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In the pursuit of a cleaner, greener, and sustainable energy future, Pakistan faces new challenges in terms of transition towards modern and renewable energy sources. The increasing prominence of clean energy technologies brings to the forefront the critical role of minerals in ensuring energy security.

Therefore, the action plan in Pakistan must address the unique demands and vulnerabilities arising from the clean mineral-intensive

by 50 per cent, mirroring the growing share of renewables in investment.

Key minerals crucial for clean energy technologies include lithium, nickel, cobalt, manganese, graphite, and rare earth elements. These minerals play a vital role in enhancing battery performance, longevity, and energy density. Rare earth elements are particularly essential for wind turbines and EV motors' permanent magnets. Additionally, electricity networks heavily rely on copper and aluminium, with copper serving as a cornerstone for all electricity-related technologies.

The transition to a clean energy system is

for copper and rare earth elements, 60-70 per cent for nickel, and cobalt, and nearly 90 per cent for lithium. Electric vehicles and battery storage have already surpassed consumer electronics as the largest consumers of lithium, and by 2040, they are set to supersede stainless steel as the primary end-user of nickel. As countries intensify efforts to reduce emissions, ensuring resilient and secure energy systems becomes paramount. Present international energy security mechanisms primarily focus on mitigating risks associated with disruptions or price fluctuations in hydrocarbon supply, predominantly oil. However, minerals present a distinct set of challenges, necessitating energy policymakers to broaden their perspective and account for potential vulnerabilities. Concerns regarding price volatility and the security of mineral supply persist even in an electrified, renewables-rich energy system.

Pakistan's transition to cleaner and sustainable energy sources necessitates addressal of the challenges posed by mineral-intensive clean energy technologies.

Pakistan's energy transition action plan must take into account the mineral requirements of clean energy technologies while ensuring energy security. Collaboration with international partners, increased investment in domestic mineral extraction, and diversification of mineral sourcing are essential strategies to address these challenges. Additionally, the nation should explore opportunities to promote research and development in mineral recycling and alternatives to reduce dependency on scarce resources.

The energy transition represents a transformative opportunity for Pakistan to reduce its carbon footprint and embrace a sustainable future. By formulating a comprehensive action plan that acknowledges the importance of minerals in clean energy technologies, Pakistan can pave the way for a resilient and secure energy system that balances environmental goals

Pakistan faces new challenges in energy transition

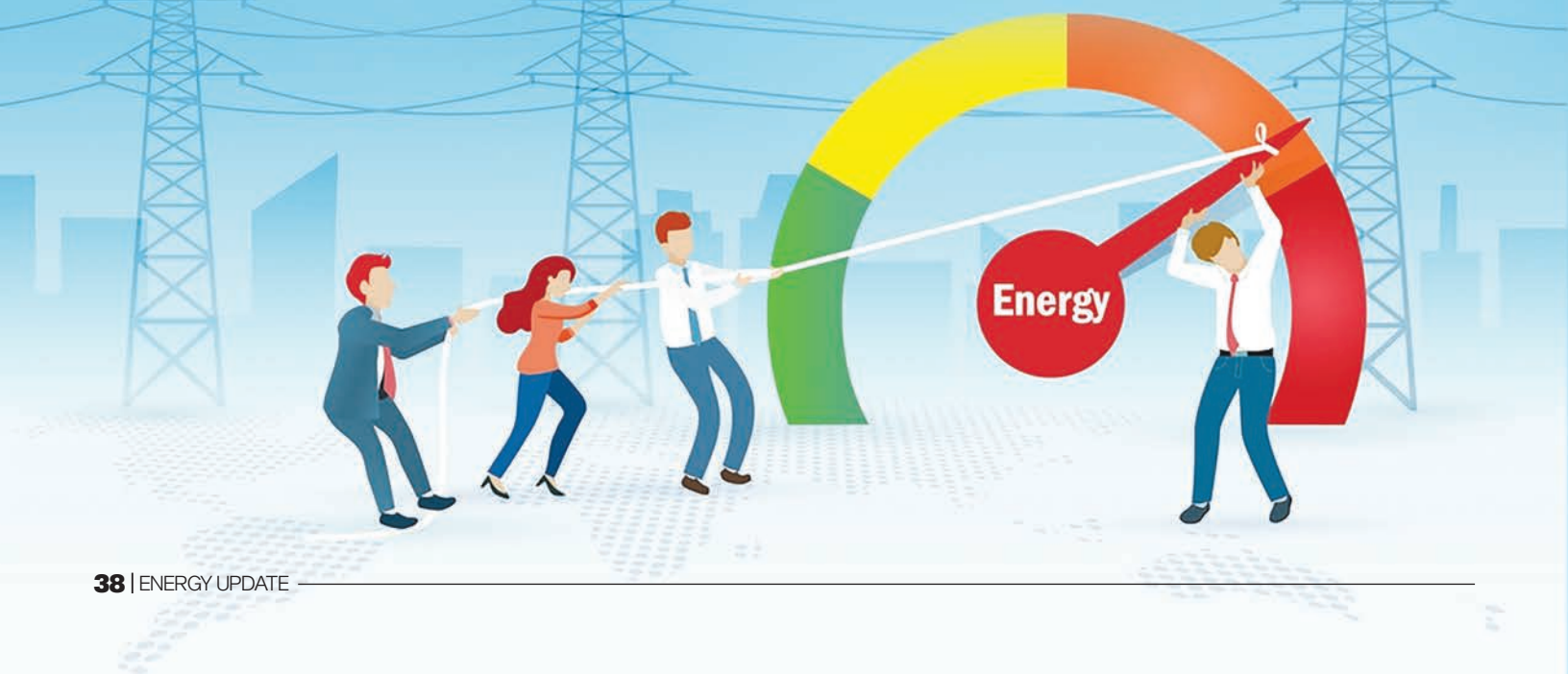
Action plan must take into account mineral requirements of clean energy technologies

nature of solar photovoltaic (PV) plants, wind power plants, and electric vehicles (EVs) compared to their fossil fuel alternatives. In this context, clean energy technologies, such as PV plants, wind plants, and electric vehicles, rely on clean minerals during their manufacturing.

The construction of an electric vehicle typically requires 6 times the mineral inputs of a fossil fuel-powered vehicle, likewise, a wind power plant imposes 9 times more mineral resources than a gas-fired plant. As per the International Energy Agency (IEA) Over the past decade, the average mineral requirements for new power generation capacity have increased

expected to drive a significant surge in demand for these minerals, placing the energy sector at the forefront of the mineral market. While in the past, the energy sector represented a minor share of total mineral demand, the rapid pace of energy transitions has transformed clean energy technologies into the fastest-growing segment. According to the International Energy Agency (IEA)'s Sustainable Development Scenario (SDS) aligned with the Paris Agreement goals, the share of total demand for minerals will rise substantially over the next two decades.

This projection includes over 40 per cent



with the challenges of mineral demand and supply. Keeping the potential in view, Pakistan has received a significant boost in exploring and researching lithium reserves through a strategic agreement between the China-Pakistan Joint Research Centre on Earth Sciences and Tianqi Lithium Co in December 2022.

Firstly, establish a National Green Mineral Exploration Program to create a dedicated program aimed at identifying and assessing Pakistan's green mineral potential, with a particular focus on the key minerals required for clean energy technologies. This program should include partnerships with international experts and leverage advanced exploration techniques to maximize the chances of discovering economically viable mineral deposits. Secondly, enhance Geological Surveys and Data Accessibility to conduct comprehensive geological surveys across the country to gather detailed information about mineral resources.

Improve the accessibility of geological data, making it available to potential investors, researchers, and industry stakeholders. This will facilitate informed decision-making and encourage investment in mineral exploration and extraction. Thirdly, create Incentives for Green Mineral Exploration and Extraction to introduce incentives and tax credits for companies engaged in green mineral exploration and extraction activities. Encourage public-private partnerships to attract investment and technical expertise in the mining sector. Streamline regulatory processes to facilitate smooth operations while ensuring environmental sustainability and social responsibility.

Fifth is to strengthen International Partnerships and foster collaboration with international partners, including countries with advanced mineral extraction capabilities, to benefit from their expertise, technology, and investment. Establish partnerships to exchange knowledge, promote capacity building, and encourage joint ventures in mineral exploration and development. Sixth, is to develop Domestic Refining and Processing Capacity. It will require investments in establishing domestic refining and processing facilities to add value to raw minerals.

Ninth caters to the building of Human Capital by developing specialized educational programs and vocational training to equip the local workforce with the skills required for mineral exploration, extraction, and processing. Foster knowledge transfer and encourage partnerships between educational institutions and the mining industry. Finally, the regulatory framework is required to be strengthened to review and update existing regulations bottlenecks related to mineral exploration, extraction, and processing to ensure environmental sustainability, worker safety, and social responsibility.

Establish robust monitoring and enforcement mechanisms to prevent illegal mining activities and promote responsible mining practices. In conclusion, Pakistan's transition to cleaner and sustainable energy sources necessitates addressing the challenges posed by mineral-intensive clean energy technologies. Collaboration, domestic investment, and diversification of mineral sourcing are essential strategies. By implementing a comprehensive policy roadmap, Pakistan can develop clean mining, reduce dependence on imports, and foster a resilient and sustainable energy sector. Emphasizing environmental sustainability and social responsibility will be key to achieving success. The writer is associated with SDPI as an energy consultant. ■