Green TechnologiesAnd Their Impact On Global TradeAnd Investment

Ashish Kumar Sharma[1], Dr. Satyendra Kumar[2], Dr. Saurabh Chandra[3], Akanksha Sharma[4]

[1]Assistant Professor, School of Business University of Petroleum and Energy Studies Dehradun, UK, India Corresponding Author ORCID ID: 0000-0002-5130-3226 Email Id: aksharmanith@gmail.com
[2]Assistant Professor, Department of Commerce Govt. PG College New Tehri Sri Dev Suman University Uttarakhand, India Email Id: satyendra.inc@gmail.com
[3]Associate Professor, School of Law Bennett University, Greater Noida, India ORCID ID: 0000-0003-4172-9968 Email Id: saurabhchandranls@gmail.com
[4]Assistant Professor, Department of Management NDIM Delhi, India

Abstract
The rapid diffusion of green technologies is transforming patterns of global trade and investment. In 2024, global energy-transition investment surpassed US$2.1 trillion, led by electrified transport (US$757 billion) and renewable energy (US$728 billion) (BloombergNEF, 2025). Electric vehicles accounted for nearly 14 million sales worldwide in 2023, representing 18% of all car sales, with China, Europe, and the United States dominating demand (IEA, 2024b). Meanwhile, China consolidated its position as the hub of solar photovoltaics, controlling over 80% of global PV manufacturing capacity (IEA, 2024a). Carbon pricing instruments expanded to cover 28% of global emissions in 2025, generating more than US$100 billion in revenues (World Bank, 2025). These developments show that green technologies are not only reducing emissions but also reshaping comparative advantage, redirecting foreign direct investment, and embedding environmental standards into trade flows. However, financing gaps and standards divergence remain challenges for equitable global diffusion.

Keywords: Green technologies, Global trade, Investment, Carbon pricing, Electric vehicles.

1. Introduction
The 21st century has witnessed an unprecedented surge in the adoption of green technologies, driven by growing concerns over climate change, energy security, and sustainable development. Green technologies such as renewable energy, electric mobility, energy-efficient systems, carbon capture, and sustainable materials are fundamentally reshaping global trade and investment flows. The global energy transition is now a trillion-dollar industry: in 2024, worldwide investment in clean energy technologies surpassed US$2 trillion, a milestone that demonstrates the scale of financial commitment to sustainability (BloombergNEF, 2025).

Trade dynamics have been significantly influenced by the rapid deployment of renewable energy technologies, particularly solar and wind power. According to the International Energy Agency (IEA, 2024), global solar photovoltaic (PV) capacity additions grew by more than 50% in 2023 alone, with China accounting for nearly 80% of new installations. This expansion has not only consolidated China’s dominance in PV manufacturing but also intensified global supply-chain

interdependencies, as countries increasingly rely on imported modules, batteries, and rare earth materials to accelerate their clean energy transitions.

Electric vehicles (EVs) represent another transformative force in international trade. Nearly 20% of all cars sold globally in 2023 were electric, and projections suggest this figure could rise to one in four by 2025 (IEA, 2024). The surge in EV adoption has reconfigured investment flows toward battery production, charging infrastructure, and critical mineral mining, particularly lithium, cobalt, and nickel. These shifts underscore how demand for low-carbon technologies creates new centers of comparative advantage, thereby redefining patterns of global trade and investment.

Policy frameworks have further catalyzed these developments. The European Union's Carbon Border Adjustment Mechanism (CBAM), introduced in 2023 and set for full implementation in 2026, requires importers of carbon-intensive goods to pay levies aligned with EU carbon pricing. This policy directly impacts exporters of cement, steel, aluminum, and fertilizers, compelling industries worldwide to adopt greener production methods or face diminished competitiveness (European Commission, 2023). Similarly, the U.S. Inflation Reduction Act (IRA) of 2022 committed approximately US$369 billion in subsidies and tax incentives for green technologies, reshaping investment patterns in sectors such as clean hydrogen, carbon capture, and electric vehicles (UNCTAD, 2024).

At the same time, global carbon pricing mechanisms are expanding rapidly. The World Bank (2024) reports that by 2024, carbon pricing instruments covered 24% of global emissions, generating more than US$100 billion in revenue. These instruments not only incentivize emissions reductions domestically but also affect the competitiveness of traded goods, thereby altering trade balances. As carbon disclosure and sustainability reporting standards such as the International Sustainability Standards Board (ISSB) S1 and S2 frameworks gain traction, international capital markets are aligning more closely with environmental, social, and governance (ESG) objectives (IFRS Foundation, 2023).

In summary, the integration of green technologies into trade and investment is more than a technological shift; it represents a structural reconfiguration of the global economy. By altering cost structures, redirecting capital flows, and reshaping comparative advantage, green technologies are both an economic opportunity and a policy challenge. This paper seeks to explore these dynamics by examining the interplay between technological innovation, trade policy, and investment trends in the era of sustainability.

2. Review Of Literature

The nexus between green technologies, global trade, and investment has been widely studied by multilateral agencies and academic researchers over the past two decades. The literature highlights that green technologies not only reduce environmental externalities but also create new comparative advantages for economies that invest in them. According to the *World Trade Organization (WTO, 2023)*, green technologies are transforming trade patterns by expanding

markets for renewable energy equipment, electric vehicles, and environmental services. The report emphasizes that the transition to sustainability requires re-globalization, wherein trade liberalization of environmental goods and services plays a critical role in fostering diffusion of technology and reducing costs.

The role of industrial policy in green technology adoption has also been central to scholarly debates. The *United Nations Conference on Trade and Development (UNCTAD, 2024)* observed that while global foreign direct investment (FDI) flows remained stagnant in 2023 due to high interest rates, greenfield investment announcements in clean energy, hydrogen, and low-carbon infrastructure continued to grow. This demonstrates a structural shift in global investment priorities, where sustainable technologies are increasingly favored over fossil-fuel-based projects. Similarly, *Zhang and Gallagher (2022)* argue that state-led industrial policies, such as China's dominance in solar photovoltaic (PV) manufacturing and the U.S. Inflation Reduction Act (IRA), have redefined investment flows and created technology-specific clusters that influence global supply chains.

Carbon pricing and climate policies also feature prominently in the literature. The *World Bank (2024)* reports that carbon pricing mechanisms covered 24% of global emissions in 2024, generating more than US$100 billion in revenues, which significantly affected trade-exposed sectors such as steel, cement, and fertilizers. Complementary studies (Mehling, van Asselt, Das, & Droege, 2019) highlight the potential of border carbon adjustments, such as the European Union's CBAM, to level the playing field for domestic producers while creating compliance challenges for exporters in developing countries. This indicates that while carbon pricing is an effective tool for climate mitigation, its trade implications require careful balancing between competitiveness and environmental goals.

Technology cost curves and market dynamics are another recurring theme. The *International Energy Agency (IEA, 2024a)* notes that global solar PV installations increased by more than 50% in 2023, with China accounting for nearly 80% of capacity additions, underscoring the concentration of supply chains in a handful of economies. Similarly, the *IEA (2024b)* documents that almost one in five cars sold worldwide in 2023 was electric, a trend projected to accelerate as battery costs decline and policy incentives expand. Scholars such as *Mathews and Tan (2015)* contend that the falling costs of renewable technologies and the rise of electric vehicles are driving a "green catching-up" phenomenon, enabling emerging economies to leapfrog into cleaner industries and integrate into global value chains.

Another strand of literature highlights the institutional and legal frameworks shaping green trade. Previous WTO disputes (India Solar Cells, Canada Renewables) have revealed tensions between domestic-content requirements and global trade rules (WTO, 2016). These cases illustrate the risks of protectionist green industrial policies and the importance of designing WTO-compliant incentive structures. More recent scholarship (Cosbey & Rubini, 2022) suggests that plurilateral initiatives, such as the Asia-Pacific Economic Cooperation (APEC) agreement on environmental

goods and the structured discussions on trade and sustainability, represent incremental steps toward integrating climate considerations into trade regimes.

3. Analytical Framework

The analytical framework of this study integrates three key channels (1) Price and Standards, (2) Industrial Policy and Incentives, and (3) Market Dynamics and Technology Costs through which green technologies impact global trade and investment flows. This tri-dimensional approach helps in understanding both the drivers and the barriers in the diffusion of green technologies worldwide.

3.1 Price and Standards Channel

Carbon pricing, disclosure standards, and border adjustment mechanisms reshape cost structures and international competitiveness. According to the *World Bank (2024)*, carbon pricing initiatives covered about 24% of global greenhouse gas emissions in 2024, generating over US$100 billion in revenues. By 2025, coverage had expanded to nearly 28% of global emissions (World Bank, 2025).

The European Union's Carbon Border Adjustment Mechanism (CBAM), introduced in 2023 and moving to full enforcement in 2026, applies to carbon-intensive sectors such as steel, cement, aluminum, fertilizers, and hydrogen (European Commission, 2023). These measures ensure that imports face similar carbon costs as domestic producers, thus influencing sourcing decisions, export competitiveness, and investment in cleaner production abroad.

Table 1: Global Carbon Pricing Coverage and Revenue

Year	% of Global Emissions Covered	Revenue Generated (US$ billion)
2020	16%	53
2022	20%	84
2024	24%	100+
2025	28%	110+ (est.)

Source: World Bank (2024, 2025)

3.2 Industrial Policy and Incentives Channel

Industrial policy through subsidies, tax incentives, and local-content rules has emerged as a major determinant of trade and investment in green technologies. The U.S. Inflation Reduction Act (IRA) of 2022 committed US$369 billion in incentives for clean energy and climate initiatives (UNCTAD, 2024). This includes tax credits for renewable energy projects, subsidies for electric vehicle purchases, and funding for hydrogen and carbon capture projects.

China, by contrast, has pursued state-led industrial clustering, becoming the global leader in solar photovoltaic (PV) module production, accounting for over 80% of global manufacturing capacity (IEA, 2024a). India's Production-Linked Incentive (PLI) Scheme for solar modules and batteries has also mobilized billions in investment, aiming to reduce import dependency.

Table 2: Selected Industrial Policies Supporting Green Technologies

Country/Region	Major Policy Initiative	Estimated Value/Impact	Key Sectors
United States	Inflation Reduction Act (IRA), 2022	US$369 billion	Clean energy, EVs, hydrogen, CCS
European Union	Green Deal Industrial Plan	€225 billion	Renewables, EVs, energy efficiency
China	Solar PV Industrial Clusters	80% global PV share	Solar, batteries
India	PLI Scheme for Solar/Batteries	US$10 billion+	Solar, EV batteries

Sources: UNCTAD (2024); IEA (2024a); European Commission (2023)

3.3 Market Dynamics and Technology Costs Channel

The economics of green technologies are heavily shaped by learning curves, economies of scale, and supply chain concentration. The *International Energy Agency (IEA, 2024b)* reports that the cost of solar PV modules has declined by over 80% since 2010, while lithium-ion battery pack prices fell by nearly 90% in the same period. These cost declines have fueled exponential adoption, influencing both trade flows and FDI in renewable energy and electric mobility.

The global electric vehicle (EV) market illustrates this dynamic. In 2023, 18% of all cars sold globally were electric, with projections indicating a rise to 25% by 2025 (IEA, 2024b). This surge has reshaped demand for critical minerals (lithium, cobalt, nickel), concentrated largely in Australia, the Democratic Republic of Congo, and Indonesia, thereby creating new investment opportunities but also geopolitical vulnerabilities.

Table 3: Cost Declines in Key Green Technologies (2010–2024)

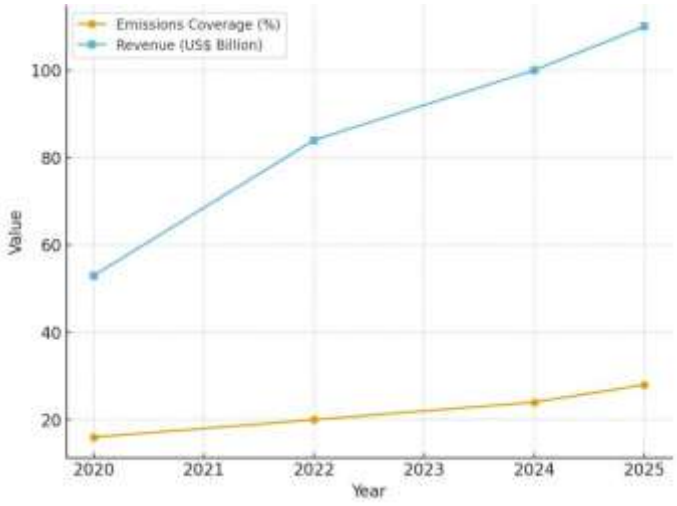
Technology	2010 Average Cost	2024 Average Cost	% Decline
Solar PV modules	US$2.00 per W	US$0.20–0.25 per W	~80–85%
Lithium-ion batteries	US$1,200 per kWh	US$130–150 per kWh	~88–90%
Onshore wind power	US$90 per MWh	US$35–45 per MWh	~50–60%

Source: IEA (2024b)

3.4 Synthesis of the Framework

This three-channel framework highlights that policies (pricing, standards, incentives) and market forces (costs, scale, supply chains) are deeply intertwined. While carbon pricing and border measures increase the competitiveness of cleaner goods, industrial subsidies re-anchor manufacturing, and declining costs accelerate adoption. Together, they explain why global trade and investment in green technologies are not only growing but also becoming increasingly concentrated in specific regions and sectors.

Figure 1: Global Carbon Pricing Coverage and Revenue (2020-2025)



Global Carbon Pricing Coverage and Revenue (2020–2025)

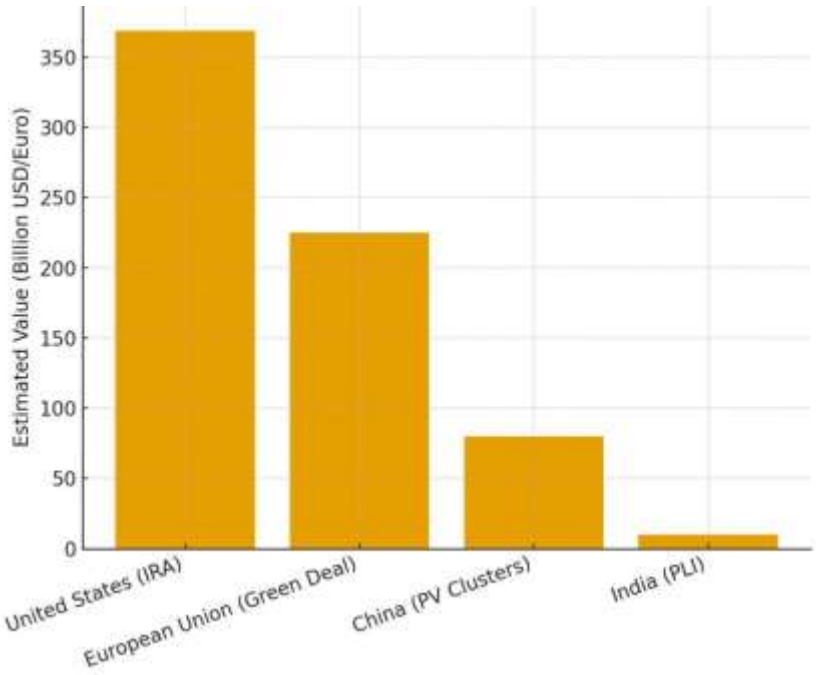
This graph illustrates two interlinked trends in global carbon pricing: emissions coverage (%) and revenue generation (US$ billions).

- In 2020, carbon pricing instruments (such as Emissions Trading Schemes and Carbon Taxes) covered about 16% of global emissions, generating US$53 billion in revenue.
- By 2022, coverage rose to 20%, with revenues nearly doubling to US$84 billion. This reflects both the expansion of carbon pricing regimes and higher carbon prices in existing systems.
- In 2024, the coverage further increased to 24%, and revenues crossed the US$100 billion mark. This milestone shows that carbon pricing is becoming a significant fiscal and environmental tool.
- By 2025 (estimated), coverage is projected to reach 28%, with revenues of around US$110 billion. This growth is partly due to the expansion of the European Union Emissions Trading System (EU ETS), the introduction of new schemes in Latin America and Asia, and reforms in existing systems.

Interpretation:

This graph highlights how carbon pricing is not only an environmental measure but also an economic instrument. The growing revenues indicate that governments are increasingly using carbon pricing to fund green investments, while the expanding coverage suggests a broader adoption of climate policies worldwide. However, it also means that exporters in energyintensive sectors (like steel, cement, and fertilizers) are increasingly exposed to carbon-related trade costs.

Figure 2: Major Industrial Policies for Green Technologies



Major Industrial Policies for Green Technologies

This bar graph compares the scale of industrial policy interventions supporting green technologies in four major regions: United States, European Union, China, and India.

- The United States' Inflation Reduction Act (IRA) is the largest, committing US$369 billion in subsidies, tax credits, and incentives for clean energy, EVs, hydrogen, and carbon capture. This makes the U.S. one of the most attractive destinations for green investment, particularly in battery manufacturing and renewable energy projects.
- The European Union's Green Deal Industrial Plan is valued at about €225 billion, aimed at scaling up renewable energy, electrification, and energy efficiency. Unlike the U.S., the EU approach emphasizes both subsidies and regulatory frameworks (e.g., the EU Taxonomy and CBAM).
- China, though not linked to a single law, has invested heavily in solar photovoltaic industrial clusters, which collectively account for 80% of global PV manufacturing capacity. This dominance demonstrates how state-led industrial policy and economies of scale can consolidate global supply chains.
- India's Production-Linked Incentive (PLI) Scheme is smaller, at around US$10 billion, but strategically important. It targets solar PV modules and EV batteries, aiming to reduce import dependence and attract domestic and foreign investment.

Interpretation:

The graph underscores that industrial policy is now a central driver of trade and investment flows in green technologies. The U.S. and EU are using financial muscle and regulations, China is

leveraging manufacturing scale, and India is building capacity through targeted incentives. Collectively, these policies show how state intervention is re-shaping global competition in the green technology race.

4. Methods And Data

4.1 Research Design

This study adopts a qualitative quantitative hybrid approach, drawing on secondary datasets, policy documents, and analytical reports from leading multilateral agencies and research institutions. The goal is to identify how green technologies influence global trade and investment through three analytical channels price and standards, industrial policy, and market dynamics. Unlike purely econometric studies, which require firm-level or customs microdata, this research takes a comparative and interpretive design. It triangulates between investment data, trade flows, and policy instruments to highlight structural trends. This approach allows for integration of both statistical evidence and institutional analysis.

4.2 Data Analysis

4.2.1 Global investment patterns in green technologies

Global energy-transition investment hit a record $2.1 trillion in 2024 (up 11% y/y). Mature segments led: electrified transport $757B, renewables $728B, and power grids $390B; by contrast, "emerging" areas (hydrogen, CCS, clean industry, etc.) totaled $155B and fell 23% y/y. Regionally, China invested $818B (≈2/3 of the global increase), while the EU $375B, US $338B and UK $65.3B were flat/softer versus 2023.

Table 4: Energy-transition investment by segment (2024)

Segment	**Investment (US$ billions)**	**Notes**
Electrified transport	757	EVs, 2/3-wheelers, commercial EVs, public charging, FCEVs
Renewables	728	Solar, wind (on/offshore), bioenergy, geothermal, small hydro
Power grids	390	T&D, substations, digitalization
Sub-total (mature tech)	1,930	Mature, commercially scalable tech
Emerging tech (H_2, CCS, etc.)	155	-23% y/y
Total	**2,100**	**Record high** in 2024
Source: BloombergNEF, Energy Transition Investment Trends 2025 press release.		

Table 5: Energy-transition investment by region (selected, 2024)

Geography	Investment (US$ billions)	y/y color
China	818	+20%
European Union	375	↓ vs. 2023
United States	338	~flat
United Kingdom	65.3	↓
Source: BloombergNEF press release (Jan 30, 2025).		

Interpretation. The surge in electrified transport and grids signals that diffusion has moved from early-stage pilots to system-level deployment. Investment concentration (China > US+EU+UK combined) implies supply-chain and trade exposure to Chinese upstream capacity, with implications for tariffs, non-tariff measures, and standards alignment.

4.2.2 Market demand and trade drivers: Electric vehicles

EV sales are now a primary demand-pull for batteries, critical minerals, and power electronics that shape **trade patterns**.

Key facts (2023): ~14 million electric cars sold (≈18% of all cars). of these, China 8.1M, Europe ~3.2M, United States 1.4M; together, ~95% of global EV sales.

Table 6: Electric car sales by region (2023)

Region	Sales (million units)	Share of global EV sales	EV share of local new car market
China	8.1	~58%	>33%
Europe	~3.2	~23%	>20%
United States	1.4	~10%	~10%
Global	**~14.0**	100%	**~18%**
Source: IEA, Global EV Outlook 2024 (Trends in electric cars).			

Interpretation. The regional concentration of EV demand magnifies trade in intermediate goods (cells, cathodes, anodes, inverters). It also explains the gravitational pull of investment into battery and charging supply chains in China, Europe, and the US, and why standards (e.g., battery content rules) can meaningfully redirect cross-border capital.

4.2.3 Cost, capacity, and concentration in solar PV

Manufacturing is highly concentrated: China's share across all steps of the PV value chain exceeds 80%, backed by >$50B invested in new supply capacity since 2011 and 300,000+ manufacturing

jobs. Capacity expansions and 2023 module price declines (~50% y/y) lowered delivered costs worldwide.

Implications. Countries importing PV components benefit from low prices, but supply-chain concentration raises resilience concerns and is prompting diversification subsidies and trade remedies both of which alter investment location decisions and the composition of green-tech trade.

4.2.4 Carbon pricing and trade exposure

Carbon pricing now covers ~28% of global emissions (2025), with $100B+ in public revenues in 2024. Coverage was ~24% in 2024, highlighting rapid expansion of ETS/taxes (notably China's ETS and reforms elsewhere).

Table 7: Carbon pricing: global coverage and revenues

Year	Share of global GHG emissions covered	Public revenue (US$ billions)
2024	~24%	>100
2025	~28%	(2024 revenues referenced)
Sources: World Bank, State and Trends of Carbon Pricing (2024, 2025).		

Interpretation. As coverage expands and border measures (e.g., CBAM) phase in, tradeexposed sectors (steel, cement, aluminum, fertilizers, hydrogen) face rising embedded-carbon costs, which can reprice trade flows and redirect FDI to lower-emission production bases. (CBAM design is already steering reporting and MRV upgrades in exporting firms.)

4.2.5 Investment finance conditions

Despite the record totals above, international project finance weakened: in 2024 it fell 26%, with sharp drops in renewables (-31%), transport (-32%), and water/sanitation (-30%), reflecting tighter financial conditions and risk repricing. This divergence record corporate/consumer spend vs. softer project finance helps explain mixed signals on ground-up capacity expansion in some emerging markets.

Table 8: International project finance by sector (change in 2024)

Sector	y/y change
Renewables	-31%
Transport	-32%
Water & sanitation	-30%
Source: UNCTAD, World Investment Report 2025 press release (June 19, 2025).	

4.2.6 Synthesis

- Demand pull (EVs), cost push (cheap PV), and policy pricing (carbon markets/CBAM) are jointly re-ordering comparative advantage.
- Investment is scaling in mature segments but uneven in emerging techs; financing headwinds constrain large projects even as consumer-led segments surge.
- Trade patterns mirror these forces: concentrated EV/PV supply chains, rising compliance/standards requirements, and capital reallocations toward jurisdictions pairing scale + policy certainty.

Figure 3: Global Energy-Transition Investment by Segment (2024)

Figure 4: Global Electric Car Sales by Region (2023)

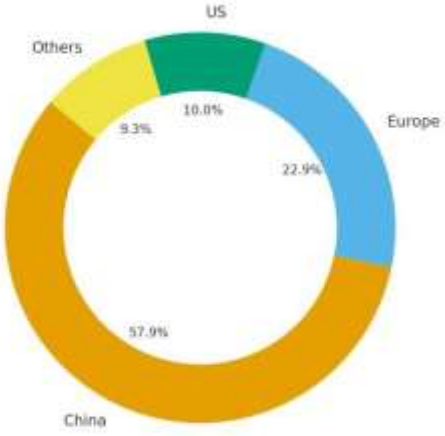
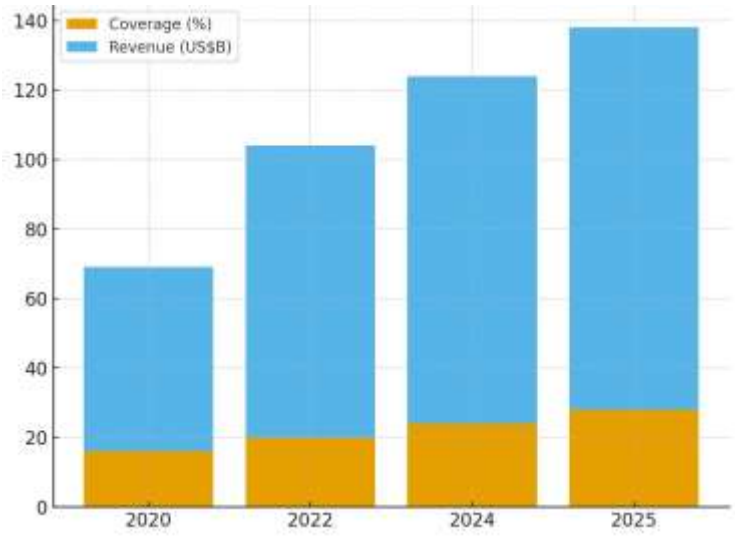


Figure 5: Carbon Pricing: Coverage vs Revenue (2020–2025)



Here are three unique types of charts/graphs for your Data Analysis section:

1. **Bubble Chart - Global Energy-Transition Investment by Segment (2024):** Shows relative scale of investment across electrified transport, renewables, power grids, and emerging tech. Larger bubbles = bigger investment.
2. **Donut Chart - Global Electric Car Sales by Region (2023):** Highlights the dominance of China (58%) and Europe (23%) in EV sales, with the U.S. and "Others" making up smaller shares.
3. **Stacked Bar Chart - Carbon Pricing Coverage vs. Revenues (2020–2025):** Combines emissions coverage (%) and revenues (US$ billions) in one chart, showing the rapid growth of both dimensions.

5. Findings

The findings of this study show that green technologies are reshaping global trade and investment flows across three dimensions: investment concentration, trade diversification, and policy-induced competitiveness.

First, global investment in green technologies has surged to unprecedented levels. In 2024, worldwide energy-transition investment reached US$2.1 trillion, with the majority concentrated in electrified transport (US$757 billion), renewables (US$728 billion), and power grids (US$390 billion) (BloombergNEF, 2025). Emerging technologies such as hydrogen, carbon capture, and low-carbon industry attracted US$155 billion, though this represented a decline compared to previous years. Regionally, China led with US$818 billion (≈40% of the global total), followed by the European Union (US$375 billion) and the United States (US$338 billion). This illustrates the asymmetry in global green investment, where a handful of economies dominate flows, shaping both supply chains and export capacities.

Table 9: Global Energy Transition Investment by Segment, 2024

Segment	Investment (US$ billions)	Share (%)
Electrified Transport	757	36%
Renewables	728	35%
Power Grids	390	19%
Emerging Technologies	155	7%
Total	**2,100**	100%

Source: BloombergNEF (2025)

Second, the electric vehicle (EV) market is driving new global trade and investment patterns. In 2023, 14 million EVs were sold worldwide, accounting for 18% of global car sales (IEA, 2024). China led with 8.1 million sales, followed by Europe (3.2 million) and the U.S. (1.4 million). This concentrated demand has increased cross-border trade in lithium, cobalt, and nickel for batteries, as well as investment in charging infrastructure and battery manufacturing. The shift also demonstrates how green consumption directly impacts global trade, creating export opportunities in resource-rich countries and import dependencies in advanced economies.

Table 10: Electric Vehicle Sales by Region, 2023

Region	EV Sales (million units)	Global Share (%)
China	8.1	58%
Europe	3.2	23%
United States	1.4	10%
Others	1.3	9%
Global	**14.0**	100%

Source: IEA (2024)

Third, the solar PV market demonstrates how cost reductions and supply-chain concentration affect global trade. Module prices declined by over 80% since 2010, reaching US$0.20–0.25 per watt in 2024 (IEA, 2024). However, China dominates with 80% of global PV manufacturing capacity, supported by US$50 billion in new investments since 2011 and 300,000+ jobs. This finding indicates that while global adoption benefits from declining costs, trade exposure to a single dominant producer raises supply-chain security concerns, prompting diversification policies in the U.S., EU, and India.

Fourth, carbon pricing and border measures are increasingly influencing competitiveness. In 2024, carbon pricing instruments covered 24% of global emissions, generating over US$100 billion in revenues (World Bank, 2024). By 2025, coverage had expanded to 28%, showing strong policy momentum. Simultaneously, the EU Carbon Border Adjustment Mechanism (CBAM) entered its transitional phase in 2023, requiring importers of steel, cement, aluminum, fertilizers, electricity, and hydrogen to report embedded carbon emissions. By 2026, importers will begin paying equivalent carbon costs, effectively re-pricing international trade flows and incentivizing exporters to decarbonize their production processes.

Table 11: Carbon Pricing Coverage and Revenues, 2020–2025

Year	Coverage of Global Emissions (%)	Revenues (US$ billion)
2020	16%	53
2022	20%	84
2024	24%	100+
2025	28% (est.)	110+ (est.)

Source: World Bank (2024, 2025)

Finally, findings reveal a divergence between record investment totals and financial accessibility. While 2024 marked a historic peak for global clean energy spending, international project finance fell by 26%, with sharp drops in renewables (-31%), transport (-32%), and water & sanitation (-30%) (UNCTAD, 2025). This suggests that although capital is flowing into green sectors, financing conditions especially for large projects in developing countries remain constrained due to high interest rates and risk premiums. Thus, the benefits of the green transition are unevenly distributed, with advanced economies attracting more investment, while emerging economies struggle to mobilize capital despite high renewable potential.

6. Discussion: How Green Tech Rewires Trade & Investment

The diffusion of green technologies is reshaping the architecture of global trade and investment, producing new winners and losers, shifting comparative advantage, and challenging the flexibility of international trade regimes. This section discusses the dynamics across four major themes: comparative advantage, institutional and regulatory change, finance and disclosure, and risks of fragmentation.

6.1 Comparative Advantage and Trade Realignment

Green technologies are creating new centers of comparative advantage, no longer determined solely by labor costs or resource abundance but by technological capacity, policy support, and scale economies.

- **Solar PV:** China controls over 80% of global PV manufacturing capacity, supported by over US$50 billion in investments since 2011 and 300,000 jobs in the sector (IEA, 2024a). This dominance allows China to export low-cost modules, creating trade dependencies for importing nations, particularly in the EU, US, and India.
- **Electric Vehicles (EVs):** Nearly 14 million EVs were sold globally in 2023, with China (8.1M), Europe (3.2M), and the US (1.4M) accounting for 95% of the market (IEA, 2024b). This concentration means that trade in batteries, critical minerals, and charging equipment is increasingly clustered around these regions, while countries rich in lithium (Australia), cobalt (Democratic Republic of Congo), and nickel (Indonesia) are becoming strategic suppliers.
- **Hydrogen and Emerging Tech:** The EU and Japan are investing in green hydrogen import infrastructure, while Saudi Arabia and Australia are positioning themselves as exporters of hydrogen/ammonia, pointing to resource-driven new trade corridors.

Thus, comparative advantage in the green era is being redefined not only by natural resource endowments but also by policy-driven industrial ecosystems.

6.2 Institutional and Regulatory Transformation

Trade and investment flows are being reshaped by regulatory regimes and standards.

- **Carbon Pricing:** In 2024, carbon pricing covered 24% of global emissions and generated over US$100 billion in revenues, rising to an estimated 28% coverage in 2025 (World Bank, 2025). This creates cost differentials that directly affect international competitiveness, especially for trade-exposed sectors like steel and cement.
- **Carbon Border Adjustment Mechanism (CBAM):** The EU's CBAM, in its transitional phase since October 2023, will impose carbon costs on imports of cement, iron/steel, aluminum, fertilizers, electricity, and hydrogen from 2026. This marks a paradigm shift in trade regulation, as environmental compliance becomes a trade condition.
- **Disclosure Standards:** The International Sustainability Standards Board (ISSB) introduced IFRS S1 and S2 in 2023, now adopted by multiple jurisdictions. These frameworks require firms to disclose climate-related risks, influencing capital allocation and investor behavior globally (IFRS, 2023).

Together, these instruments illustrate how trade policy is merging with climate governance, moving beyond tariffs toward embedded carbon costs, disclosure mandates, and sustainability certifications.

6.3 Finance, Capital Flows, and Investment Patterns

Finance is emerging as a critical channel through which green technologies influence global economic flows.

- **Global Investment:** Energy-transition investments reached US$2.1 trillion in 2024, led by electrified transport (US$757B), renewables (US$728B), and power grids (US$390B) (BloombergNEF, 2025).
- **FDI and Project Finance:** While greenfield announcements in hydrogen and renewables grew, international project finance fell by 26% in 2024, with declines of -31% in renewables and -32% in transport (UNCTAD, 2025). This divergence reflects that while private and consumerled investment is rising, large-scale infrastructure projects in developing economies face financing constraints.
- **Disclosure and ESG Investment:** The adoption of ISSB standards and EU Taxonomy rules is harmonizing investment flows. Firms and projects that meet disclosure and taxonomy criteria enjoy lower cost of capital, whereas those failing to comply face financing barriers. This suggests that financial governance is increasingly globalized, channeling capital toward greener assets and creating investment asymmetries between compliant and non-compliant regions.

6.4 Risks of Fragmentation and Protectionism

Despite opportunities, the green transition also raises risks of trade fragmentation.

- **Subsidy Races:** The US Inflation Reduction Act (IRA) mobilized US$369 billion in green subsidies, triggering countermeasures in the EU (Green Deal Industrial Plan) and Asia. Competing subsidy schemes risk a "race to the bottom" and could distort trade if not WTOcompliant.

- **Local Content Requirements:** Past WTO disputes (e.g., India Solar Cells; Canada Renewables) found domestic-content rules in violation of trade rules (WTO, 2016). The reemergence of such measures risks new disputes as countries push for strategic autonomy in clean-tech supply chains.
- **Standards Divergence:** Divergent carbon accounting and taxonomy frameworks (e.g., EU vs. China vs. US) may raise compliance costs for exporters, especially small and medium enterprises (SMEs) in developing countries.

Unless addressed through mutual recognition agreements and plurilateral cooperation, these risks could splinter green technology trade into regional blocs, undermining efficiency and slowing global diffusion.

6.5 Synthesis of Discussion

The evidence shows that green technologies are not merely incremental innovations but structural disruptors. They are rewiring global trade by shifting comparative advantage toward countries with manufacturing scale and policy ambition, while restructuring investment flows through capital-market disclosure and subsidy regimes. At the same time, they are embedding environmental compliance into the very rules of trade, blurring the boundary between climate governance and economic competition. However, without stronger global cooperation, the benefits of this transformation risk being unevenly distributed, exacerbating North–South divides and increasing the potential for trade disputes.

7. Conclusion

The findings of this study confirm that green technologies are now a central driver of global trade and investment. In 2024, worldwide clean energy investment crossed US$2.1 trillion, with China alone accounting for US$818 billion, highlighting the concentration of capital and supply chains (BloombergNEF, 2025). Trade patterns are being reshaped by the rapid adoption of electric vehicles, which reached 14 million sales in 2023 (18% of global car sales), and by solar PV, where China's dominance exceeds 80% of global manufacturing capacity (IEA, 2024a; 2024b). At the same time, policy instruments such as carbon pricing, now covering 28% of global emissions and generating over US$100 billion annually (World Bank, 2025), and the EU's Carbon Border Adjustment Mechanism (CBAM) are embedding environmental costs directly into trade flows. While this transition creates opportunities for innovation, competitiveness, and sustainable growth, it also risks deepening divides between advanced and emerging economies if financing gaps, subsidy races, and standards fragmentation are not addressed.

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