

The paper reviews the U.S.-Pakistan Green Alliance partnership and assesses its feasibility for Pakistan amid the competition offered by China. Historically, the U.S. has demonstrated a pattern of security-driven relationship towards Pakistan, generally referred to as a relationship influenced by the 'external factor' with its oscillating twists and twins. The fundamental question in the context of US-Pakistan relationship is to how to look beyond the security nexus of the past to construct a new, viable and long lasting non-periodic relationship such as in the realm of energy security and green energy transition.

In line with this strategic outlook, the 'Greening Diplomacy Initiative' (GDI) was launched in April 2023 (US Mission Pakistan, 2024). This initiative operates under the framework of a clean energy partnership agreement signed by the United States and Pakistan in 2022. Through cooperative ventures such as the US-Pakistan Green Alliance, the U.S. approach to clean energy investment is ostensibly designed to tackle critical environmental challenges. These include improving water management, advancing climate-smart agricultural practices, and facilitating the transition to renewable energy sources.

The article seeks to analyse the rationale of US-Pakistan Greening Diplomacy Initiative to ascertain whether the US-Pakistan Green Alliance is driven by strategic considerations or motivated by developmental or environmental concerns. The United States, operating within the broader context of global power politics has consistently sought to establish and maintain regional alliances that reinforce existing geopolitical hierarchies. This strategy serves to prevent any shifts in regional power dynamics that could challenge the US-led international order. Consequently, this paper posits that the US-Pakistan Green Alliance is less of an initiative for sustainable energy cooperation and more of a geopolitical manoeuvre aimed at countering emerging threats to U.S. hegemony most notably, China's expanding influence in the energy sector of Pakistan. According to Rafiq-uz-Zaman (2023) CPEC will become the foundation of Industrial and economic growth in Pakistan.

This article examines Pakistan's trajectory of international commitments within the green energy transition paradigm. Pakistan's engagement in the global climate agenda commenced in 1972 with its participation in the United Nations Conference on the Human Environment in Stockholm. This was followed by the development of a National Conservation Strategy (NCS) in 1992, positioning Pakistan as an early adopter of national environmental planning. The nation further solidified its international obligations by ratifying key multilateral agreements, including the UN Framework Convention on Climate Change (UNFCCC) in 1994, the Montreal Protocol, and the International Convention to Combat Desertification. Subsequent adherence to the Kyoto Protocol in 2005, ratification of the Paris Agreement, and the adoption of a national Alternative and Renewable Energy Policy in 2019 demonstrate a continued commitment to this agenda (United Nations, 2024). However, as a developing economy grappling with acute circular debt and political instability, Pakistan's aspiration for a green energy transition remains contingent on international support. This ambition is formally encapsulated in its Nationally Determined Contribution (NDC), which establishes a target of achieving 60% renewable energy by 2050 (Government of Pakistan, 2021).

Methodology

This research employs a mixed-methods approach, combining both qualitative and quantitative techniques. The study draws upon primary and secondary sources. Primary data includes expert interviews with US foreign policy specialists, as well as official statements and speeches of prominent figures to identify the intentions behind the US–Pakistan "Green Alliance" framework. Additionally, data from USAID's official assistance database and Our World in Data were collected, cleaned, and analysed using Google Data Analytics techniques. Progression analysis was applied to predict the level of aid Pakistan would require achieving 10,000 MW of solar energy capacity by 2030.

Secondary sources consist of authoritative reports and fact sheets from institutions such as the World Bank, the US State Department, USAID, IRENA, IEA, and the World Economic Forum. Academic journal articles and policy analyses were also used to provide theoretical grounding and contextual insights into the geopolitical and economic implications of renewable energy transitions. This triangulation of qualitative and quantitative evidence ensures both analytical rigor and a balanced assessment of feasibility and strategic intent.

Limitations and Scope of the Study

- The temporal scope of the study is limited to the period between 2021 and 2024 under the Biden administration.
- Developments occurring after 2024, including restructuring measures concerning USAID, have not been included.
- Disaggregated aid data specific to solar energy was not consistently available, which required reliance on estimates and extrapolations.
- Quantitative data was sometimes aggregated at a broader level, limiting precision in the Pakistan-specific solar sector.
- Expert interviews, while insightful, reflect individual perspectives that may not fully represent the wider policymaking community.

Power Transition Theory as an Analytical Lens

This article employs Power Transition Theory (PTT), first introduced by Organski, 1958 and refined by Lemke, (1997) as its central analytical framework. The theory posits that a hegemon, such as the United States in the post-WWII era, establishes an international order to secure benefits like wealth and security, codifying rules that reflect its interests and define a status quo. PTT contends that power, derived from internal growth and measured by GDP, is dynamic and constantly fluctuates between states. A fundamental challenge to the hegemon arises only when a dissatisfied challenger, like China, achieves power parity and seeks to restructure the existing order. To prevent this, the hegemon forges alliances to maintain its preponderance and uphold regional hierarchies, as a stable distribution of power is considered essential for preserving peace. This framework is applied to critically evaluate the U.S.-led Green Diplomacy Initiative in Pakistan, analysing it as a strategic element of this broader competitive dynamic.

Hegemonic ascendancy has historically been propelled by technological superiority. For example, advancements in European navigational technology enabled trade with India and East Asia, which was subsequently manipulated through naval and military power to establish colonial empires. Consequently, Great Britain attained its hegemonic status largely due to its relative technical supremacy. Similarly, the United States supplanted Britain as the global hegemon by wielding its own superior technological and economic capabilities. In the 21st century, the renewable energy sector constitutes the new domain for hegemonic competition between the U.S. and China. Presently, the U.S. confronts a significant challenge, as China has achieved considerable advantage in renewable energy technology. This obligates the U.S. to pursue a strategy of containment through trade measures, technological competition, and the capture of international markets to counter China's rise.

Applying a Power Transition theoretical lens, three strategic interests likely guide U.S. international conduct: first, to arrest the ascent of competitors; second, to forge alliances that reinforce a regional hierarchy favourable to the status quo; and third, to ensure American preponderance, by force if necessary. It can be argued that all three of these objectives are subsumed within the broader framework of U.S. security interests in the South Asian region.

U.S. Interests in Pakistan's Energy Transition

The historically significant partnership between the United States and Pakistan could be revitalized through substantive U.S. technological and economic assistance for Pakistan's energy transition. As an economy with limited fiscal capacity, Islamabad is dependent on foreign partnerships to achieve its energy objectives. This dynamic is set against a regional backdrop where China is constructing an extensive network of connectivity across South Asia, facilitating a regional order that aligns with its strategic interests. While U.S. strategic interests in the region have persisted, American policymakers have consistently criticized the China-Pakistan Economic Corridor (CPEC) for serving as a vehicle for expanding Chinese influence.

The assertion that the U.S. yearns to lead the international race for renewable energy, particularly when compared to China, is a subject of significant debate within energy studies. While the U.S. possesses advanced technological capabilities, Pakistan's acute need for external assistance in its clean energy transition is clear

(Abdullah et al., 2021). Historically, Pakistan has depended more heavily on the United States than on China or Russia for such technological and economic support. A potential shift in this bilateral relationship was signalled in 2024 by U.S. Ambassador David Bloom, who articulated American interest in collaborating on Pakistan's green energy transition (Sattar & Sattar, 2020). This suggests a strategic pivot away from a traditionally security-centric partnership toward one focused on sustainable development.

The U.S.-Pakistan green energy partnership aims to inject new vitality into existing trade relations. The United States, being Pakistan's largest export destination with a market valued at $10.1 billion in 2024 (The United States Trade Representatives, 2025), provides a substantial economic foundation for this collaboration. American involvement in Pakistan's energy infrastructure has historically been significant, including the rehabilitation and completion of major hydroelectric projects such as Mangla, Tarbela, and Satpara. A key example is the pivotal role played by the U.S. in the upgradation of the Mangla Dam, which involved the installation of new General Electric turbines designed to extend the facility's operational life by fifty years. Beyond energy projects, U.S. commitment was also demonstrated through substantial humanitarian aid, including a grant of $215 million for flood relief efforts in 2023 (The US Embassy Islamabd, 2024).

China as a Peer Competitor

China's escalating global influence signals an imminent geopolitical power shift, a central concern of Power Transition Theory. supremacy in the renewable energy sector is poised to be a decisive factor in determining the next global hegemon. Scholars such as Freeman posit that China is the most critical actor in the contemporary energy competition, possessing the technological prowess and economic capacity to fundamentally reshape geopolitics. This capability is compelling numerous states to reconsider their traditional alliance structures (Freeman, 2023).

China's Supremacy in Renewable Energy

In the domain of renewable technology, China's industrial policy, notably the "Made in China 2025" initiative (McBride, 2019), has strategically positioned it as the world's dominant manufacturer. It now produces the majority of global solar panels, wind turbines, and critically, holds a commanding share of the supply chain for the rare earth minerals essential to these technologies (WEF, 2024). This manufacturing dominance, combined with aggressive international investment and project development through its Belt and Road Initiative (BRI), grants China unparalleled influence over the future of global energy infrastructure, presenting a direct challenge to U.S. technological and strategic leadership.

In the case of Pakistan, China has invested in several renewable energy projects under the China-Pakistan Economic Corridor (CPEC) initiative, encompassing wind, solar, and hydroelectric power generation (Ministry of Planning and Development, 2024). The financial dimension of the U.S.-China rivalry in this sector is not entirely mismatched due to three key structural factors: the source of investment, financial regulations, and currency dominance (Pepe et al., 2023). Chinese investment in green energy is predominantly channelled through State-Owned Enterprises (SOEs), reflecting a state-directed economic model. In contrast, U.S. investment derives from a combination of public funding and significant private sector participation, creating a more diversified financial base. Regarding regulation, the field remains fragmented, with neither power having established a cohesive, internationally aligned regulatory framework. Lastly, China operates under the constraint of U.S. dollar dominance within the global financial system. This provides the U.S. with considerable foreign policy leverage, including the capacity to weaponize financial access through sanctions against entities deemed threatening to its national interests. This strategic competition extends beyond finance into the maritime and cyber domains, where China's expanding renewable energy infrastructure and associated trade routes increasingly challenge traditional U.S. control over global maritime chokepoints and supply chains.

China's rise as an energy power has deep historical roots. According to Pomeranz, the widespread accessibility of domestic coal resources was a foundational element of China's early energy dominance, mirroring the role coal played in fuelling the Industrial Revolution in Europe via steam engine technology (Pomeranz, 2021). China's socialist economic model was instrumental in this development, as state control enabled the direct mobilization of vast resources—including machinery, manpower, and capital—toward the

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systematic exploitation of domestic energy reserves. By the 1970s, this centralized approach had facilitated a considerable degree of industrialization, prior to its diplomatic rapprochement with the U.S. in 1972. Furthermore, major investments in hydroelectric power ensured China's energy self-sufficiency throughout the 1980s. A persistent domestic challenge, however, has been the efficiency of energy distribution from source to end-user. This issue remained manageable until China's unprecedented economic growth eventually outstripped its domestic energy production capacity. This forced the nation to seek resources abroad, creating a dependency on impd oil and gas and fundamentally reshaping its foreign energy policy (Freeman, 2023).

A critical question emerges as to whether China is truly energy dependent, or if the perceived dependency highlighted earlier is more of an illusion. Evidence from the International Energy Agency (IEA) report provides insight into this debate. The data indicates that only about 19 percent of China's electricity is produced from oil, while coal remains the dominant source at approximately 61 percent, with the remainder supplied by renewable energy sources (IEA, 2022). Notably, China's oil imports have been in decline, reflecting a gradual reduction in reliance on oil. Simultaneously, the country has been expanding its investment in renewable energy while attempting to substitute coal, signalling a structural shift in its energy portfolio. Despite the decline in oil imports, this adjustment underscores China's continued vulnerability due to its heavy dependence on coal. Consequently, energy security remains a central theme in China's domestic discourse. According to Li et al (2007), China's initial interest in renewable energy can be traced back to the 1980s. A significant turning point occurred in 2014, when President Xi Jinping called for an "energy revolution," (Bloomberg News, 13 June, 2014) a move that has since positioned China as the leading global power in renewable energy generation. A comparative table below illustrates the distinction between the United States and China in terms of renewable energy production.

Table 1

China–United States Renewable Energy Comparison

Year	China	US	World
2014	414 651	180 970	5 304 340
2015	479 103	196 009	5 512 471
2016	541 016	216 174	5 869 293
2017	620 856	230 714	6 237 087
2018	695 463	245 595	6 633 769
2019	758 870	263 821	6 994 086
2020	896 412	293 527	7 458 042
2021	1 017 852	326 733	7 872 657
2022	1 156 126	354 314	8 439 671
2023	1 453 701	385 205	N/A

Source: International Renewable Energy Agency (IREA, 2024).

The data presented in the table above demonstrates that China's share in global renewable energy capacity has increased significantly over the past decade. In 2014, China's installed renewable capacity was approximately 414,651 MW, compared to 180,970 MW for the United States and 5,304,340 MW globally. At that time, China accounted for about seven percent of the world's total renewable capacity. By 2022, these figures had risen substantially, with China reaching 1,156,126 MW, the United States 326,733 MW, and the global total 7,872,657 MW. In percentage terms, China's share of global renewable energy more than doubled between 2014 and 2022. Turning to energy transition investments, China also occupies a leading position. According to the Bloomberg NEF report, China represents the world's largest market for energy transition investment, with a volume exceeding $670 billion. This figure is more than twice the investment level of the United States, approximately 6.5 times that of Germany, and nearly nine times the total investment of the United Kingdom. The graph below provides a visual representation of this comparison.

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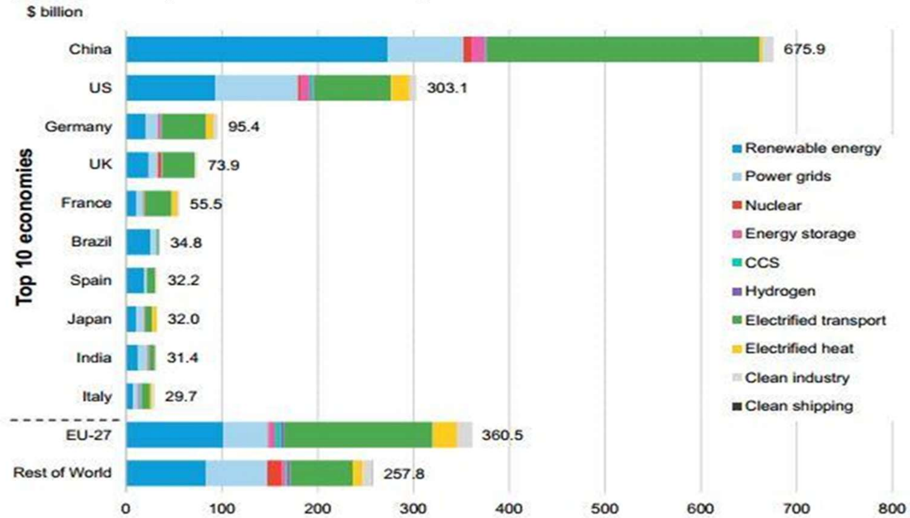
Figure 1
Countries with the highest levels of investment in Energy Renewables.



Source: (BloombergNEF, 2024).

These trends underscore China's central role in shaping the global renewable energy landscape and highlight the scale of its commitment to driving the energy transition relative to other major powers.

According to Power Transition Theory, a "rising power" becomes a challenger once it develops the ambition to alter the existing "status quo." The preceding discussion highlighted China's leading role in the renewable technology sector, though it has so far lacked the capacity to weaponize the renminbi (RMB). Achieving such leverage would require replacing the dominance of the U.S. dollar, a goal China has actively pursued through its engagement with BRICS. Within the framework of Power Transition Theory, China's pursuit of currency reform combined with its technological dominance in renewables reflects not only material growth but also a revisionist ambition that directly challenges the established order. The United States has viewed these efforts with caution, particularly as China's growing supremacy in renewable energy further complicates America's position as the "dominant power." Consequently, Washington has sought to safeguard its global standing by reasserting itself in the renewable energy race while simultaneously working to constrain China's attempts to reshape regional hierarchies through large-scale infrastructure initiatives. The strategies adopted by the United States, particularly under the Biden Administration, are discussed below.

U.S. Strategic Response to China's Renewable Energy Ambitions

Power Transition Theory emphasizes that a state within the status quo is not perceived as a threat unless it demonstrates dissatisfaction with the existing order and the ambition to alter it. For example, if the United Kingdom's economy were to surpass that of the United States and it emerged as the global leader in energy transition, this development would not necessarily provoke U.S. concern, since the United Kingdom is not considered a dissatisfied power. In contrast, China represents a dissatisfied state with clear ambitions to reshape the international status quo, as reflected in its active role within BRICS and its pursuit of alternatives to U.S.-dominated global structures. Against this backdrop, China's leadership in renewable energy is perceived by Washington not simply as a matter of technological competition, but as a challenge with structural implications for global power hierarchies. The key question, therefore, is how the United States responds to the perceived threat of China positioning itself as the dominant energy power of the future.

In articulating the U.S. stance, Secretary of State Antony Blinken recently wrote in Foreign Affairs that "if the United States wants to remain the dominant power, it must lead the world in energy transition. He outlined the Biden Administration's strategy, beginning with legislative initiatives designed to accelerate the green transition. Measures such as the 2022 CHIPS and Science Act have incentivized major multinational corporations to invest in the U.S. green economy. For instance, Samsung and Toyota have committed billions of dollars toward facilities in Texas and North Carolina, with total pledged investments amounting to approximately $300 billion (Blinken, 2024; The White House, June 13, 2024).

Blinken also highlighted the importance of securing global alliances. The Indo-Pacific Economic Framework has been advanced as a mechanism to ensure resilient and secure clean-energy supply chains, reducing dependence on Chinese influence. In addition, the U.S. and its G7 partners launched the Partnership for Global Infrastructure and Investment in 2022, pledging up to $600 billion to support underdeveloped states in addressing climate change. A critical component of this initiative involves financing infrastructure projects in resource-rich countries such as the Democratic Republic of Congo and Zambia, which possess essential critical minerals for the green transition (Blinken, 2024).

Blinken's framing underscores China as a "peer competitor" in the renewable energy domain, which has prompted Washington to respond through a comprehensive strategy. The United States has effectively adopted a three-pronged approach: first, enhancing domestic renewable capacity; second, constructing regional and global alliances to secure clean-energy supply chains independent of China; and third, investing in the development of countries rich in rare-earth minerals to prevent Beijing from establishing monopolistic control over these resources. Within the logic of Power Transition Theory, this approach represents the response of a "dominant power" attempting to preserve its hegemony in the face of a "rising power" seeking to revise the global order.

The U.S.–Pakistan Partnership within the Framework of Power Transition Theory

Power Transition Theory conceptualizes the international system as a hierarchical structure comprising four categories of states. At the top stands the Dominant Power, a state or a coalition of states that defines the rules of the system and shapes the behaviour of other actors. There are the Great Powers, which are rising in stature. These may be classified into two types: satisfied powers, which accept and benefit from the established order, and dissatisfied powers, which are discontented with the dividends they receive and thus seek to revise the system. The third category consists of Middle Powers, which occupy an intermediate position, neither rising rapidly nor insignificant in influence. Finally, at the bottom of the hierarchy are the Small Powers, which exert little influence on the international system and primarily benefit through alignment with either the Great Powers or the Dominant Power (Tammen et al., 2017). These states are usually dependent on others for economic, technological, and security needs.

Within this framework, the alliance of a small power with the Dominant Power is typically motivated by a desire for material or security gains, such as economic assistance, technological transfers, or defence guarantees. Such partnerships rarely enable small powers to shape or challenge the established order. Their role becomes significant only when their cooperation is deemed vital to the interests of the Great Powers or the Dominant Power. Thus, their participation in broader strategic ventures is best understood as an attempt to secure national interests rather than to revise the international system. At most, small powers may align with Great Powers in order to balance the influence of other actors. Seen in this light, the U.S.–Pakistan partnership has historically represented a relationship between a Dominant Power and a Small Power, where Pakistan's engagement has been driven primarily by the pursuit of economic, technological, and security interests rather than any ambition to reshape the global order.

Pakistan United States Energy Transition Phase 2021 to 2024

Power Transition Theory argues that a dominant power forges alliances with smaller powers when the latter contribute to sustaining systemic stability and advancing the strategic objectives of the hegemon. The Pakistan–United States energy relationship can be understood within this framework. This partnership dates back more than five decades, beginning with the installation of the first turbines at Mangla Dam, a historical point underscored by United States Ambassador David Bloom in a conference (Bloom, 2024). Despite its long-standing nature, energy cooperation rarely figured prominently in bilateral dialogue until recently.

The structural transformation of the international system, particularly the rise of China as a dissatisfied and revisionist power, has compelled the United States to reconsider its engagement with Pakistan in the field of energy transition. In 2022, after the passage of significant legislation in the United States Congress promoting renewable energy investment, the notion of a Pakistan–United States Green Alliance began to emerge (Salik, 2023). Under this framework, Washington initiated several projects in Pakistan. These include the Mangla Dam Rehabilitation Project, the Kaitu Weir Project, Power Sector Services Improvement, Energy Sector Advisory Services, Voluntary Carbon Market Activity, and Promoting Access to Finance for Small to

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Medium Enterprises (U.S. Mission Pakistan, 2024)

For Pakistan, the goal of achieving 60 percent renewable energy in its national energy mix by 2030 requires projects that can deliver results more rapidly. However, projects involving turbine replacement, refurbishment of dams, or other large hydropower undertakings are time-intensive and therefore insufficient to meet short-term needs. In such circumstances, two renewable sources, solar and wind energy, emerge as the most feasible options for accelerating progress. The relevant question is how the United States–Pakistan Green Alliance framework addresses these pressing requirements.

The United States Pakistan Green Alliance Framework

The institutionalization of bilateral cooperation in the energy sector has been articulated through the Green Alliance framework, which was formally presented by Ambassador David Bloom in 2023. The fact sheet released by the United States Embassy provides detailed information on the scope of assistance. The document highlights American support for the modernization of Pakistan's major dams, particularly Mangla and Tarbela. The rehabilitation of these projects is expected to enhance the efficiency and longevity of Pakistan's energy infrastructure. Specifically, the Mangla Dam is projected to achieve a 30 percent increase in capacity after refurbishment, while the Tarbela Dam is expected to extend its operational lifespan by approximately thirty years (The U.S. Embassy, Islamabad, 2024). The most promising aspect of American involvement within the Green Alliance framework concerns the enhancement of Pakistan's solar photovoltaic capacity. The plan aims to expand capacity from less than 1,000 megawatts at present to approximately 10,000 megawatts by 2030. This transformation is directly aligned with Pakistan's objective of securing 60 percent of its energy mix from renewable sources by the end of the decade.

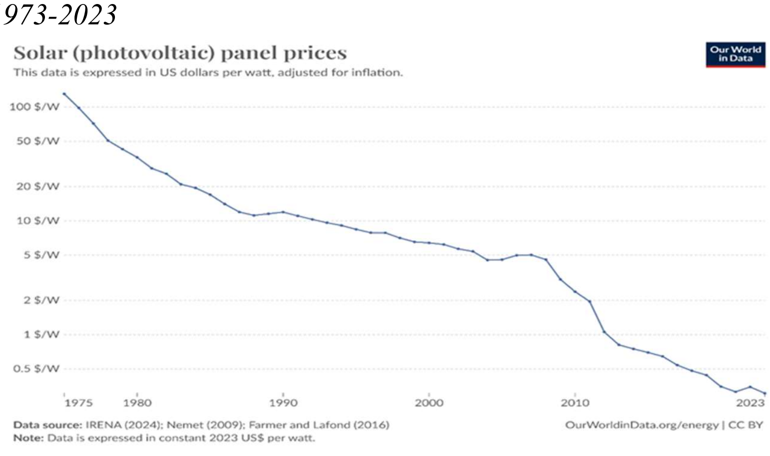
To examine the feasibility of this partnership, two interrelated dimensions must be considered. The first is the economic cost of implementing the ambitious targets articulated in the Green Alliance framework. The second is the technological feasibility of United States–Pakistan cooperation in enabling Pakistan's energy transition. Together, these dimensions determine whether the partnership can effectively contribute to Pakistan's renewable energy goals while simultaneously serving the strategic purpose of reinforcing the position of the United States as the system's dominant power in the face of China's rise.

Economic Cost of Pakistan United States Solar Energy Transition Partnership under the Green Alliance Framework

The target for renewable energy transition defined by the Green Alliance framework by the year 2030 is the generation of approximately 10,000 megawatts of electricity through solar photovoltaic technology. To analyse the financial implications of this target, the study first considers the cost of solar photovoltaic modules. Using data from the World in Data database, it is evident that the cost of solar energy has declined dramatically in the last fifty years. In 1975 the cost of energy generated through solar technology was above 100 United States dollars per watt. By 2023 this cost had fallen to approximately 0.31 United States dollars per watt (Our World in Data, 2024).

Figure 2

Solar PV Price from 1973-2023



Source: (Our Word in Data, 2024).

If this figure is taken as a benchmark, the estimated cost of generating one megawatt of electricity through solar photovoltaic technology amounts to 310,000 United States dollars. Consequently, the generation of 10,000 megawatts would require a total of 3.1 billion United States dollars. This calculation only covers the cost of solar panels. If Pakistan is to achieve this target during the five-year period between 2025 and 2030, it would require an allocation of approximately 620 million United States dollars annually for solar panels alone. When the costs of batteries and inverters are added, the total expenditure increases substantially.

Lithium-ion batteries represent the second major expense. Their prices have also been declining over the years. As of 2024, the cost ranges between 0.3 and 0.5 United States dollars per watt, as reported by an international private energy storage company (RIGL, 2024). Taking the average cost of 0.4 United States dollars per watt, the financial requirement for one megawatt of storage capacity is approximately 400,000 United States dollars. Consequently, storage for 10,000 megawatts would amount to 4 billion United States dollars. Given that storage capacity generally needs to be two to three times greater than generation capacity in order to account for variations in sunlight availability, if the storage requirement is assumed to be double the generation capacity, the total cost rises to 8 billion United States dollars. This translates into an annual requirement of 1.6 billion United States dollars between 2025 and 2030 solely for lithium-ion batteries.

The third essential component is the Battery Management System (BMS), which plays a critical role in the efficiency and safety of large-scale renewable energy projects. The cost of a BMS typically amounts to between 5 and 10 percent of the total system cost. For a two-megawatt system, the cost of the BMS is estimated at approximately 800,000 United States dollars (RIGL, 2024). At the scale of 10,000 megawatts, this cost increases to around 40 million United States dollars. Spread over the five-year period until 2030, this translates into an annual requirement of approximately 8 million United States dollars. When combined with the earlier components, the total annual requirement by this stage stands at approximately 2.208 billion United States dollars.

The fourth major expense involves the Energy Management System (EMS), which ensures the efficient supply and regulation of generated electricity. The cost of EMS systems varies from 3 to 5 percent of the total system expenditure (RIGL, 2024). If the lower bound of 3 percent is used, and the cost for a two-megawatt system is estimated at 25,920 United States dollars, then a system of 10,000 megawatts would require approximately 120.6 million United States dollars. Calculated annually, this amounts to nearly 26 million United States dollars. This increases the total annual financial requirement to approximately 2.234 billion United States dollars.

The fifth cost element is the Power Conversion System (PCS), which is responsible for converting direct current generated by solar photovoltaic technology into alternating current that can be supplied to the national grid. On average, the PCS for a two megawatt system costs approximately 133,500 United States dollars (RIGL, 2024). At the level of 10,000 megawatts, this scales up to an estimated 667.5 million United States dollars. This translates into an annual requirement of 133.5 million United States dollars between 2025 and 2030. Including this cost raises the total annual requirement to approximately 2.3675 billion United States dollars.

Finally, infrastructural costs must also be considered. For a two-megawatt system, infrastructure expenditure typically ranges between 100,000 and 300,000 United States dollars (RIGL, 2024). Taking the average figure of 200,000 United States dollars, the infrastructure requirement for a 10,000-megawatt system would amount to approximately 1 billion United States dollars. Spread over five years, this translates into an annual cost of about 200 million United States dollars. At this stage, the total annual requirement rises to approximately 2.5675 billion United States dollars, with the total cost by 2030 reaching nearly 13 billion United States dollars.

It is important to emphasize that these figures do not account for maintenance costs, which usually constitute between 3 and 5 percent of the total system cost (RIGL, 2024). Therefore, the actual financial requirement is likely to be even higher. The table below provides a breakdown of the total cost of Pakistan's solar photovoltaic energy transition under the Green Alliance framework.

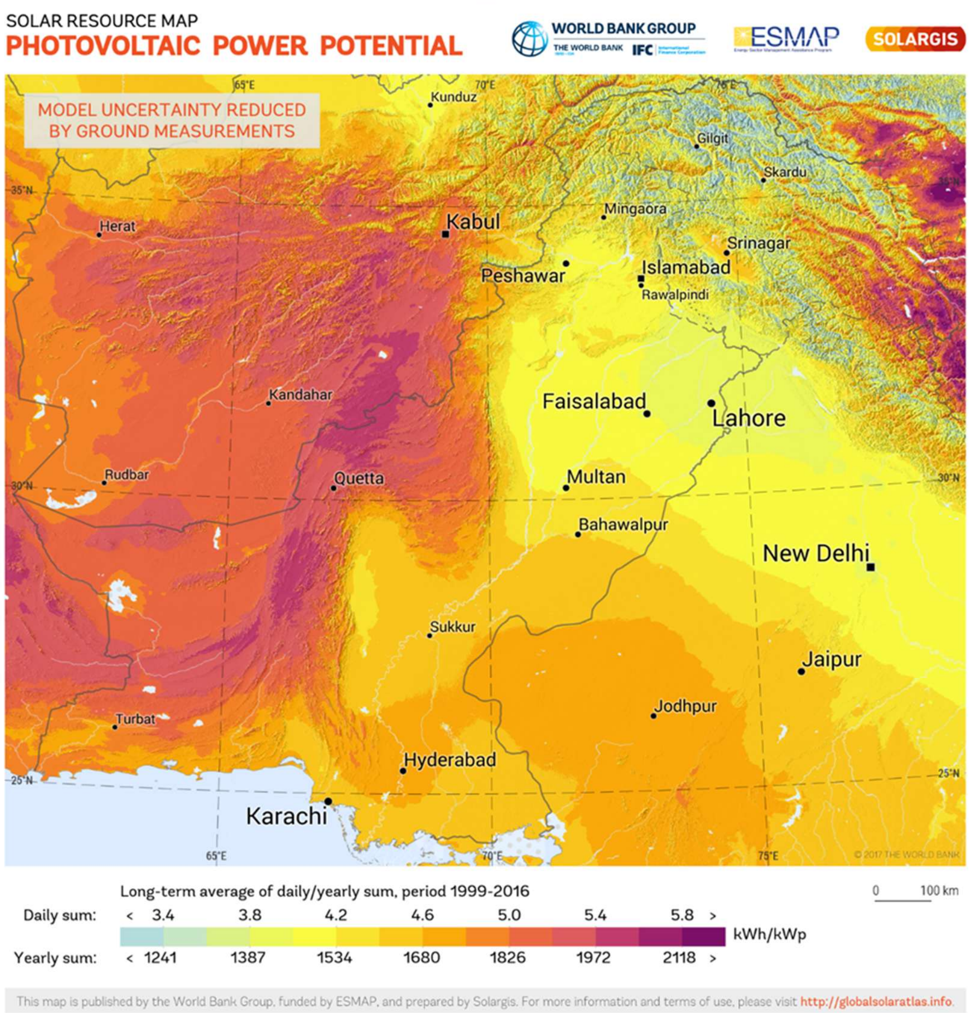
Table 2
Estimated Cost of 10,000 MW Solar System

Components	Price in US Dollars
Solar PV Panel	$3.1 billion
Lithium-ion Batteries (20,000 MW)	$8 billion
Battery Management System	$40 million
Energy Management System	$120.6 million
Power Conversion System	$667.5 million
Infrastructure	$1 billion
Total Cost	$12.928 billion

Source: Estimation based on international organizations' reports.

Having estimated the cost of achieving 10,000 megawatts of solar energy generation by 2030 under the Green Alliance framework, it is essential to evaluate whether Pakistan possesses the necessary potential to meet this target. By potential, the study refers specifically to the country's natural capacity to harness solar energy, which depends on the amount and intensity of sunlight it receives throughout the year. To assess this factor, the study drew on data from the World Bank's Global Solar Atlas, which provides a comparative overview of solar photovoltaic resources worldwide.

Map 1
Solar PV Potential of Pakistan



Source: (The World Bank, 2020).

According to the World Bank's 2020 report, Pakistan has an average annual solar capacity of approximately 4.5 kilowatt-hours per square meter per day, placing it among the most promising countries globally for solar energy deployment (The World Bank, 2020). This level of solar irradiation is consistent across large parts of the country, spanning both urban and rural regions, which enhances the feasibility of scaling up both grid-connected and decentralized off-grid systems. The World Bank further highlighted that Pakistan's solar potential is not only sufficient to meet its domestic renewable energy targets but also strong enough to contribute to broader regional clean energy ambitions if strategically developed.

The analytical significance of this finding lies in the structural weaknesses of Pakistan's existing energy system. Pakistan continues to face recurring circular debt, heavy reliance on imported fossil fuels (Raza et al., 2022), and inefficiencies in electricity transmission and distribution. These vulnerabilities undermine the country's energy security and place a considerable burden on its economy, particularly through foreign exchange outflows for fuel imports (Zafar et al., 2022). Against this backdrop, solar energy offers a cost-effective, indigenous, and sustainable alternative that could reduce dependence on imported fuels while also mitigating fiscal pressures linked to circular debt. Moreover, the scalability and modularity of solar systems make them particularly suitable for Pakistan, where rural electrification remains a challenge and where the national grid faces persistent inefficiencies.

Therefore, when considered in relation to Pakistan's energy security challenges, the World Bank's assessment underscores that the country not only possesses one of the strongest natural potentials for solar energy worldwide but also that this resource directly aligns with its structural need to overcome dependency, inefficiency, and economic vulnerability. Pakistan's solar potential thus represents both an environmental and a strategic opportunity, making it central to any serious partnership on energy transition.

Despite this natural advantage, the study finds that the United States' engagement in Pakistan's energy sector appears to be guided more by its own strategic security concerns than by a commitment to addressing Pakistan's systemic energy challenges. This conclusion is drawn from the absence of significant economic assistance from the United States Agency for International Development (USAID) since 2021 (USAID, 2024). The data, obtained from USAID's official database and filtered specifically for energy-related economic assistance, reveals a mismatch between the substantial investment required to meet the 10,000-megawatt target and the limited financial support actually provided. While the rhetoric of partnership emphasizes a shared commitment to renewable energy, the material aid offered thus far does not correspond with the scale of Pakistan's needs.

The tables below present a year-by-year breakdown of the financial assistance that Pakistan has received through USAID for energy-related initiatives, thereby illustrating the gap between policy commitments and economic realities.

Table 3

USAID to Pak's related to Energy in 2021

Projects	Fiscal Year	Amount
Government-to-Government Monitoring	2021	1283027
Technical Collaboration on Advanced Energy Systems	2021	1000000
Power Sector Improvement Activity (PSIA)	2021	500000
USAID redacted this field by the exceptions	2021	51640
USAID Pay and Benefits	2021	46892
Modern Energy Services	2021	19350
Monitoring, Inspection, Milestone Verification	2021	-387831
	Total Sum	**2513078**

Source*:* (USAID, 2024).

Table 4

USAID to Pak's related to Energy in 2022

Projects	Fiscal Year	Amount
Power Sector Improvement Activity (PSIA)	2022	7600000
Pakistan Private Sector Energy	2022	2000000
Government-to-Government Monitoring	2022	1577738
USAID Pay and Benefits	2022	1062279
Partnership for Decarbonized	2022	1000000
Pakistan Private Sector Energy	2022	500000
USAID Energy Policy Project	2022	209024
Department of Energy (DOE) 632(B) Transfer	2022	-38260
Modern Energy Services	2022	-436895
Clean Energy for Pakistan's Economy (CEPE)	2022	-610000
Gharo Keti Bandar, Wind Power Project (WPP)	2022	-6042952
	Total Sum	**6820934**

Source: (USAID, 2024).

Table 5

USAID to Pak's related to Energy in 2023

Projects	Fiscal Year	Amount
Power Sector Improvement Activity (PSIA)	2023	7500000
FATA Infrastructure Project (FIP)	2023	2270453
Modern Energy Services	2023	1158947
Partnership for Decarbonized and Climate-Resilient	2023	1010000
Government-to-Government Monitoring	2023	690471
INVEST	2023	500000
Technical Assistance Project	2023	125962
Modern Energy Services	2023	9922
USAID redacted this field	2023	2
FATA Infrastructure Project (FIP)	2023	-857118
FATA Infrastructure Project (FIP)	2023	-2572282
	Total Sum	**9836357**

Source: (USAID, 2024).

Table 6

USAID to Pak's related to Energy in 2024

Projects	Fiscal Year	Amount
Mangla Dam Rehabilitation Project	2024	19767774
Power Sector Improvement Activity (PSIA)	2024	5139055
Pakistan Private Sector Energy (PPSE) Activity	2024	2000000
Government-to-Government Monitoring	2024	909529
Pakistan Private Sector Energy (PPSE) Activity	2024	500000
Power Sector Improvement Activity (PSIA)	2024	500000
Power Sector Improvement Activity (PSIA)	2024	400000
Modern Energy Services	2024	-3606
Water and Power Development Authority	2024	−19,767,774
	Total USAID in 2024	**8944978**

Source: (USAID, 2024).

If the study considers a rough estimate of the financial assistance provided by the United States Agency for International Development (USAID) to Pakistan for the energy sector in general, the figures stand at approximately 25 million dollars in 2021, 7 million dollars in 2022, 10 million dollars in 2023, and 9 million dollars in 2024. A critical point to note is that none of these funds were allocated to solar energy projects, despite the commitments made under the Green Alliance framework. The lack of directed financial support is significant because, in order for Pakistan to achieve its stated goal of producing 60 percent of its energy from renewable sources by 2030, the country must install 10,000 megawatts of solar capacity. Based on the financial calculations outlined earlier in this study, this target requires a cumulative investment of approximately 13 billion dollars by 2030.

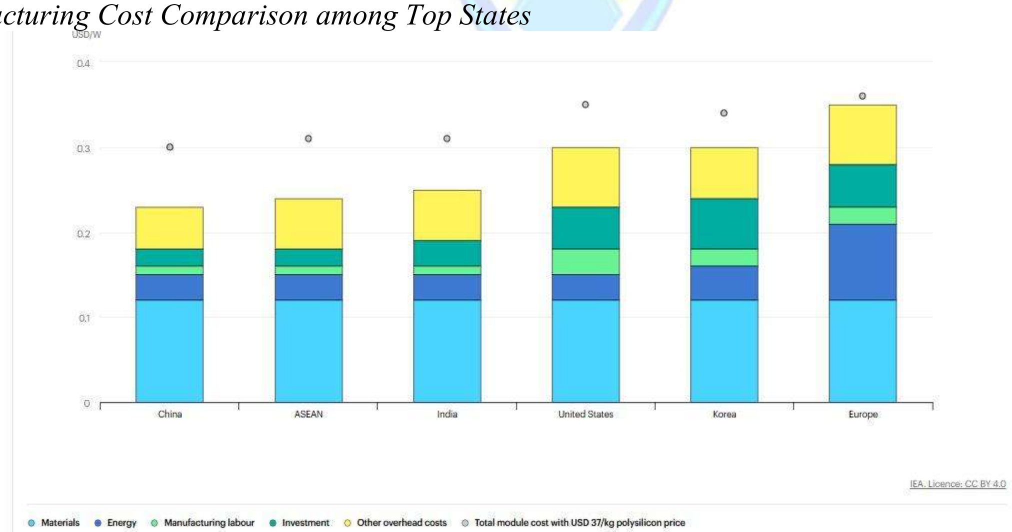
Given the present pace of U.S. assistance, the prospect of reaching this target appears highly improbable. The financial flows recorded so far indicate a wide gap between rhetorical commitments and material contributions. Consequently, the U.S.–Pakistan energy relationship, when viewed in economic terms, does not appear to be feasible in supporting Pakistan's ambitious transition to renewable energy.

Comparative Technological Viability

The Global Solar PV Supply Chain Report published by the International Energy Agency (IEA) highlights that nearly 80 percent of Solar PV production, regardless of the manufacturing stage, takes place in China. This raises the question of what the United States can realistically offer to Pakistan in terms of solar technology. To explore this issue, the study examines another IEA report released following the policy shifts introduced in the United States, India, and Europe in 2022 (IEA, 2022). The purpose of this report was to evaluate whether these regions could maintain market competitiveness with China.

Figure 3

Manufacturing Cost Comparison among Top States



Source: *International Energy Agency (IEA, 20222)*

The IEA divided the overall costs into several categories, including materials, energy, manufacturing labour, investment, other miscellaneous expenses, and a fixed module cost that assumes a polysilicon price of 0.37 dollars per kilogram (IEA, 2022). The chart illustrates the cost breakdown for China, ASEAN, India, the United States, Korea, and Europe.

This paper discusses only the comparison between China and the United States. In the case of China, the material cost is 0.12 dollars per watt, the energy cost is 0.03 dollars per watt, the manufacturing labour cost is 0.01 dollars per watt, the investment is 0.02 dollars per watt, and other miscellaneous expenses are approximately 0.05 dollars per watt. Given the fixed polysilicon price of 0.37 dollars per kilogram across all regions, the total cost of solar PV manufacturing in China amounts to 0.6 dollars per watt when polysilicon is included. Without polysilicon, the cost is reduced to 0.23 dollars per watt.

For the United States, the material cost also stands at 0.12 dollars per watt, the energy cost is 0.03 dollars per watt, manufacturing labour is 0.003 dollars per watt, investment is 0.05 dollars per watt, and other miscellaneous expenses total 0.07 dollars per watt. Consequently, the overall cost including polysilicon is 0.67 dollars per watt, whereas excluding polysilicon it is 0.3 dollars per watt.

When applied to the Pakistani context, if the United States were to provide Pakistan with the same technology, the cost of producing 10,000 megawatts of solar energy would amount to approximately 3 billion dollars. By comparison, the same energy capacity through Chinese technology would cost around 2.3 billion dollars. This demonstrates that the United States is not the most economically viable option for Pakistan. According to the IEA report, the United States ranks as the fourth-best option after China, ASEAN, and India. The implications of these findings are further analysed in the context of Power Transition Theory in the subsequent section.

Strategic Dynamics of the US–Pakistan Partnership

In contemporary global politics, scarcity of resources often shapes strategic relations. However, if resources were abundant, the focus of political competition would shift towards the scarcity of technology, economic power, and human capital required to exploit those resources. Within the domain of renewable energy, the competition revolves around the development of advanced technology, securing access to critical minerals, improving methods to harness energy efficiently, and cultivating a skilled workforce capable of driving the energy transition forward.

In this race, the United States has emerged as a late participant. Its delayed entry raises doubt about whether it can realistically catch up with China, which is already well ahead. When a hegemon finds itself unable to match a rising power in a specific sector, it often prioritizes preserving the existing international order. Protecting the status quo requires forging alliances that can sway the closest partners of the rising competitor. The United States' "Green Alliance" framework can be understood as one such initiative. It seeks to counterbalance Chinese influence in Pakistan and is rooted in Washington's security considerations.

The United States has adopted a three-pronged strategy to expand its role in the renewable energy sector, as discussed earlier. Its engagement with Pakistan under the energy transition agenda forms part of this broader strategy. Pakistan, being a regional power, plays a significant role in shifting the balance of power in favour of the United States at the regional level. For this purpose, the United States presented Pakistan with the seemingly attractive proposal of the "Green Alliance." Yet, as the findings of this study demonstrate, Washington's claims have not been supported by concrete actions. The United States has not delivered substantial assistance that could reinforce its security objectives.

In an interview, a foreign policy expert compared the relationship between Pakistan and the United States to a marriage where both parties are unable to divorce due to deep interdependence. This analogy underscores the complexities of their partnership. Had there been stronger commitments from both sides, the proposal might already have materialized. Nonetheless, the "Green Alliance" still remains a work in progress. It is possible that in the coming years, tangible steps may be taken, and the goal of generating 10,000 megawatts of solar energy could be achieved.

Authors Contributions

All the authors participated in the ideation, development, and final approval of the manuscript, making significant contributions to the work reported.

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Statement of Data Availability

The corresponding author can provide the data used in this study upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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