PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS

Knowledge Brief

No. 2026:158 | July, 2026

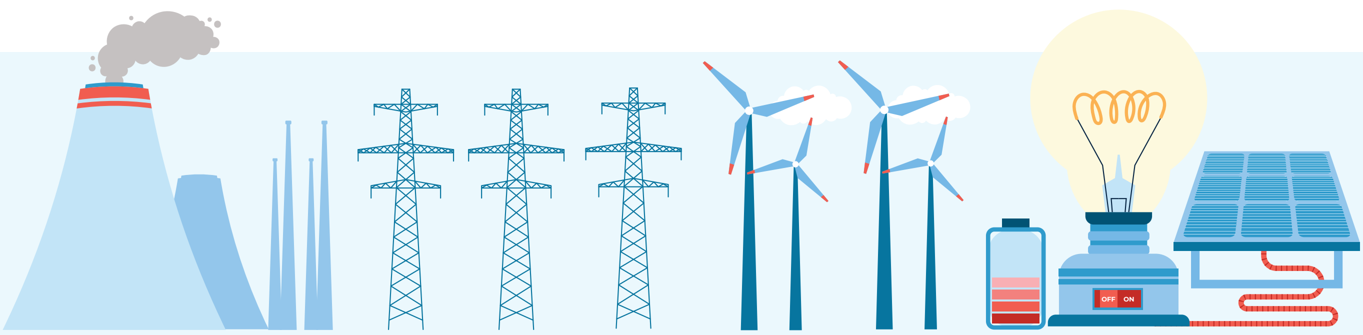
Energy Transition: What It Means, What the Evidence Shows, and What It Implies for Pakistan

A synthesis of concepts, empirical evidence, international policy experience, and financing approaches

Dr. S. M. Naeem Nawaz
Professor of Economics, PIDE

Executive Summary

Energy transition refers to long-term technological, fuel, infrastructure, market, institutional, and socio-cultural changes in how energy services are supplied and used. According to recent policy discussions, the term means transitioning away from an energy system based on fossil fuels towards increased efficiency, electrification, and decreasing emissions. The literature shows that transitions tend to be path-dependent and intensive in infrastructure. But new technologies can diffuse rapidly as soon as their cost falls if other conditions are met. Recent research provides evidence for four key propositions. First, the flow of clean energy investments is rising. Second, reliability depends on grid capacity, flexibility, and end-use efficiency. Third, finance and institutional risk matter in the case of emerging countries. Fourth, badly-managed distributional consequences could undermine the legitimacy of a transition process. International experience further indicates that targets are operationalized only if procurement processes, network planning, industrial capacity, finance tools, and social protection are considered. For Pakistan, the brief proposes a workable definition of energy transition in terms of the coordinated transition of energy supply, demand, networks, markets, finance, industry, and institutions. The criteria of success include affordability, reliability, energy security, financial sustainability, access, competitiveness, emission reductions, and distributive impact.



STATE OF KNOWLEDGE: FIVE FINDINGS

01 Energy transition is a socio-technical system change, not a single fuel switch (Geels, 2002; Markard et al., 2012).

02 Historical transitions are often slow, but policy-supported technologies can diffuse much faster (Smil, 2010; Sovacool, 2016).

03 Low technology costs do not remove the need for grids, flexibility, bankable contracts and capable institutions (IEA, 2023; IRENA, 2026b).

04 High costs of capital can outweigh technology cost advantages in emerging and developing economies (IEA, 2024).

05 Benefits and burdens are unevenly distributed, making justice and participation central to implementation (Carley & Konisky, 2020; ILO, 2015).

ENERGY TRANSITION AS SYSTEM TRANSFORMATION

SUPPLY
Low-carbon resources

DEMAND
Efficiency & electrification

NETWORKS
Grids, storage & flexibility

MARKETS
Prices, procurement & rules

FINANCE
Risk allocation & capital

PEOPLE & INSTITUTIONS
Skills, access, participation

Source: Synthesis of Geels (2002), IPCC (2022), IEA (2023) and IRENA (2024)

Outcomes are jointly evaluated based on affordability, reliability, security, access, competitiveness, and emissions.

WHY TRANSITION IS CRITICAL NOW

Dimension	What the literature establishes	Source
Climate and health	Energy production and use account for the dominant share of greenhouse-gas emissions and are major sources of local air pollution.	IPCC (2022)
Security and macro stability	Fuel-import dependence exposes economies to geopolitical disruption, price shocks, subsidies and foreign-exchange pressure. Efficiency and domestic clean supply can reduce this exposure.	IEA (2022); IRENA (2026b)
Growth and competitiveness	Electricity quality, energy productivity, carbon intensity and access to green finance increasingly shape industrial costs, trade and investment.	IRENA (2024); World Bank (2023)

Energy transition matters because it is simultaneously an environmental, security and development issue.

1. Introduction: Purpose, Scope and Limitations

Energy systems in the world are being transformed under certain pressures including climate commitments, fuel-price volatility, technological learning, industrial competition and rising electricity demand. This Knowledge Brief aims to synthesize the literature on energy transition to understand its meaning. Furthermore, it attempts to answer certain questions. These include what empirical evidence establishes with reasonable confidence, which issues remain contested, and what international experience implies for Pakistan. Thus, it is equally relevant to researchers, practitioners and informed policy audiences.

SCOPE AND LIMITATIONS

The brief covers system-wide transition, focusing on electricity, end-use efficiency, finance and just-transition concerns. It synthesises peer-reviewed research, major international assessments and official policy documents. However, it does not evaluate any lowest-cost path for Pakistan, analyze the project-based funding needs, or view the selected country case studies as replicable. This is because the institutional capabilities, resource bases, and development priorities differ between countries.

2. Definitions and Theoretical Foundations

Historically, energy transition has been understood as a transformation involving fuel sources, conversion technologies, and energy-use patterns. Following this, the sustainability transitions literature further elaborates on this notion by defining energy provision as a socio-technical system where technological artifacts relate to infrastructure, regulation, firms, consumers/users, skills, and social conventions (Geels, 2002; Markard et al., 2012). The multi-level perspective explains transitions through interactions between protected innovations – "niches," existing systems – "regimes," and wider economic, political, and ecological dynamics. Such an approach provides an understanding of why the simple availability of more affordable technology is often insufficient to overcome existing asset stocks and contractual/behavioral relationships.

Table 1: Key Concepts and Their Meaning in the Energy Transition Literature

Concept	Meaning in this brief	Knowledge anchor
Energy transition	Long-term transformation of energy supply, conversion, networks, demand, markets, institutions and practices.	Smil (2010); Markard et al. (2012)
Decarbonisation	Reduction in carbon intensity and absolute emissions; a major objective, but not the full transition.	IPCC (2022)
Renewable expansion	Deployment of replenishing sources such as solar, wind, hydro, geothermal and sustainable bioenergy.	IRENA (2024)
Electrification	Substitution of direct fuel use with electricity in transport, heat, buildings and industry where technically and economically suitable.	IEA (2021)
Net zero	Balance between anthropogenic greenhouse-gas emissions and anthropogenic removals over a specified period.	IPCC (2022)
Just transition	A process that anticipates effects on workers, consumers, communities and regions and embeds participation, decent work and social protection.	ILO (2015); Carley & Konisky (2020)

Related concepts should not be used interchangeably.

Source: Author's synthesis

WHY THEORETICAL FRAMING MATTERS

Three propositions follow. First, transition is path-dependent: existing plants, grids, subsidies, contracts and skills shape feasible choices. Second, it is multi-sectoral: power-sector decarbonisation enables but does not complete transition in transport, buildings and industry. Third, it is political and distributive: incumbent firms, consumers, workers and regions have different exposure to costs and benefits. These propositions caution against treating transition as an engineering capacity target alone.

Table 2: Analytical Lenses for Understanding Energy Transitions

Analytical lens	Core question	Value for policy analysis
Historical systems lens	Examines shifts among fuels, technologies and infrastructures over long periods.	Clarifies inertia, scale and the role of sunk assets.
Multi-level perspective	Explains interaction among innovations, established regimes and wider economic or political pressures.	Shows why niches need markets, networks and institutional change to scale.
Political-economy lens	Focuses on interests, rents, ownership, subsidies, state capacity and coalitions.	Explains resistance, policy instability and differences between formal targets and delivery.
Energy-justice lens	Assesses distributional, procedural and recognition dimensions of change.	Makes affordability, participation, workers and affected regions part of transition design.

Complementary theoretical lenses used in energy-transition research.

Source: Author's synthesis

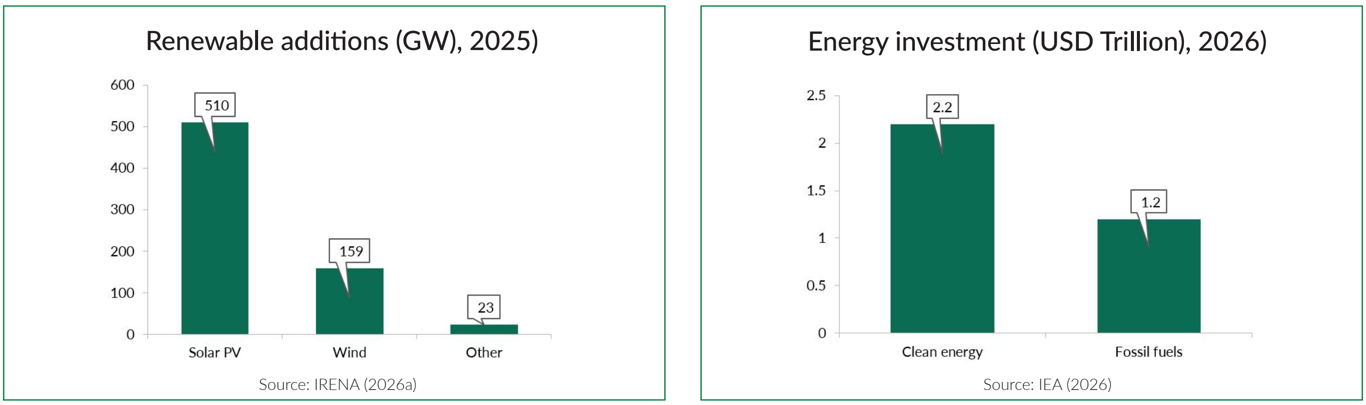
WHAT THEORY DOES NOT IMPLY

The literature does not identify a universal fuel mix, an optimal pace or a specific institutional model. It instead identifies recurring mechanisms (learning, lock-in, coordination, risk allocation and distribution) that need to be tested against each country's resource base, demand trajectory and administrative capacity.

3. What Does Empirical Evidence Show?

Recent data show a strong reallocation of global capital and capacity toward clean technologies, but not a uniform transition. IRENA reports that 692 GW of renewable power was added in 2025, accounting for 85.6 percent of all power capacity additions; 79.5 percent of new renewable capacity was concentrated in China, the United States and the European Union (IRENA, 2026a). The IEA estimates global energy investment at USD 3.4 trillion in 2026, with USD 2.2 trillion directed to clean energy and USD 1.2 trillion to fossil fuels (IEA, 2026).

Figure 1: Global Transition Momentum is strong, but unevenly distributed



Technology economics have also changed. In 2025, global weighted-average levelised costs were about USD 33/MWh for onshore wind and USD 44/MWh for utility-scale solar PV, while more than 90 percent of new utility-scale renewable projects were cheaper than the lowest-cost new fossil-fuel alternative. Four-hour battery installed costs fell to around USD 140/kWh, but financing conditions and grid availability increasingly explain cross-country differences in delivered costs (IRENA, 2026b). Way et al. (2022) similarly find that conventional models have often underestimated learning-driven cost declines in solar, wind, batteries and electrolysers.

Table 3: Areas of Consensus and Continuing Debate

Issue	Broad consensus	What remains contested
Pace of transition	System-wide transitions are path-dependent and infrastructure-intensive.	How rapidly policy can compress transition timelines without creating reliability, fiscal or social stress.
Technology costs	Solar, wind and batteries have experienced substantial learning and cost declines.	Future supply-chain, financing and integration costs; appropriate roles for nuclear, gas, hydrogen and carbon capture.
Grid and flexibility	Transmission, distribution, storage, interconnection and demand response are essential complements to variable renewables.	Optimal mix of storage, flexible generation, regional trade and demand-side measures in each system.
Finance	Policy stability, credible offtakers, currency risk and project preparation materially affect the cost of capital.	How much concessional finance is needed and how effectively it mobilises additional private capital.
Distribution	Transitions create winners and losers across households, workers, firms and regions.	Which compensation, participation, and regional development arrangements deliver durable fairness?
Energy security	Efficiency and domestic clean energy resources can reduce exposure to imported fuel.	New vulnerabilities related to minerals, equipment concentration, cyber risks, and weather-dependent supply.

Source: Author's synthesis

Table 4: Evidence Beyond Capacity Additions

Evidence domain	What is known	Interpretation
Integration	The IEA estimates that around 80 million kilometres of grids may need to be added or replaced globally by 2040 to meet national goals.	Network planning is a transition investment, not a secondary technical issue.
Finance	In emerging and developing economies, financing can make up half or more of solar PV levelised costs; energy-sector risks explain part of the premium.	A low equipment price does not guarantee low delivered electricity cost.
Distribution	Research documents uneven exposure to energy bills, job displacement, environmental burdens and access to new opportunities.	Aggregate gains can coexist with concentrated losses and political resistance.
System security	Renewables reduce recurring fuel exposure, while variability, supply-chain concentration and critical-mineral dependencies create new risk-management needs.	Security should be assessed across fuels, infrastructure, technology and institutions.

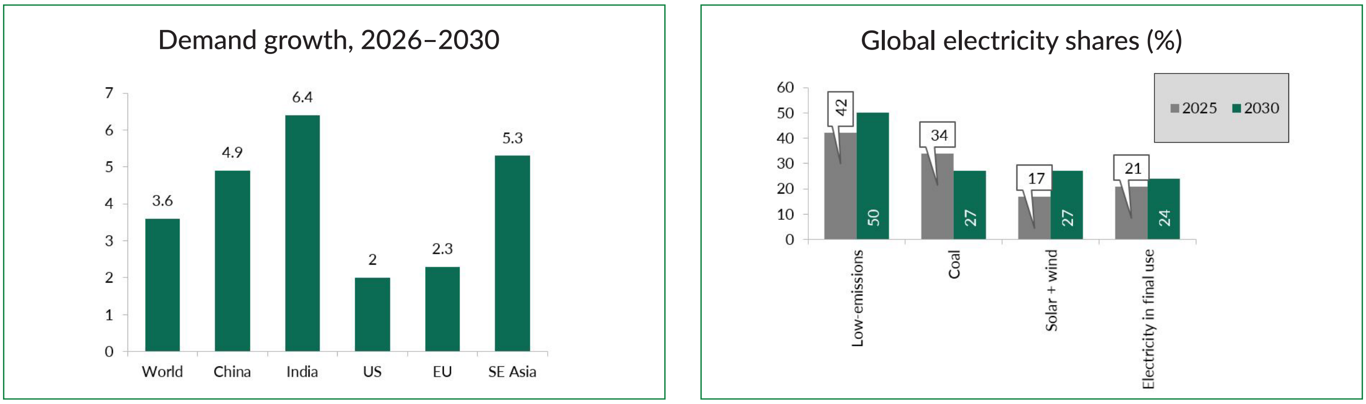
Deployment statistics are necessary but insufficient measures of transition progress.

Source: Author's synthesis

3.1 Forward Outlook: Electricity Demand, Supply Mix and Pakistan Scenarios

The forward outlook strengthens the central finding of this brief: the transition is occurring alongside faster electricity-demand growth, rather than through declining energy-service needs. The IEA projects global electricity demand to expand by an average of 3.6 percent a year during 2026-2030, raising consumption from about 28,200 TWh in 2025 to 33,600 TWh in 2030. Growth is expected to be particularly strong in India, Southeast Asia and China. At the same time, demand resumes sustained growth in the United States and the European Union because of data centres, cooling, electric mobility, heat pumps and industrial electrification (IEA, 2026b).

Figure 2: Global electricity outlook to 2030: demand growth and changing generation shares

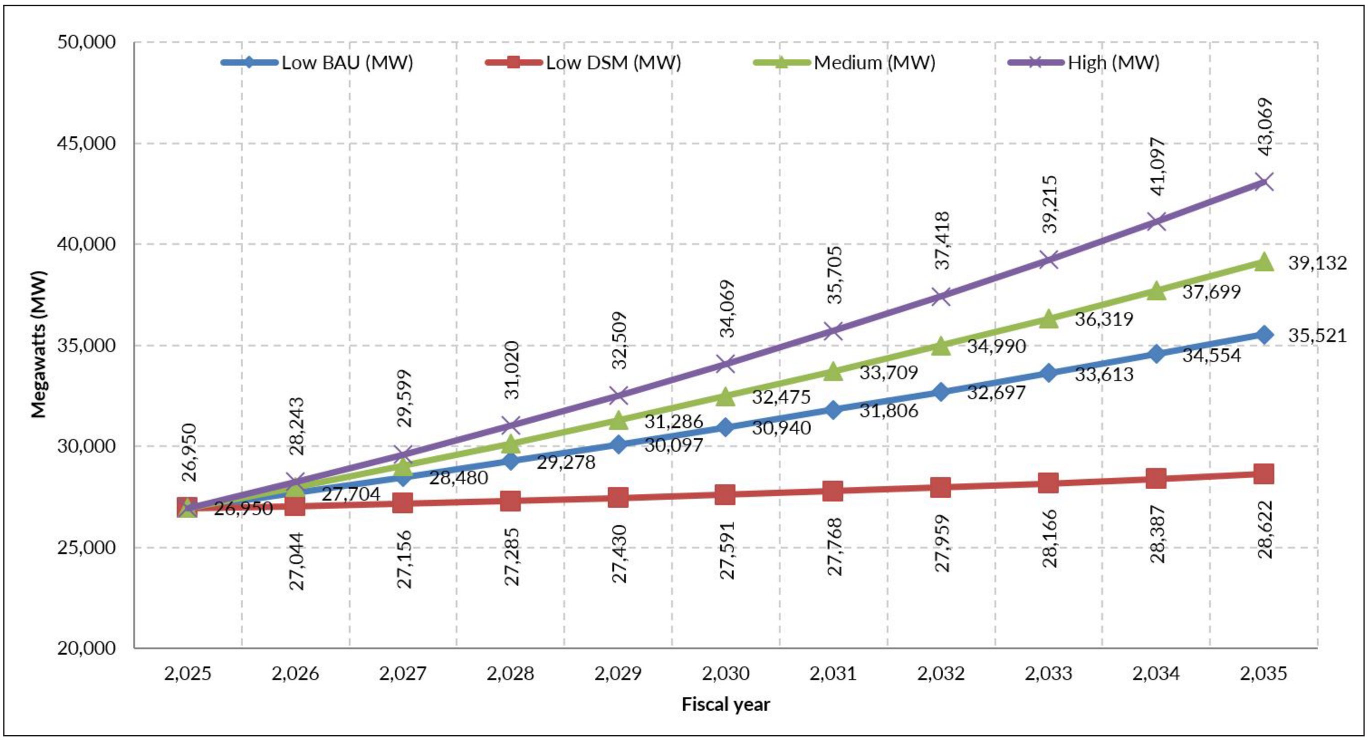


Source: IEA (2026b)

On the supply side, low-emissions sources (renewables and nuclear) are forecast to account for 50 percent of global electricity generation by 2030, up from 42 percent in 2025. The combined share of solar PV and wind rises from 17 percent to 27 percent. Coal's share falls from 34 percent to 27 percent. Furthermore, the IEA forecasts 4,600 GW of renewable capacity additions during 2025-2030, including 80 percent solar PV. These projections also highlight the infrastructure constraint: annual grid investment needs to rise by roughly 50 percent from the current level of about USD 400 billion (IEA, 2025; IEA, 2026b).

Planning scenarios in Figure 3 show why uncertainty must be explicit. According to the Revised IGECP 2025-2035, the peak national demand in FY2035 is estimated at 28.6 GW in the Low demand-side management (DSM[1]) scenario, 35.5 GW in the Low business-as-usual (BAU[2]) scenario, 39.1 GW in the Medium Growth scenario, and 43.1 GW in the High Growth scenario. The difference between the minimum and maximum estimates equals 14.4 GW, which is large enough to have significant implications for generation, transmission, reserve, and financing requirements (Government of Pakistan, NEPRA, 2025).

Figure 3: Pakistan peak-electricity-demand scenarios, FY2025–FY2035



Source: Revised IGCEP 2025–2035

Table 5: Low-BAU Country Energy Demand before and after the IGCEP Net-Metering Adjustment

Fiscal year	Gross demand (GWh)	After net metering (GWh)	Difference (GWh)
2025	137,025	133,233	3,792
2030	157,313	146,454	10,859
2035	180,605	167,293	13,312

Source: Government of Pakistan, NEPRA (2025)

It is important to note that the introduction of net metering requires a proper understanding that although energy produced beyond the meter reduces demand recorded or served by the interconnected grid system, it does not eliminate the inherent demand for energy services. This implies that there will be a need for a dual planning approach.

4. Comparative and International Perspectives

International experience is most valuable when considered through comparative analysis. The industrialized countries usually have well-developed capital markets and administrative capabilities. At the same time, emerging and developing countries have to deal with the issues of fast-growing demand, underdeveloped utilities, high levels of sovereign and exchange risks, and challenges related to affordability and accessibility. Therefore, the important point is not which model should be followed by Pakistan, but which design features persist under different situations.

Table 6: Selected Developed- and Developing-Country Experiences

Country	Policy architecture	Main instruments	What the case adds to knowledge
Germany Developed	Climate Change Act; renewable-electricity legislation; climate-neutrality goal for 2045.	Long-term legal direction, renewable auctions, grid planning, efficiency, industrial support and public-bank finance.	Durable targets need permitting, network expansion and attention to costs in buildings, transport and industry.
United Kingdom Developed	Climate Change Act and carbon budgets; Contracts for Difference; Clean Power 2030 Action Plan.	Independent carbon governance, competitive long-term contracts, regulated networks and connection reform.	Accountable milestones and bankable procurement can mobilise capital, but grid queues and system balancing remain binding.
China Emerging	Carbon-peaking and neutrality framework; 2024 energy-transition white paper.	State-led grids, manufacturing scale, electrification, renewables, storage and green finance.	Industrial capability and infrastructure accelerate diffusion; continued coal investment illustrates security and lock-in tensions.
India Developing	Renewable auctions and obligations; Green Energy Corridors; National Green Hydrogen Mission.	Competitive procurement, transmission support, open access and targeted industrial incentives.	Predictable demand creation can crowd in private capital, but rapid load growth and financing needs complicate substitution.
South Africa Developing	Just Transition Framework and Just Energy Transition Investment Plan 2023–2027.	Grid investment, coal-region diversification, skills, municipal capacity and blended international finance.	Utility viability, local jobs and regional development need to be embedded in the investment plan.
Viet Nam Developing	Power Development Plan VIII and Just Energy Transition Partnership (JETP) Resource Mobilisation Plan.	Renewable and network expansion, market reform, project pipeline and international partnership finance.	Large pledges do not automatically become investment; project bankability, terms and domestic reform determine delivery.

Sources: Official country policy documents listed in the references.

1.Low DSM means the low-demand scenario after incorporating Demand-Side Management measures, especially energy efficiency and peak-load reduction.
2.Low BAU means the low-demand business-as-usual scenario, without additional demand-management intervention.

4.1 Country Cases in Practice: From Policy Design to Delivery

Comparative analysis of countries helps identify how the energy transition can be implemented successfully. As follows from the examples presented below, there is an evident difference between the policy instrument used for triggering the energy transition and the constraint generated when implementing the first step. It becomes evident that any energy-transition policy must necessarily be iterative; solving one constraint (e.g., price and investment risks) and facing the next (network constraints).

Germany | Developed

Mechanism

The 2045 climate-neutrality objective is linked to renewable auctions, grid planning, efficiency measures, industrial support and public-bank finance.

Delivery constraint

Permitting, local acceptance and transmission expansion must keep pace, while buildings, heat and transport move more slowly than electricity.

Learning

Legal direction becomes credible when auction calendars, permits, network plans and finance institutions are aligned; power-sector progress does not automatically complete an economy-wide transition. (Federal Ministry for Economic Affairs and Climate Action, 2024).

United Kingdom | Developed

Mechanism

Legally binding carbon budgets are combined with competitive Contracts for Difference (CfDs), which give generators long-term revenue certainty; Clean Power 2030 targets at least 95 percent clean generation.

Delivery constraint

Grid queues, connection reform, transmission and flexibility have become binding, with the plan implying around GBP 40 billion of annual investment during 2025-2030.

Learning

Bankable procurement can mobilize private capital, but successful deployment shifts the policy frontier toward networks, storage, spatial planning and system balancing. (Department for Energy Security and Net Zero, 2024).

China | Emerging

Mechanism

Long-term carbon goals are supported by state-led grids, manufacturing scale, electrification, storage and green finance, allowing rapid diffusion and lower equipment costs.

Delivery constraint

Coal continues to be retained and expanded for reliability and energy-security reasons, creating tensions between flexibility needs and long-lived carbon lock-in.

Learning

Coordinated industrial policy and infrastructure can compress deployment timelines, but capacity growth still requires market, dispatch and flexibility reforms and a strategy for legacy coal assets. (State Council Information Office of the People's Republic of China, 2024).

India | Developing

Mechanism

Repeated renewable auctions, central procurement, solar parks, purchase obligations and Green Energy Corridors reduce price, land and evacuation risks; the hydrogen mission extends policy toward industry.

Delivery constraint

Rapid load growth, financially weak distribution companies and uneven state-level implementation affect payment security and the delivered cost of electricity.

Learning

Predictable demand creation crowds in investment when transmission, credible offtakers and implementation capacity are developed alongside generation. (Government of India, Ministry of New and Renewable Energy, 2023).

South Africa | Developing

Mechanism
The Just Energy Transition Investment Plan (JET IP) combines electricity and grid investment with coal-region diversification, worker skills, municipal capacity and social support; estimated needs are about USD 98 billion for 2023-2027.

Delivery constraint
The requirement exceeds the initial international package, while Eskom viability, grid availability, domestic reform, project preparation and financing terms condition delivery.

Learning
The "just" component becomes operational only when affected places, workers and local institutions are linked to funded programmes and measurable outcomes. (Government of South Africa, Presidential Climate Commission, 2022).

Viet Nam | Developing

Mechanism
Power Development Plan VIII and the Just Energy Transition Partnership (JETP) Resource Mobilization Plan translate an international pledge into pipelines, including 37 existing or planned investments, 181 proposed investments and 61 technical assistance projects.

Delivery constraint
Bankable power-purchase arrangements, approvals, grid readiness, capable sponsors and the mix of concessional and commercial finance determine disbursement.

Learning
A financing pledge is not yet investment; project selection, contracts, permits, risk allocation and domestic reform determine whether announced resources reach implementation. (Government of Viet Nam & International Partners Group, 2023).

Table 7: The Recurring Policy-To-Delivery Chain

1 **LEGAL DIRECTION** Targets and milestones	2 **BANKABLE PROCUREMENT** Auctions and contracts	3 **GRID & PERMITS** Networks and approvals
4 **INDUSTRY & SKILLS** Supply chains and workers	5 **SOCIAL ADJUSTMENT** Consumers and regions	6 **MONITOR & REVISE** Data and accountability

The ordering is iterative rather than rigid: solving one constraint often reveals the next.

Source: Author's synthesis of the six country cases

CROSS-COUNTRY SYNTHESIS

Five common themes are evident. First, there is the building of credibility through procurement, grid, and efficiency gains. Second, additional generation without commensurate investments in the grid and interconnections would limit the ability of the system to operate, causing power reductions. Third, countries use industrial policies for employment and supply chain advantages, but wrong localization may result in higher costs. Fourth, public and concessional finance works best in situations where the emphasis is on risk mitigation and creating an enabling environment and not on commercial finance. Fifth, acceptability depends on the project design in terms of cost-effectiveness, labor adjustments, and size of geography.

A CAUTION ON POLICY TRANSFER

These policy tools are institutionalized. For example, policies like carbon pricing, auctions, subsidization, government-owned finance, or local content policy may produce different results depending on the credibility of regulations, the solvency of the utilities, fiscal space, competition, and administrative capacity. The lessons from comparison, therefore, suggest customization of the underlying principles rather than adoption of certain policy mixes.

Table 8: How Major Instruments Contribute

Instrument	Contribution	Common implementation problem
Legal targets and carbon budgets	Provide direction and accountability.	Weak when not backed by delivery institutions, finance and near-term milestones.
Auctions and long-term contracts	Reveal prices and reduce revenue uncertainty for mature technologies.	Require credible offtakers, competition, land, permits and grid access.
Grid and spatial planning	Coordinate generation, networks, storage and demand.	Often delayed relative to generation because returns and responsibilities are fragmented.
Efficiency standards and codes	Reduce demand, bills and required supply investment.	Depend on enforcement, testing, information and financing for retrofits.
Just-transition and regional funds	Support workers, firms, communities and economic diversification.	Need participation, credible local pipelines and long-term development institutions.

Instruments are complementary; no single measure can deliver a system transition.

Source: Author's synthesis

5. Financing the Transition: What Evidence Shows

The main features of clean energy infrastructure are relatively high capital needs for such investment, with large upfront expenses, while benefits of reduced fuel consumption accrue over time. Thus, the cost of funding and its term are key factors in determining affordability. According to the International Energy Agency, investments in clean energy will have to be increased annually in emerging and developing countries from about 270 billion to 870 billion US dollars by the early 2030s to cover national obligations. A saving of 1% in the capital cost may save 150 billion dollars per year in the funding cost (International Energy Agency, 2024). The core financing problem is therefore risk allocation, not simply the volume of available money.

Table 9: Financing Channels for Energy Transition: Roles and Enabling Conditions

Financing channel	Appropriate role	Key condition
Commercial debt and equity	Mature, contracted generation, storage and efficiency projects.	Requires predictable revenues, credible offtakers, permits and enforceable contracts.
Public budgets and utilities	Grids, access, public infrastructure, data, social protection and early project preparation.	Fiscal and contingent liabilities need transparent appraisal and prioritisation.
Concessional and development finance	Guarantees, long-tenor debt, currency-risk support, first-loss capital and institutional strengthening.	Most additional when targeted at risks that prevent otherwise viable projects.
Domestic capital markets	Green bonds/sukuk, infrastructure funds, banks, pensions and insurance capital.	Needs credible taxonomies, disclosure, pipelines and local-currency instruments.
Carbon and transition finance	Methane reduction, industrial abatement, asset repurposing and community benefits.	Depends on integrity, additionality, measurement, reporting, verification and fair benefit sharing.

Source: Author's synthesis

6. From Global Evidence to a Pakistan-Specific Energy Transition Framework

The preceding conceptual, empirical and comparative review shows that energy transition cannot be adequately defined through renewable energy deployment or emissions reduction alone. The literature identifies transition as a system-wide process involving technologies, infrastructure, markets, institutions, finance and patterns of energy use. Country experiences further show that progress depends on the interaction among credible policy direction, procurement, networks, industrial capability, financing arrangements and mechanisms for managing distributional effects. These findings have particular relevance for Pakistan. The country must respond simultaneously to imported fuel exposure, circular debt, constrained electricity networks, rising and changing energy demand, distributed solar generation, limited fiscal space, uneven access and industrial competitiveness. Drawing on the review in the preceding sections and Pakistan's existing energy and climate policy frameworks, this brief proposes the following working definition and analytical framework.

PROPOSED WORKING DEFINITION

For Pakistan, the energy transition can be considered an organized and phased transformation of its energy system. It starts with changes in energy production and electricity generation. Then it moves to distribution, markets, financing, and consumption of energy. The goal must be set to create an energy system that is efficient, diversified, electrified, and increasingly clean. This involves goals such as making energy cheaper, more reliable, and secure, reducing reliance on imports and price fluctuations. It will make the energy system financially sustainable, more efficient, and competitive for industries. At the same time, it will improve the welfare of consumers, workers, and regions. As such, ensuring sustainable energy infrastructure must not be considered a choice. Under this definition, energy transition is neither limited to increasing renewable generation capacity nor interpreted as immediate elimination of all fossil fuels. It requires coordinated changes in technologies, infrastructure, demand, markets, financing arrangements, institutional capabilities and social protection mechanisms, consistent with Pakistan's development needs, resource endowment and implementation capacity.

Figure 4. Pakistan Energy Transition Framework: Pressures, Dimensions of Transformation and Intended Outcomes

TRANSITION PRESSURES

Imported fuel exposure; circular debt; rising and changing demand; constrained grids; distributed solar; climate risks; industrial competitiveness; limited fiscal space

↓

SUPPLY & RESOURCES Diversification and progressively lower-emissions resources assessed against system cost, reliability and import exposure.	**DEMAND & EFFICIENCY** Efficiency, conservation, demand management and appropriate electrification across final-use sectors.
NETWORKS & FLEXIBILITY Transmission, distribution, storage, forecasting, demand response and system operation for utility-scale and distributed resources	**MARKETS & FINANCE** Pricing, procurement, contracts, utility viability, competition and risk allocation capable of supporting bankable investment.
INDUSTRY & ECONOMY Productivity, technology, skills, domestic capability and lower exposure to fuel- and equipment-related foreign-exchange risks.	**PEOPLE & INSTITUTIONS** Access, affordability, participation, worker and regional adjustment, protection, data, coordination and accountability.

↓

INTENDED TRANSITION OUTCOMES

Affordability; reliability; energy security; financial sustainability; competitiveness; access; emissions reduction; distributional fairness

Source: Author's synthesis based on Geels (2002), Markard et al. (2012), IPCC (2022), IEA (2023), IRENA (2024), and the national policies.

The framework distinguishes the instruments of transition from their intended outcomes. Renewable generation, storage, electrification, efficiency, and market reform are means through which transition may occur; they are not sufficient measures of success in themselves. For Pakistan, progress should be evaluated through the quality, reliability and affordability of energy services, exposure to imported fuels, financial and fiscal sustainability, industrial competitiveness, access, emissions and the distribution of costs and benefits. Renewable-capacity expansion accompanied by worsening grid instability, circular debt or energy affordability would therefore constitute an incomplete transition.

Table 10: Operational Questions for Pakistan's Energy Transition

Dimension	Question for assessing progress
Supply and resources	Does the evolving energy mix reduce import and price exposure while meeting reliability and environmental requirements?
Demand and efficiency	Are energy services and economic output being delivered with lower energy intensity and improved demand management?
Networks and flexibility	Can transmission and distribution systems reliably integrate utility-scale and distributed resources?
Markets and finance	Are prices, contracts, procurement and risk allocation financially sustainable and capable of mobilising investment?
Industry and economy	Does the transition improve productivity, skills, technological capability and competitiveness?
People and institutions	Are vulnerable consumers, workers and affected regions recognized? Are responsibilities, data and accountability clearly defined?

Source: Author's synthesis

The proposed framework does not prescribe a predetermined technology mix, investment plan or timeframe. As such, it provides a common analytical lens for examining Pakistan's existing policies, identifying evidence gaps and assessing contributions of individual interventions to coherent system transformation. The following sections use this framework to organize Pakistan-specific knowledge gaps and implications for policy and practice.

7. Knowledge Gaps

Table 11: Key Knowledge Gaps in Pakistan's Energy Transition

Unresolved question	Why it matters
Transition sequencing in lower-middle-income economies	Evidence remains limited on how to balance rapid demand growth, affordability, reliability and decarbonisation under tight fiscal and foreign-exchange constraints.
Distributed solar and utility finance	More research is needed on tariff design, cost recovery, storage and fair allocation of network costs as high-value consumers self-generate.
Pakistan-specific system data	Open, consistent data on hourly demand, network congestion, distributed generation, losses, contract obligations and asset performance remain inadequate for transparent modelling.
Employment and regional effects	Pakistan lacks robust estimates of jobs gained, jobs displaced, skills needs and place-based effects across coal, thermal power, renewables, transport and industry.
Cost of capital and domestic finance	The relative contributions of sovereign, currency, offtaker, regulatory and project risks are not sufficiently quantified for different technologies.
Legacy assets and lock-in	Further analysis is required regarding the retirement, renegotiation, repurposing and fiscal treatment of contracts and assets that may become under-utilised.

Source: Author's synthesis

8. Implications for Practice and Policy in Pakistan

In Pakistan's ARE Policy 2019, National Electricity Policy 2021, National Electricity Plan 2023-2027, NEEC Policy and Action Plan 2023-2030, updated IGCEP 2025-2035, National Climate Finance Strategy and NDC 3.0, many of the aspects of the energy transition are already covered. Based on the framework presented in Section 6, it is clear that Pakistan's primary concern is not a lack of individual tools, but insufficient coherence among the interlinked dimensions of the energy transition. Planning for electricity generation, network development, efficiency measures, distributed solar power, utility finances, climate policies, industrialization and social protection are normally addressed through separate processes. Their cumulative effect on affordability, reliability, budgetary exposure and competitiveness is often unclear. Based on international and empirical experience, the following recommendations can be considered without dictating any specific technology portfolio and investment program.

Table 12: Evidence-Based Implications of Energy Transition for Pakistan

Evidence-based implication	Meaning for Pakistan
Planning coherence	Generation, transmission, distribution, efficiency, distributed solar and climate commitments are more informative when assessed through common demand and cost assumptions.
Whole system value	Technology choices need to be compared on delivered system cost, reliability, flexibility, fuel & foreign-exchange exposure, emissions & legacy obligations, and not headline generation cost alone.
Financial viability	Private finance is unlikely to compensate for weak offtakers, unstable rules or unresolved circular debt. Sector fundamentals and risk allocation are critical to shape bankability.
Distributional design	Tariff reform, self-generation and asset restructuring have different effects across consumers, workers and regions. Transparent incidence analysis and participation improve legitimacy.
Implementation evidence	An annual public dashboard covering cost, reliability, grid readiness, investment, emissions, access and distributional outcomes would improve learning and accountability.

Source: Author's synthesis

9. Conclusion

Neither current knowledge nor experience favors a technology-driven transition or a straight-out continuation of the status quo. While renewable and storage technologies have seen cost reductions, increased uptake, and domestic clean energy resources to enhance energy security, the energy system transition cannot be achieved through low-cost technologies alone. The achievement of the benefits of technology development in terms of energy service provision relies on infrastructure, demand-side efficiency, market designs, institutional arrangements, financial mechanisms, and distribution management. In the case of Pakistan, literature shows that the first step in analysis is one of integration, in which current plans need to be evaluated using common assumptions and a wider set of outcomes. Future research needs to include system-level data transparency, risk assessment related to financing, effects of solar power, employment and regional adjustments, and economics of existing assets. This will allow for informed policy decisions, which will be based on systemic value and social impact rather than isolated capacity goals.

SIGNIFICANCE FOR FUTURE RESEARCH AND PRACTICE

Pakistan-specific research on the future energy transition needs to incorporate modeling of the electricity system, its fiscal vulnerability, industrial competitiveness, and household impacts. The scenario analysis would also be critical for studying capacities and emissions, network implications, exchange-rate risk, financing assumptions, stranded assets, job impacts, and distributional impacts based on income and region.

REFERENCES

Carley, S., & Konisky, D. M. (2020). The justice and equity implications of the clean energy transition. Nature Energy, 5, 569–577. https://doi.org/10.1038/s41560-020-0641-6

Department for Energy Security and Net Zero. (2024). Clean Power 2030 action plan: A new era of clean electricity. Government of the United Kingdom.

European Commission. (2022). REPowerEU plan (COM/2022/230 final).

European Union. (2023). Directive (EU) 2023/2413 on the promotion of energy from renewable sources.

Federal Ministry for Economic Affairs and Climate Action. (2024). Germany's current climate action status. Government of Germany.

Geels, F. W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. Research Policy, 31(8–9), 1257–1274. https://doi.org/10.1016/S0048-7333(02)00062-8

Government of India, Ministry of New and Renewable Energy. (2023). National Green Hydrogen Mission.

Government of Pakistan, Ministry of Climate Change and Environmental Coordination. (2024). National Climate Finance Strategy of Pakistan.

Government of Pakistan, Ministry of Climate Change and Environmental Coordination. (2025). Pakistan's Nationally Determined Contribution (NDC) 3.0.

Government of Pakistan, Ministry of Energy (Power Division). (2019). Alternative and Renewable Energy Policy 2019.

Government of Pakistan, Ministry of Energy (Power Division). (2021). National Electricity Policy 2021.

Government of Pakistan, Ministry of Energy (Power Division). (2023). National Electricity Plan 2023–2027.

Government of Pakistan, National Energy Efficiency and Conservation Authority. (2023a). National Energy Efficiency and Conservation Action Plan 2023–2030.

Government of Pakistan, National Energy Efficiency and Conservation Authority. (2023b). National Energy Efficiency and Conservation Policy 2023.

Government of Pakistan, National Electric Power Regulatory Authority. (2024). State of Industry Report 2024.

Government of Pakistan, National Electric Power Regulatory Authority. (2025). Revised Indicative Generation Capacity Expansion Plan 2025–2035.

Government of South Africa, Presidential Climate Commission. (2022). South Africa's Just Energy Transition Investment Plan 2023–2027.

Government of Viet Nam, & International Partners Group. (2023). Resource Mobilisation Plan for the Viet Nam Just Energy Transition Partnership.

International Energy Agency. (2021). Net zero by 2050: A roadmap for the global energy sector.

International Energy Agency. (2023). Electricity grids and secure energy transitions.

International Energy Agency. (2024). Reducing the cost of capital: Strategies to unlock clean energy investment in emerging and developing economies.

International Energy Agency. (2025). Renewables 2025. IEA.

International Energy Agency. (2026a). Electricity 2026: Analysis and forecast to 2030. IEA.

International Energy Agency. (2026b). World Energy Investment 2026. IEA.

International Energy Agency, & International Finance Corporation. (2023). Scaling up private finance for clean energy in emerging and developing economies.

International Labour Organization. (2015). Guidelines for a just transition towards environmentally sustainable economies and societies for all.

International Renewable Energy Agency. (2024). World Energy Transitions Outlook 2024: 1.5°C pathway.

International Renewable Energy Agency. (2026a). Renewable capacity statistics 2026.

International Renewable Energy Agency. (2026b). Renewable power generation costs in 2025.

Intergovernmental Panel on Climate Change. (2022). Climate Change 2022: Mitigation of climate change. Cambridge University Press. https://doi.org/10.1017/9781009157926

Markard, J., Raven, R., & Truffer, B. (2012). Sustainability transitions: An emerging field of research and its prospects. Research Policy, 41(6), 955–967. https://doi.org/10.1016/j.respol.2012.02.013

Smil, V. (2010). Energy transitions: History, requirements, prospects. Praeger.

Sovacool, B. K. (2016). How long will it take? Conceptualizing the temporal dynamics of energy transitions. Energy Research & Social Science, 13, 202–215. https://doi.org/10.1016/j.erss.2015.12.020

State Council Information Office of the People's Republic of China. (2024). China's energy transition.

Way, R., Ives, M. C., Mealy, P., & Farmer, J. D. (2022). Empirically grounded technology forecasts and the energy transition. Joule, 6(9), 2057–2082. https://doi.org/10.1016/j.joule.2022.08.009

World Bank. (2023). Scaling up to phase down: Financing energy transitions in the power sector.

PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS
QAU Campus, P.O. Box 1091, Islamabad 44000, Pakistan.

Tel: 051-9248094