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The "Green Dilemma": Geopolitical Risks and Technological Competition in the Green Energy Transition

Ashmeet Kaur

BVSc Scholar, College of Veterinary Sciences, Guru Angad Dev Animal and Veterinary Sciences University, Rampura Phul, Punjab, pin code 151003

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*Corresponding Author
Ashmeet Kaur*

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INTRODUCTION

In the 21st century, the traditional concept of sovereignty is undergoing a profound transformation. Influence is no longer solely a byproduct of liquid geography but is defined by what can be termed as Silicon-Mineral Nexus. This nexus represents the structural interdependence between the secure possession of critical raw material and the high-tech industrial capacity required to process them into functional technology. The sense of superiority in global statecraft has shifted from the oil derricks to the semiconductor fabrication plant and high-end chemical refinery. Sovereignty now rests on the nation's ability to minimize vulnerabilities within the framework, so as to ensure that their transition to renewable energy does not merely trade one form of foreign dependence to another.

This shift is best characterised by the emergence of the Electro-state as a successor to the 20th century Petro-state. While the petro-state derived its power from the continuous flow of hydrocarbons, the electro-state thrives on the accumulation of mineral stocks and intellectual property.

Once a nation installs a solar array or an electric vehicle fleet, it holds a permanent "stock" of energy that does not require a daily refuel from a hostile neighbour. However, the path to becoming an Electro-state requires massive initial inputs of lithium, cobalt, and rare earth elements, most of which are refined through technological monopolies. Consequently, geopolitical leverage has moved from the territorial control of transit routes, like the Strait of Hormuz, to the networked control of processing hubs and the compute layers that manage smart grids.

As Daniel Yergin explores in The New Map: Energy, Climate, and the Clash of Nations (2020), this energy transition is not a "peace dividend" but a catalyst for structural realignment. Yergin argues that the drive toward a low-carbon future is occurring simultaneously with a "new cold war" between established and emerging powers. The "New Map" is defined by fragmented globalism, where nations are moving away from efficient, globalized trade toward "friend-shoring". Yergin's analysis suggests that the security paradox of the 21st century lies in the fact that while renewable energy promises long-term independence, the short-term reality is a deepening, risky reliance on a handful of dominant midstream processors. For the modern state, survival now depends on navigating these new chokepoints where energy, climate policy, and technological supremacy collide.

Concentration of the big three: Lithium, Cobalt, REEs

In the 20th century, the global oil market was characterized by a relatively diverse set of producers and a highly liquid, globalized trade infrastructure. In contrast, the 21st-century transition to "Green Metals" such as lithium, cobalt, and rare earth elements is defined by an extreme geographic concentration of the "midstream" stage. While the raw ores are often extracted in various parts of the world, the high-tech chemical processing and refining required to make these minerals usable for batteries and magnets are consolidated within a few key jurisdictions. According to the International Energy Agency (IEA, 2021), a typical electric vehicle requires six times the mineral inputs of a conventional car, yet the supply chains for these inputs are significantly more vulnerable to geopolitical disruption than petroleum.

The most significant chokepoint in the global energy transition is China's dominance over the midstream refining process. Currently, China controls approximately 85% of global rare earth processing and 60% of lithium refining. This concentration means that even when minerals are mined elsewhere such as lithium in Australia or rare earths in the United States the material must often be shipped to Chinese facilities to be transformed into high-purity chemicals or permanent magnets. This creates a structural dependency that allows for the "weaponization" of supply chains, as seen in recent export restrictions on gallium and germanium. This dominance is not merely a result of resource endowment but of decades of strategic industrial policy and a willingness to absorb the environmental costs of heavy-metal refining.

The upstream extraction of these metals presents its own set of geopolitical and ethical "paradoxes." In the Democratic Republic of the Congo (DRC), which produces over 70% of the world's cobalt, the transition to "clean" energy is marred by a grim reality of human and political costs, including systemic labor abuses and corruption. This creates a moral dilemma for Western tech manufacturers who must balance the urgent need for decarbonization with ethical supply chain mandates. Simultaneously, in South America's "Lithium Triangle" (comprising Chile, Argentina, and Bolivia), we see intense geopolitical maneuvering. These nations, which hold over half of the world's known lithium reserves, are increasingly adopting "resource nationalism" imposing export bans or state-led mining models to force foreign tech companies to invest in domestic value-added processing rather than just extraction.

The IEA's (2021) report, The Role of Critical Minerals in Clean Energy Transitions, serves as the definitive framework for understanding this shift, highlighting that the "mineral intensity" of the energy system is skyrocketing. The report argues that for a nation to achieve true energy security in the 2030s and beyond, it must look past the mine and focus on the refinery. The "Green Dilemma" is thus not just a matter of finding more resources, but of breaking the technological and geographic

monopolies that currently govern the midstream. Without a diversified refining infrastructure, the global move toward Net Zero remains tethered to a handful of strategic chokepoints that could be closed at any moment for political leverage.

Technological protectionism and export controls:

In the contemporary geopolitical landscape, the traditional tools of trade have been repurposed into strategic instruments of statecraft. Technological protectionism and the strategic use of export controls represent a shift toward "non-kinetic" warfare, where nations use trade barriers to handicap the industrial and military evolution of rivals. By restricting access to critical components or the machinery required to produce them, dominant powers can effectively "freeze" a competitor's technological progress. As highlighted in Chris Miller's Chip War (2022), hardware control is the ultimate form of geopolitical leverage; in a world where everything from missiles to power grids runs on silicon, the ability to deny a rival the most advanced chips is as potent as a naval blockade.

While semiconductors are often associated with consumer electronics or defense, they are the indispensable foundation of the green energy transition. High-end semiconductors are required to manage the intermittent nature of renewable energy, optimize the efficiency of long-range Electric Vehicle (EV) batteries, and operate the AI-driven "smart grids" of the future. The "Chip Wars" are therefore a critical front in the climate race. Control over the sub-7nm logic chips—predominantly produced by TSMC in Taiwan—dictates which nations can deploy the most energy-efficient infrastructure. For an "Electro-state," a lack of access to these high-end chips results in a massive loss of efficiency, making their green transition more expensive and less resilient than that of their technologically shielded competitors.

Beyond restrictive export controls, nations are engaging in a form of "friendly" resource competition through massive domestic subsidies. The U.S. Inflation Reduction Act (IRA) and the EU's Green Deal Industrial Plan represent a departure from globalized free-market principles toward a new era of industrial policy. By offering billions in tax credits and incentives for domestic manufacturing, these policies aim to "onshore" or "friend-shore" the production of EVs, batteries, and solar components. While these are ostensibly environmental policies, they function as protectionist measures designed to break midstream dependencies on geopolitical rivals. This subsidy race creates a "pull factor," drawing investment away from globalized supply chains and into regionalized, secure blocs, effectively using the treasury as a weapon to secure technological dominance.

The rise of mineral security partnerships:

The pursuit of a green energy transition has catalyzed a departure from the "efficiency-first" model of globalized free markets toward a security-centric model of "Friend-shoring." Central to this shift is the formation of strategic alliances like the Mineral Security Partnership (MSP), a coalition of Western-aligned nations aiming to bolster supply chains for critical minerals outside the influence of geopolitical rivals. This represents a transition into Bloc-Based Geopolitics, where trade is no longer governed merely by price and proximity, but by ideological alignment and shared security interests. As explored by Indra Overland in The Geopolitics of Renewable Energy (2019), while the move to renewables may mitigate traditional conflicts over oil transit, it introduces a fresh set of tensions rooted in the exclusive control of the material "building blocks" of the new economy.

The emergence of these exclusive mineral blocs has placed developing, mineral-rich nations—primarily in the Global South—at the center of a "New Cold War" for resources. As the U.S. and its allies promote "friend-shoring," and China continues to expand its "Belt and Road" infrastructure, resource-wealthy countries in Africa, Southeast

Asia, and Latin America are under increasing pressure to choose sides. This dynamic creates a structural conflict: developing nations often seek to maintain neutrality to maximize foreign investment from all sides, yet "security partnerships" often demand exclusive access or strict adherence to specific regulatory and environmental standards. This puts these nations at risk of becoming battlegrounds for economic coercion, where access to international finance or technology is traded for guaranteed mineral off-take agreements.

Overland's research highlights that the geopolitics of renewable energy are characterized by fragmentation. Unlike the global oil market, which operates through a relatively unified price mechanism, the mineral market is becoming increasingly bifurcated into "trusted" and "non-trusted" supply chains. This fragmentation increases the complexity of global trade and can lead to significant market inefficiencies and price volatility. For developing nations, the risk is twofold: they may suffer from "resource nationalism" as they attempt to leverage their minerals for domestic growth, or they may be trapped in a new form of dependency, where they provide raw materials to one specific bloc in exchange for technological and security guarantees, limiting their own economic autonomy.

The ultimate goal of Mineral Security Partnerships is to minimize supply chain shocks by creating a closed-loop system among ideological allies. However, this strategy hinges on the ability to rapidly develop new mining and refining capacity within the bloc—a task that remains difficult due to strict environmental regulations and long lead times for infrastructure development. Consequently, the "Green Dilemma" in the geopolitical sphere is a race against time: Western blocs are attempting to decouple their technological future from rivals before the next major supply disruption, even as their current green infrastructure remains deeply integrated with the very globalized networks they are trying to exit.

CONCLUSION

The global shift toward renewable energy is frequently characterized as a "peace dividend"—a move toward a cleaner, more harmonious world where energy is democratized by the sun and wind. However, a rigorous geopolitical analysis reveals that the green transition is, in fact, a fundamental and structural transformation of global power. It does not eliminate resource competition; it merely relocates it from the oil fields of the 20th century to the "Silicon-Mineral Nexus" of the 21st. The geopolitical leverage once held by those who controlled the flow of molecules is being rapidly replaced by those who control the stocks of critical minerals and the patents of semiconductor logic.

In this new era of heightened competition, success will not be determined by the sheer volume of green infrastructure deployed, such as the number of wind turbines or solar farms a nation can build. Instead, the true measure of national power will be the resilience and ethical transparency of supply chains. As nations navigate the "Green Dilemma," they must balance the urgent environmental need for speed with the strategic necessity of breaking midstream processing monopolies. The rise of mineral security partnerships and the "Chip Wars" suggest that the global energy map is being redrawn into ideological blocs, where technological autonomy is the ultimate form of sovereignty.

Ultimately, the transition to a low-carbon economy is as much an industrial and military race as it is an environmental one. To survive this realignment, the "Electro-states" of the future must go beyond simple resource extraction to master the complex, high-tech refining and manufacturing processes that turn raw earth into global influence. The green transition is not a departure from the struggle for power; it is the most sophisticated and high-stakes chapter of that struggle yet.

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