SUSTAINING THE GLOBAL ENERGY TRANSITION

Valerie J. Karplus
Carnegie Mellon University

Harvard Project on Climate Agreements

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The Harvard Project on Climate Agreements is a Harvard-University-wide initiative established in 2007 to identify and advance scientifically sound, economically sensible, and politically pragmatic public policy options for addressing global climate change. Drawing upon leading thinkers from around the world, the Harvard Project conducts research on policy architecture, key design elements, and institutional dimensions of international and domestic climate-change policy. The Harvard Project is directed by Robert N. Stavins, A.J. Meyer Professor of Energy and Economic Development, Harvard Kennedy School. For more information, see the Harvard Project's website: www.hks.harvard.edu/hpca.

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Valerie J. Karplus

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ABSTRACT

High interest rates, trade tensions, and energy geopolitics have coincided with an about face on climate policy in the United States, raising questions about the future of the global energy transition. This paper examines the implications of these developments for momentum to deploy technologies aligned with deep decarbonization across industries around the world. Enablers of deep decarbonization are now more differentiated across industries. Installed costs of clean technologies are achieving parity with incumbents in some industries, while in others deployment faces formidable capital and operating cost hurdles or supply chain security concerns. While dedicated climate policy support remains important, sustaining momentum will require attention to the broader institutional enablers of energy transition. Addressing bottlenecks in the construction of new energy infrastructure, building trust in supply chain relationships, and increasing availability of low-cost sources of financing for energy and infrastructure projects are hypothesized as no-regret strategies for addressing near-term development needs while increasing the likelihood and potential of future opportunities to increase climate ambition.

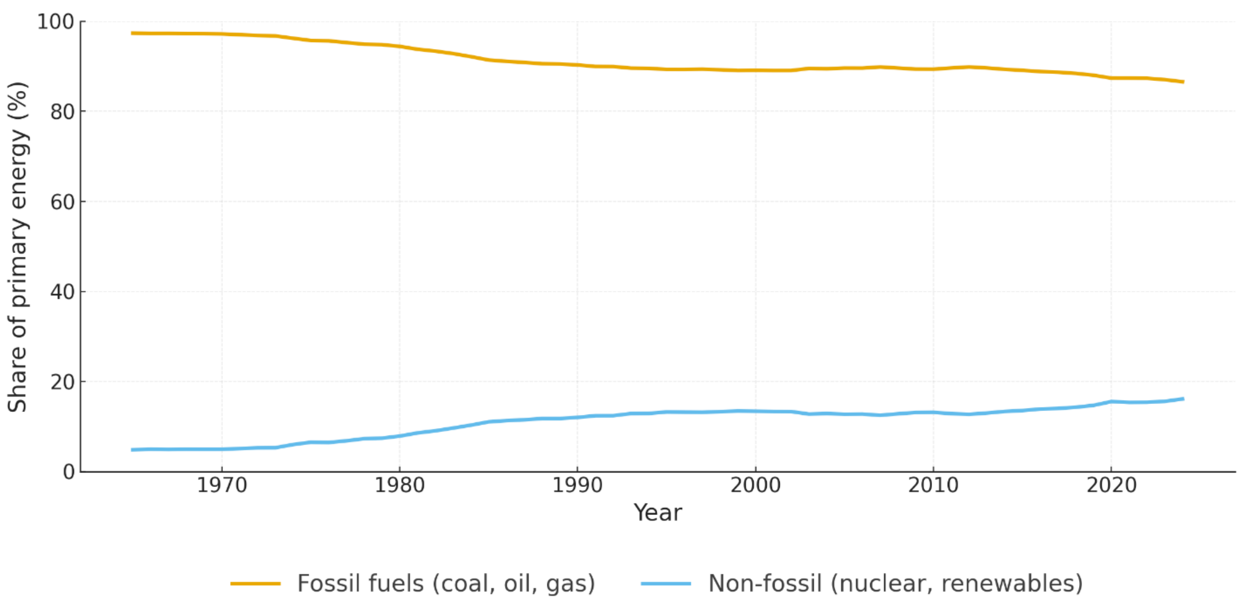
1. INTRODUCTION

The global energy transition has reached a crossroads. The costs of many technologies needed for deep decarbonization, particularly in electric power and transportation, have fallen to at or near cost parity. In 2024, 91% of newly commissioned utility-scale renewable energy delivered power at a lower levelized cost than the cheapest fossil-fuel based alternative (Dardour *et al*. 2025), while since 1991, the real price of lithium ion batteries has fallen by 97% (Ziegler and Trancik 2020). At the same time, appetite for climate action is waning, at least in some countries (Groom 2025; Sabin Center 2025). Emerging clean energy technologies are developed and produced in a handful of countries, with China playing an outsized role (S&P Global Commodity Insights 2025). Concern over the geographic concentration of supply chains, rising interest rates, and a surge in protectionist trade agendas threatens to slow the development and diffusion of clean technology, even in countries with ambitious climate goals (BNEF 2025). As shown in Figure 1, a shift in the composition of primary energy use from fossil to non-fossil sources is visible over the past 60 years, but the pace has been gradual thus far, relative to projected climate change mitigation needs. What avenues exist to sustain and eventually accelerate transition momentum, sheltered from these headwinds?

Answering this question is increasingly complex: as the costs and broader dynamics of transition grow more differentiated across sectors, so do the leverage points for change. In electric power and transportation, low carbon technologies are at or near parity with incumbents, so uptake depends on integration within evolving systems. As these technologies scale, a growing bottleneck is infrastructure

— including electric vehicle (EV) charging, electricity generation, transmission, and distribution siting and upgrades, and increased operational flexibility. As the electricity system supplies an ever greater range of end uses, resilience to outages from cyber-physical threats or climate-driven extreme events has grown more important. The industrial sector, by contrast, faces very different challenges. Implementing technologies to deeply decarbonize industrial processes involves large capital outlays and higher operating costs. Indeed, whenever decarbonization requires substantial upfront cost — a utility commissioning large electricity generators, a household purchasing a new vehicle, or an industrial plant redesigning a process — momentum can suffer as borrowing and equipment costs rise, due to higher interest rates or tariffs. In part due to increasingly differentiated technological and institutional landscapes, scholars have argued that these differences strengthen the case for a sectoral focus of policy efforts (Stock 2021). At the international level, a sectoral focus is compelling because many activities, including complex supply chains, transcend national borders, making it harder to coordinate transition efforts (Oberthür *et al*. 2021).

Figure 1: Fossil and non-fossil (renewable and nuclear) energy sources as a share of primary energy (1965–2024).



Source: Energy Institute (2024)

The goal of this paper is to examine paths to advance climate change mitigation for major energy-consuming activities, given ongoing developments in the climate ambition of key actors, technology costs, and macroeconomic, trade, and national security priorities. In the second section, the analysis describes the increasingly differentiated patterns of innovation and deployment of energy transition technologies in three major carbon dioxide (CO_2) emitting sectors: electric power, industry, and transportation. It describes abatement strategies that are both projected to be cost effective and examines their alignment with sectoral and economic development priorities more broadly. The third section describes the changing climate policy landscape and considers where the gaps are, given current costs and adoption incentives. It examines the role of businesses alongside governments in closing those gaps. The fourth section recognizes a broader set of priorities that have the potential to interact with transition: trade and industrial policy, national security, and macroeconomic stability. The fifth section proposes several opportunities to modernize energy systems and support economic and security objectives, while contributing to the likelihood, ambition, and durability of future climate policy.

2. Diverging Barriers to Transition Across Sectors

While reducing a unit of greenhouse gas (GHG) emissions anywhere in the world contributes roughly equally to mitigating climate change, the cost and complexity of achieving that unit of reduction varies widely.[1] Much of this variation is driven by technology and institutional dynamics at the level of sectors, industries, firms, and processes and their uneven geographic distribution across countries. It is therefore important to recognize the role of sectors and industries in the global energy transition and their effect on the deployment of decarbonization technologies. Together, electric power, transportation, and industry are estimated to comprise over 65% of global GHG emissions (Ritchie and Roser 2020). The focus of this paper is on these three sectors and therefore primarily on abatement of CO_2 emissions. This choice is not intended to diminish the importance of advancing solutions for reducing GHG emissions from agriculture, waste, and land use, which would also benefit from a dedicated analysis of gaps and strategies to address them.

Anticipated growth in electricity demand from a variety of end-uses will shift the structure of energy and GHG emissions across sectors, complicating the challenge of decarbonization. The energy transition to date has largely involved clean energy addition and shifts from coal to natural gas. However, reducing the share of coal and other fossil fuels in electric power generation factors centrally in many modeled pathways to net zero GHG emissions by mid-century (IEA 2021; Larson *et al*. 2020; CEEW 2022; He *et al*. 2022; Roelfsema *et al*. 2020). Electrification of end uses, such as vehicles and industrial processes, will increase electricity demand. This shift will be further augmented by anticipated increases in data center electricity demand, especially for training artificial intelligence Large Language Models (LLMs), and process automation. According to the International Energy Agency, data center electricity demand is projected to reach 1,200–1,700 TWh by 2035, accounting for 20% of projected electricity demand growth in advanced economies and 10% globally (IEA 2025a). To contain costs while supporting steady reductions in GHG emissions, it will be important to allow a range of technologies to meet demand. The pace and extent of electrification will be affected by the availability and affordability of new generation and of competing applications of traditional fossil fuels, especially natural gas, as well as oil, electrofuels, and hydrogen.

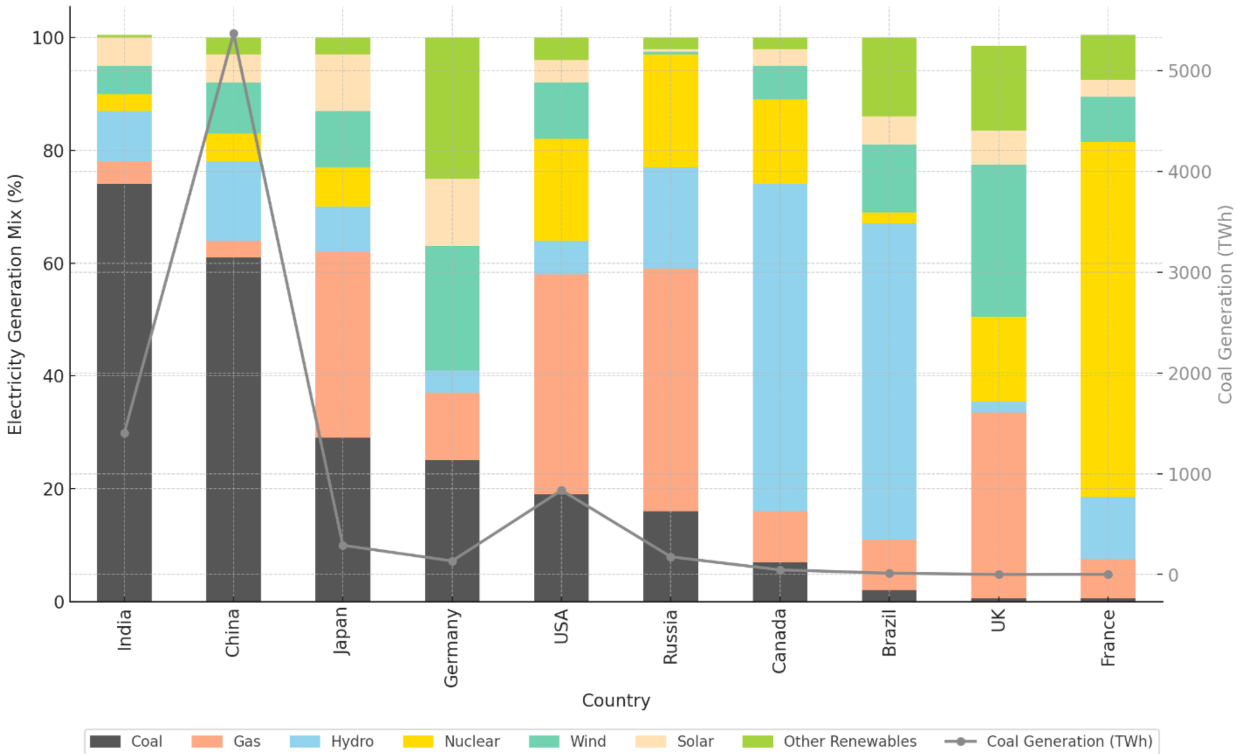
2.1 Electric Power

Power generation from fossil fuels remains a major source of greenhouse gas emissions, 31% of the global total in 2023. Electricity is one of the least internationally traded commodities, with only 2.8% of electricity supplied globally crossing national borders (IEA 2020). System structure and efficiency, institutional and policy context, the cost of generation, including the cost of deploying decarbonized alternatives, vary across countries (World Bank 2024a). Electricity markets reflect varying degrees of liberalization, which affects technology choices and the pass through of costs through

1 The projected benefits of an additional unit of GHG reduction also vary widely across countries and regions.

to end consumers. These markets also vary in the natural availability of wind and solar resources and their technological and regulatory readiness to deploy advanced nuclear and carbon capture and sequestration (CCS) for coal and natural gas generation.

Figure 2: Electricity generation mix by country.

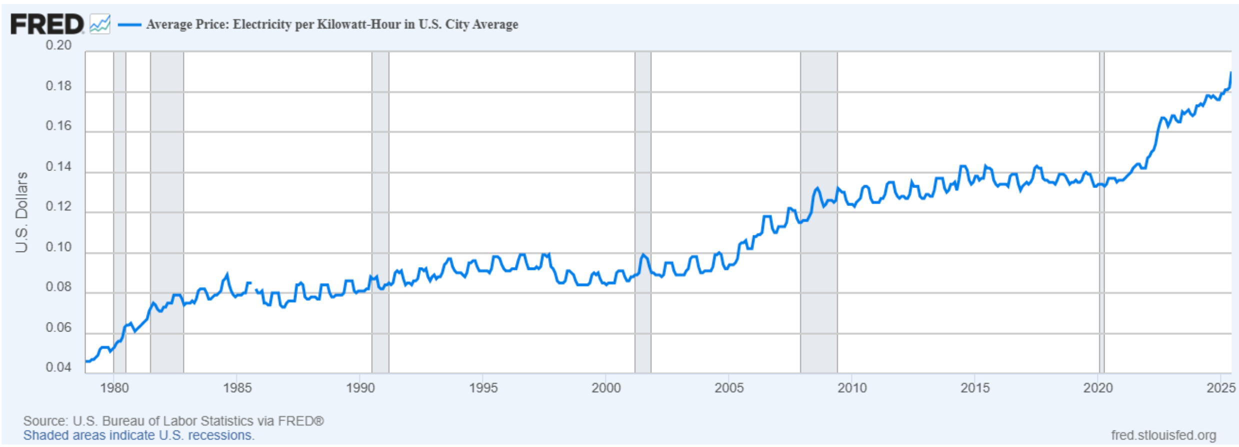


Sources: China – Ember (2024); United States – U.S. Energy Information Administration (U.S. EIA 2024); India – Central Electricity Authority (CEA 2023); Germany – Fraunhofer Institute for Solar Energy Systems (ISE 2024); Japan – Agency for Natural Resources and Energy (ANRE 2024); Brazil – Operador Nacional do Sistema Elétrico (ONS 2024); Canada – Statistics Canada (2024) and National Resources Canada (NRCan 2024); Russia – International Energy Agency (IEA 2023), 2022 data; United Kingdom – UK Department for Energy Security and Net Zero (DESNZ 2024); France – Réseau de Transport d'Électricité (RTE 2024). Data is for 2023 unless otherwise indicated.

Expanding clean and renewable energy will not lower power sector GHG emissions without reductions in generation from unabated coal. As shown in Figure 2, consumption of coal in electric power is highest in China, where coal accounted for 61% of the country's 9,548 TWh/year of generation in 2023 (IEA 2024). Coal power generation in China alone accounted for 15% of the world's total CO_2 emissions in the same year. Many of these plants are relatively new construction, on average 12–14 years old, compared to the global average of 26 years. In India, coal is 74% of the country's generation mix, but the size of the system is around 1,900 TWh, less than a quarter of China's. Many industrialized countries, including the U.S., Germany, and Japan are still progressing on transitions away from coal, which have been largely accomplished in France and the UK (see Figure 2).

At the same time, countries are struggling to keep or make electricity affordable to buyers, including to the industries governments may aim to retain or attract. In the U.S., the average real electricity price in U.S. cities tripled between 1980 and 2024, with sharp growth since the pandemic, shown in Figure 3 (U.S. Bureau of Labor Statistics 2025). Average electricity prices in Europe similarly increased over time, doubling between 1990 and 2024 in real terms (Eurostat 2025). The projected wave of demand is expected to place additional pressure on affordability; therefore, coal phasedown will need to be structured in a manner that allows ratepayers to reap the benefits of newly built, less expensive generation.

Figure 3: Average electricity price per kWh, U.S. cities.



Source: U.S. Bureau of Labor Statistics (2025)

Electricity systems differ in how economic incentives to fuel, produce, and deliver electric power are spread across the value chain. Electricity systems worldwide are highly regulated, with differences in the degree to which costs of technology and any associated costs of integration (e.g., storage, balancing, and transmission) are covered by electricity rates. The business case for clean and renewable energy hinges on perceptions of installed cost compared to alternatives, how any incremental costs along the value chain are shared or covered by policy, and the level and degree of certainty surrounding the availability of subsidies or other forms of support. However, incentivizing the phase out of fossil fuels in electricity generation is more challenging, as these electricity sources may be important revenue generators for localities. Downstream buyers, especially those in markets subject to binding GHG targets, may seek to encourage clean electricity sourcing among their upstream suppliers, for example to support attainment of corporate climate targets, expanding demand for clean and renewable energy in markets where suppliers produce. These needs have grown in recent years but are still modest compared to generation from coal and other fossil fuels in many markets.

The task of phasing down coal in electricity generation and replacing it with clean and renewable energy sources must overcome several economic and institutional hurdles. While the cost of providing electricity with variable renewable sources through power purchase agreements (PPAs) is now often lower than the cost of fossil baseload power, integrating these sources on the power grid imposes additional costs associated with ramping to accommodate fluctuations, reduced utilization of baseload generators, and maintaining sufficient firm backup capacity, ranging as high as 25–35 Euro/MWh on systems with 30–40% wind (Hirth *et al*. 2015). These costs are inconsistently reflected in PPA prices (Duldinger 2023). Reflecting the cost of integration in the consumer price can drive up the financial burden for an otherwise willing buyer, especially on inefficient or relatively inflexible power systems.

While the falling costs of variable renewable energy favor decarbonization, they will be far from sufficient to drive the transition. How electricity grids will need to be designed or reinforced, for instance, for greater operational flexibility to handle two-way power flows, resilience to natural and human threats, and to support more distributed energy resources, including microgrids, EVs, variable renewable energy, and storage, remains broadly similar regardless of the specific generation mix (Slaria *et al*. 2023). At the same time, efforts to promote reliability and cost control in electricity systems will increase confidence in the ability of these systems to handle expansion, especially additions of variable renewable energy. In other words, support for the transition is likely to grow if commercial, industrial, and residential customers directly experience the favorable costs of clean and renewable energy (NCSL 2023).

2.2 Transportation

Heavy and light-duty vehicles, maritime shipping, rail, and aviation contribute approximately 15% of global GHG emissions. GHG emissions are primarily associated with the use phase of transportation equipment.[2] Within each of the major transportation modes, patterns of decision-making and adoption of low-emitting technologies varies widely. For instance, in the light-duty segment, household or fleet owner choices are driving adoption of EVs, with 17.3 M new EVs (including plug-in hybrids) sold globally in 2024, most of them in China, compared to 3 M in 2020 (IEA 2025b). Business models that focus on providing EV fleet services have evolved and are profitable in many parts of the world (IEA 2025b; Becerra and Galarza 2022; Chauhan *et al*. 2023). For the rail sector, electrification is an important component of decarbonization strategy. Many rail networks globally have already electrified, and the U.S. federal government focused on electrification in its transportation sector decarbonization plan for the United States (Ellis 2023). Maritime shipping is more complicated, as shipping emissions are often excluded from national GHG emissions accounting and subject to separate governance arrangements. Abatement strategies for maritime shipping include addressing methane leaks, adopting low carbon fuels such as hydrogen, and altering routing and trade patterns (Hirata *et al*. 2024). Aviation decarbonization is underway, supported by the International Civil Aviation Organization (ICAO) and international conventions among major stakeholders setting forth timetables for development, demonstration, and deployment of sustainable aviation fuel (SAF). The costs of SAF are currently 120–700% higher than fossil-based jet fuels and use reduces CO_2 emissions by 27–28% (Watson *et al*. 2024). The remainder of this section focuses on EV deployment to address vehicle transportation GHG emissions, while recognizing the importance of ongoing efforts to decarbonize aviation, rail, and maritime shipping.

Reductions in the cost of EVs have largely changed the perception that the light-duty vehicle sector is hard to decarbonize. EVs produced in China have capital costs competitive with internal combustion engine (ICE) vehicles today, both in China and overseas. In most other markets, EVs are still more expensive than ICE vehicles upfront, but often compete favorably with ICE vehicles once lifetime fuel costs are included. In addition, consumers that value environmental or other amenities in Europe and the United States have been willing to pay more for the EV equivalent of an ICE model (Buhmann and Criado 2023).

2 Although the production and end-of-life phases are nontrivial contributors, they are typically counted as part of industrial sector emissions.

Given the relative success of EVs in achieving cost parity and growing market share, attention has shifted sharply to the supply chain implications of production and deployment at large scale. These implications are perhaps most acute for the EV battery, its components, and precursor materials. China's dominance of multiple stages of the EV supply chain has raised concern about the long-term implications for the competitiveness of automotive producers outside of China and vulnerabilities to supply shortages or disruptions as EV production scales to keep pace with decarbonization goals (Cheng *et al*. 2024a). Such vulnerabilities also exist in semiconductors — ICE vehicles contain 300–1000 semiconductors, while newer EVs can contain over 3,000. Increasing use of autonomous features in vehicles will further drive this demand. Concern over related vulnerabilities has prompted unprecedented investment in semiconductor manufacturing in the United States. The additional credits for domestically-manufactured EV batteries in the U.S. Inflation Reduction Act of 2022 were also intended to mitigate these vulnerabilities by incentivizing onshoring of upstream supply chain activities (Cheng *et al*. 2024b). The European Union's Critical Raw Material Act similarly aims to diversify the raw materials supply chain for battery EVs, with targets of 10% for extraction, 40% for processing, 25% for recycling, and no more than 65% of EU consumption annually from any single third country (European Commission 2025a).

Today, China's EV producers are increasingly focused on selling and producing globally, building on the industry's successful expansion within China. BYD anticipates that by 2030, it expects to sell over half of the EVs it produces outside of China (Goh and Carey 2025). Other companies in China, including Great Wall Motors, Geely, Chery, and Wuling, have similar plans (AP 2025). As the European Union and the United States imposed tariffs on EVs from China (an additional 17% to 35.3% in the EU on top of the standard 10%, and 100% in the United States), competition for market share has been concentrated in other markets, notably in developing Asia, Latin America, and Africa. Increasing EV sales and use in these markets would accelerate deep decarbonization, if accompanied by the deployment of decarbonized electric power sources.

2.3 Industry

The industrial sector, which includes GHG intensive activities such as production of iron and steel, cement, chemicals and petrochemicals, and pulp and paper, is expected to be the major source of GHG emissions by 2040 (IPCC 2022). The need for sustained, high-temperature heat in many industrial and manufacturing processes makes it difficult to substitute electricity for fossil fuels. Direct substitutes, such as hydrogen or electrofuels, are not yet cost effective. A second challenge is the substantial contribution from process GHG emissions. Already today, direct emissions from the industrial sector account for 24% of GHG emissions globally; that share rises to 34% if indirect GHG emissions from electric power and heat are included (IPCC 2022).

Since demand for industrial goods is most acute during periods of rapid economic expansion and these goods are often hard to transport, it is perhaps unsurprising that the production of iron and steel, cement, and chemicals is concentrated in China, at 54%, 51%, and 44% of global production, respectively. Today, production is growing rapidly to meet domestic demand in India, Southeast Asia, and other emerging markets. The remaining share of production is concentrated in industrialized countries, many of which are now trying to answer the question of how much activity to retain domestically to satisfy defense, national security, and employment objectives (Millot and Rawdanowicz 2023).

The industrial sector produces many commodities that are globally traded and thus exposed to both tariffs and carbon border adjustment mechanisms (CBAMs). Within the industrial sector, intermediates such as automotive parts and high-value chemicals account for a large share of trade in the steel and chemical industries, while the share is lower for cement due to its low value-to-weight ratio. Here, China's contribution is prominent: China supplies around 45% of sales for chemicals, 12% of sales for the world's auto parts, and 15% of sales for paper (Atkinson 2024; Tendata 2024a; Tendata 2024b). The pathways used to produce steel and chemicals in China still rely heavily on coal to produce coke, ammonia and methanol.

Innovation and deployment of low-emissions technology in the iron and steel and chemical industries alone could lower global GHG emissions from industry substantially. If the technology that enables this shift could be made inexpensive and widely available, as in the success stories of wind, solar, and EV batteries, it would help many countries worldwide to decarbonize. It could also bring substantial benefits in the form of avoided air pollution health damages (Li *et al*. 2018).

In the industrial sector, major barriers to deploying decarbonization technologies are the cost, uncertainty over performance, and the nascency of markets and supply chains for many decarbonization technologies. These challenges are exacerbated for activities with thin margins and outsized exposure to trade and macroeconomic shocks. Capital and operating costs of technologies that could support deep decarbonization are perceived as too high at current levels to support a transition at scale, even in geographies with emissions trading systems covering GHGs. However, the economics of alternative production routes depend critically on the availability of scrap and alternative iron sources such as direct reduced iron (DRI) produced with natural gas and/or hydrogen or iron produced via electrolysis, which would support further expansion of the role of the scrap-based, lower emitting electric arc furnace (EAF) route relative to the globally dominant, higher emitting blast furnace-basic oxygen furnace (BF-BOF) route. The BF-BOF process emits over two tons of CO_2 per ton of crude steel produced, while a shift to the EAF route could reduce this figure by 50–75% or more, with costs generally increasing with deeper decarbonization. Developing carbon management for industrial sources, including CCS, carbon capture and utilization (CCU), and direct air capture (DAC), will very likely be needed to achieve net zero targets.

In some isolated cases, buyers have paid a premium for decarbonized industrial products. Even for technologies with relatively high abatement costs of $90/ton or more, some consumers, particularly in the automotive sector but increasingly in the tech and eCommerce industries, have indicated willingness to pay for steel produced with lower GHG emissions, especially when steel represents a modest share of overall costs. Stegra, which is constructing hydrogen-based iron and steelmaking facilities in northern Sweden, has signed contracts for over 50% of its output at a 30–35% premium. In China, BMW has contracted with HBIS to supply green steel for its Shenyang automotive manufacturing facility (HBIS Group 2023). The contract provides initially for the production of reduced-emissions steel (10–30% reduction in GHG emissions compared to the integrated route) and plans to achieve a 95% reduction by transitioning to hydrogen DRI-EAF production by 2026. The steel will be used both in cars and parts exported to the European Union as well as EVs in China. An important question is whether these examples of first-of-a-kind production at scale, enabled by buyers with higher willingness to pay, will be able to drive down costs and/or prove out technologies in ways that unlock greater global demand.

Many industrial commodities, including steel, cement, and plastics, may benefit from an increased role for recycled production routes. Recycling will increasingly offer an important strategy for advancing deep decarbonization as more product scrap becomes available, especially in rapidly industrializing economies. The prevalence and low cost of scrap-based steelmaking is one of the main reasons why the U.S. market has one of the lowest CO_2 intensities of steel production in the world, despite not having a policy constraining that industry's GHG emissions.

Incentivizing incremental changes to existing production setups can also meaningfully reduce GHG emissions (by 10% or more, relative to high-carbon incumbents) with limited changes to the existing capital stock. In the case of steel, producers are considering opportunities to adjust BF-BOF operations in ways that substantially lower CO_2 emissions, for instance by including more pre-reduced material in the BF, e.g. hot-briquetted iron (HBI, an easily transported form of direct reduced iron or DRI) or scrap or injecting an alternative reductant, such as hydrogen, to lower the coke rate. Some of these strategies could lower steelmaking emissions from the integrated route by around 20% at existing mills. Deeper reductions would require CCS for integrated mills. While the details differ, analogous opportunities exist in other industries.

Deeply decarbonizing heavy industry will likely require a portfolio of tailored strategies that are capable of meeting diverse heating and process needs. Electrification is expected to be an important part of the solution for the iron and steel and chemicals industries, but it will depend on the benefits of continuing to rely on coal, natural gas, or other fuel substitutes, such as hydrogen produced from decarbonized electricity sources. While industrial decarbonization globally may benefit in the near term from increasing supplies of natural gas that replace coal, the key will be to ensure that process equipment, such as boilers or furnaces, can readily move from natural gas to alternatives, such as electricity or hydrogen, without major new capital investments. Here, the staged introduction of technologies, such as DRI with increasing blends of hydrogen, offers a viable path, while recognizing that abundant, low cost, decarbonized electricity could enable more possibilities.

3. CLIMATE POLICY AND BUSINESS STRATEGY

Recognizing the differences in major abatement opportunities and challenges across the three sectors considered above, this analysis turns to ask: how effective are the public policies and business strategies in place today at incentivizing decarbonization? This discussion integrates the sectoral lens above within a country/bloc perspective. In United National Framework Convention on Climate Change (UNFCCC) process following the 2009 Conference of Parties (COP) in Copenhagen, Denmark, countries offer Nationally-Determined Contributions (NDCs) and then governments design and implement policies to achieve them. The result has been announcements of dedicated policies aimed at growing momentum to limit CO_2 emissions. Nevertheless, there remains a disconnect between the Paris Agreement goal of limiting temperature rise to 2 degrees C or 1.5 degrees C above preindustrial levels and countries' NDCs, and between the stated goals of NDCs and implementation (UNEP 2023; Meckling and Karplus 2023). Prior work suggests finds that carbon pricing systems have been effective, particularly as part of well-designed policy mixes that address other externalities (Stechemesser *et al*. 2024). Other externalities that interact with society's ability to respond to climate change include knowledge spillovers, coordination failures, and financial frictions (Armitage *et al*. 2023; Acemoglu *et al*. 2012).

This section examines the state and direction of climate policy ambition in three major countries/regional groups that represent climate policy leaders and/or constitute major centers of rapid economic and GHG emissions growth: China, the European Union, and India and Southeast Asia, with attention to other regions as noteworthy. It considers the relationship between policy ambition today and the major sources of GHG emissions, both present and anticipated. Both the roles of government policy and business strategy related to mitigating climate change are considered. Approaches range from targets, market-based instruments, and sectoral strategies through mid-century in China and the European Union to targets and plans that hinge on affordability in India and Southeast Asia. At the same time, the number of businesses reporting to the Climate Disclosure Project (CDP) continues to grow year-over-year, reaching 4,000 in 2024 (PwC 2025). The fact that the most GHG-intensive stages of many global supply chains are in places with existing or growing climate policy pressure suggest there may be opportunities to harness public funds and support for technology demonstration and scaling of production in sectors where decarbonization pathways are precommercial. Countries without strong climate policies, by contrast, may become less attractive to businesses with ambitious climate goals.

China. To implement its goal of peaking emissions by 2030 or earlier and reaching net zero by 2060, China has adopted an extensive road map, codified in the 1+N Framework. National policymakers expect approximately half of the targeted reductions will be achieved via its emissions trading system, which began in 2021 with electric power and has recently been expanded to include iron and steel, cement, and aluminum (Zhang *et al*. 2025). Action Plans for industries simultaneously help to overcome coordination challenges, providing explicit guidance on acceptable abatement technologies and targeted adoption time frames. The China Renewable Energy Law was instrumental in establishing conditions for the rapid growth of wind and solar in electricity generation, while grid expansion and electricity market reforms have been important to reducing curtailment and increasing the contribution of variable renewable energy to the primary energy mix. Scholars have recognized a disconnect between institutional arrangements in place today in China and those that will likely be needed to incentivize a transition to net zero (Li *et al*. 2025), but an active ongoing conversation centers on improving future alignment. The ability of the 1+N policy framework to support a steady, managed transition over the next three decades will be vitally important for global climate change mitigation efforts. In parallel, the continued uptake in domestic and export markets of clean technologies developed or produced in China will be important to maintaining the support of the country's leadership for transition. Given the long decision horizons of China's leadership, policy continuity is virtually assured, although how it is implemented will reflect economic and geopolitical realities.

Business initiatives are helping China to meet its climate goals. The climate commitments of multinational companies often include upstream suppliers, which effectively translates into pressure on many companies operating in China. These companies have responded by purchasing green electricity certificates or by participating in the country's Green Power Trading (GPT) system (Reuters 2024a), while pushing for supply expansion and price transparency. Suppliers in many large sectors, such as electronics and heavy equipment manufacturing, are not currently covered by the emissions trading system. Corporate pressure, from multinationals and more recently from brands in China, may be causing many suppliers to source decarbonized electricity when they would not have done so otherwise. This pressure is likely to be important to further decarbonization of China's power sector, helping to accelerate deployment of clean and renewable energy. In the industrial sector, two of China's leading iron and steel producers, HBIS and Baosteel, have constructed industrial-scale demonstration facilities for hydrogen DRI production (Tenova 2023; HBIS Group 2023), in part as a response to the decarbonization ambitions of automotive brands. Construction and operational expertise gained in China will diffuse around the world through the growing expertise of domestic and international equipment manufacturers and project developers.

India and Southeast Asia. The contributions of India and Southeast Asia are one of the greatest unknowns in future GHG emissions projections. India's energy-related CO_2 emissions rose by 5% in 2024 (IEA 2025c), while Southeast Asia is expected to account for 25% of global energy demand growth between now and 2035 (IEA 2025d). Given the relative nascency and strong cost dependence of climate policy ambition in these countries, the availability of affordable clean energy technologies is likely to be paramount in accelerating the transition. Countries in this group have submitted NDCs, including primarily intensity-based mitigation targets and targets for increasing clean energy and reducing the share of fossil fuels. Indonesia and Vietnam are in the process of establishing carbon market frameworks but these efforts are in an earlier stage of development and expected to cover the electric power and industrial sectors. Just Energy Transition Partnerships (JTEPs) in both countries aim to channel low-cost financing for power sector decarbonization (Dwitiyasih *et al.* 2025). India has committed to peak CO_2 emissions by 2070. The country's NDC targets a reduction of 45% in the emissions intensity of GDP by 2030, relative to 2005 levels, 50% renewable energy in cumulative installed capacity in the power sector, and 2.5–3 billion tons of CO_2-equivalent sequestration through afforestation. India has further published a long-term low carbon development strategy that focused on implementation measures over an extended horizon (MoEFCC 2022). For developing nations, the favorable cost of wind, solar, and EV batteries is likely to be a stronger driver of decarbonization, especially in the power and transportation sectors.

The climate ambition of multinational corporations is an important driver of clean energy demand for suppliers located in India and Southeast Asia as well as developing countries more broadly. Corporate Power Purchase Agreements (CPPAs) have rapidly expanded across Southeast Asia to assist corporations in meeting their climate pledges (KPMG International 2022). While new CPPAs benefit from the falling costs of renewable energy, efforts to drive the early closure of coal power plants, many of which are relatively young in Southeast Asia, face challenges from investors who would lose returns (Reuters 2024b). The diffusion of EVs in developing countries is likely to further accelerate with the globalization of China's EV industry, which include BYD's plans for a manufacturing site in Hyderabad, India, to produce 20 GW of batteries and 600,000 EVs annually (Business Standard 2025).

European Union. Enshrined in the European Climate Law (European Commission 2025b), the EU's commitment to achieving net zero by 2050 remains firmly in place, despite emerging headwinds in part due to higher-than-expected costs. By 2030, the bloc further targets a 55% reduction in GHG emissions relative to 1990 levels. The EU Emissions Trading System (EU-ETS) covers 40% of GHG emissions, including power, industry, and aviation. A CBAM that extends the GHG price to imported goods based on embodied carbon was announced in 2023 and will enter force in 2026. Starting in 2027, maritime emissions will be part of the EU-ETS and a separate ETS for transportation and buildings will be established. Phase 4 reforms target more ambitious annual cap reductions and the phase-out of free allowances in some sectors. The EU's Effort Sharing Regulation sets binding targets for reductions in non-ETS sectors, with the first target of 40% below 2005 levels by 2030. The EU stands out for its comprehensive, net-zero aligned approach, while the EU-ETS has served as a model for many other systems, including China's.

Perhaps in part due to its strong and consistent climate policy stance, many EU countries are centers of innovation in the design and operation of clean energy technologies and systems, although many systems, technologies, and components are increasingly manufactured overseas. EU leadership has expressed concerns about relying on imports, to the extent that doing so threatens the technological leadership of the bloc in important areas such as automotive design and heavy manufacturing. In October 2024, the EU implemented countervailing duties on EVs produced in China, in addition to the 10% duty on vehicle imports. Many corporations headquartered in the EU are pushing to decarbonize energy across their global supply chains to meet net-zero targets and to limit any adverse effects of the CBAM when it is fully online in 2026.

4. INTERACTIONS: TRADE, INDUSTRIAL POLICY, NATIONAL SECURITY, AND THE MACROECONOMY

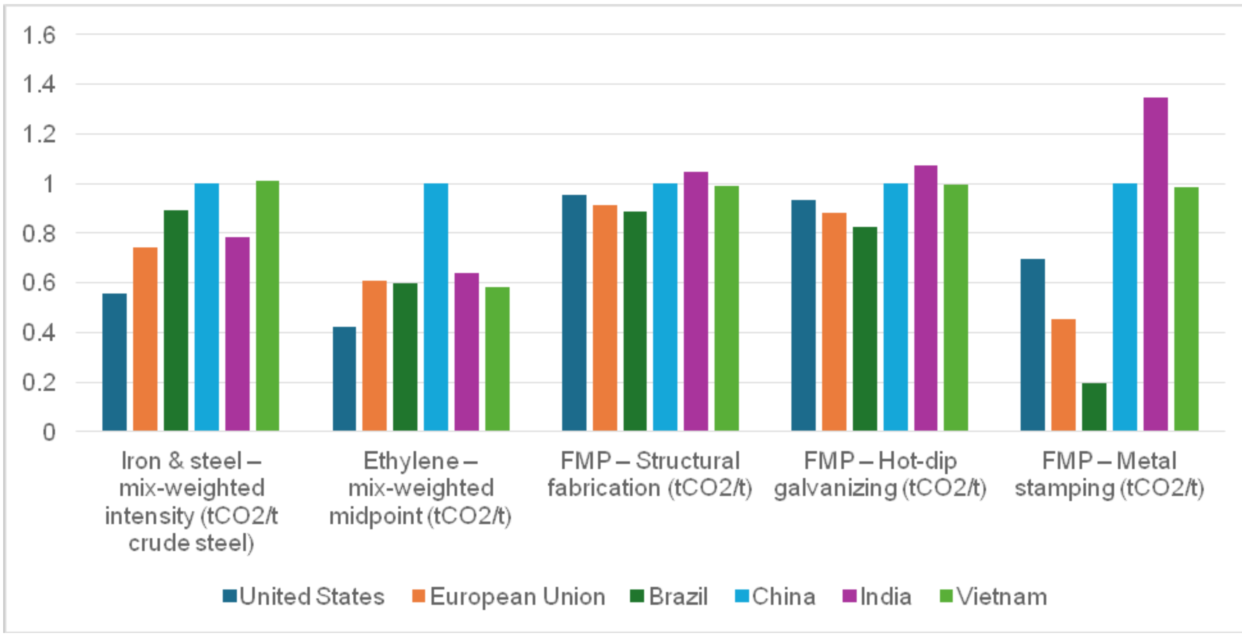
Although climate policy is a direct and tangible way to incentivize decarbonization, a broader set of priorities and associated policies influence the pace and direction of the energy transition. Trade has been a major focus in the wake of the recent U.S. tariffs announcements, but it is far from the only one. Here, this analysis examines the influence on the transition of several of these priorities: trade and industrial policy, national security, and macroeconomic policy. This analysis focuses on the ways each category interacts with efforts to accelerate deep decarbonization around the world. In some cases, the influence of these other priorities and related policies may have more powerful effects on climate change mitigation than targeted climate policy to date, although stronger policy signals will be necessary for deep decarbonization. However, focusing on these synergistic priorities may be especially important in settings where climate policy is currently constrained.

4.1 Trade and Industrial Policy

Trade and industrial policy interacts with climate ambition in important ways. Across product categories, trade flows are biased towards relatively CO_2 intensive production. Shapiro (2021) shows that in most countries, import tariffs and non-tariff barriers are much lower for industries with high CO_2 intensity (which tend to be upstream commodity and heavy equipment producers) compared to those with low CO_2 intensity (which tend to include more downstream service providers). New tariffs will interact with this preexisting bias.

Within product categories, differences in CO_2 or GHG emissions intensities across countries can also be stark. Blunt tariffs indirectly reward or penalize CO_2 emissions depending on the difference in CO_2 emissions intensity between domestic and imported products and the magnitude of the tariff. Figure 4 shows a comparison of emissions intensities for a select set of products. The comparison suggests that for some products, tariffs in the U.S. would advantage lower-CO_2 domestic production, which has a lower CO_2 intensity than production in other countries. The gap is especially large for products with relatively high CO_2 intensity such as iron and steel and ethylene production. By contrast, the U.S. is no longer the least CO_2 intensive in categories of fabricated metal products processing, especially metal stamping, which primarily requires electricity as an energy input. To the extent that tariffs encourage reshoring of some U.S. production, displacing production elsewhere, global CO_2 emissions may trend lower. However, reductions may be attenuated if CO_2-intensive exports are instead redirected to other countries, at the same time as U.S. production increases.

Figure 4: CO_2 intensity of different product categories subject to tariffs by country, using a cradle-to-gate accounting methodology, relative to levels in China.



Notes: Iron and steel intensities are weighted by technology route using worldsteel 2024 benchmarks (BF-BOF 2.32; DRI-EAF 1.43; scrap-EAF 0.70 tCO_2 per t) combined with route shares at the country level (worldsteel 2023, 2024, 2025). Chemicals use ethylene as a proxy (plant-gate Scopes 1 and 2): route midpoints are approximately 1.1 (ethane), 1.9 (naphtha), 1.5 (LPG), and 7.0 (coal/MTO), multiplied by assumed national feed mixes (Shin et al. 2025; Energy Transitions Commission 2022; U.S. DOE 2022; U.S. EIA 2023). Fabricated metal products show on-site Scopes 1 and 2 for representative processes (AISC 2021; AGA 2022) and GREET (U.S. DOE 2024); country differences reflect grid CO_2 intensities. Grid emissions factors from U.S. are from EIA (2025), Ember (2023, 2024, 2025), and Climate Transparency (2020, 2021). Natural gas emissions factor is 56.1 kg CO_2 per GJ (IPCC 2006). Upstream material and feedstock emissions are excluded.

Relative to blunt tariffs, a CBAM is a much more targeted instrument for limiting carbon leakage and the economic consequences of carbon pricing for domestic producers. To the extent that many associated GHG emissions transfers fall outside the purview of climate policy at the country level, these contribute to a "carbon loophole" (Hasanbeigi *et al*. 2018). A CBAM is designed to alter the prices of traded goods based on their embodied CO_2 content. Generic tariffs only indirectly target CO_2 emissions if they are levied against countries with a higher CO_2 intensity of producing a particular good, which is not uniformly the case.

Trade has also reduced the costs of technologies required for the transition by accelerating adoption, experience, and learning. For example, trade has allowed solar PV manufacturers in China to take advantage of installation subsidies in Germany and the United States. Low-cost equipment produced overseas has been a major driver of the growth and competitiveness of renewable energy developers and installers in the United States. By routing production to markets with attractive input costs and products to markets with the highest willingness to pay, trade has accelerated the transition. Counterfactual analysis suggests that slower learning due to limited market access would have raised aggregate costs from 2008 to 2020 for solar PV in China, Germany, and the United States by $36 billion, $7 billion, and $24 billion, respectively (Helveston *et al*. 2022).

Against this backdrop, it is important to consider how recent developments in trade policy are likely to alter the CO_2 emissions embodied in global trade as well as the diffusion of technologies important for the transition. For the first, we have seen two flavors of new trade barriers implemented. One is uniform ad valorem tariffs applied across a wide swath of products, such as those announced by the U.S. Administration in early 2025. Another is a tariff proportional to a product's embodied CO_2, as is coming into force in 2026 with the CBAM in the European Union and under discussion in parts of Asia. Apart from tariffs enacted by the U.S. administration in 2024 that targeted clean technologies (e.g., EVs) from China, the uniform ad valorem tariffs may or may not have pro-climate effects as discussed above, while the CBAM is more directly targeted. To the extent that they encourage process efficiency, clean fuel mixes, and energy conservation, sustained tariff or CBAM price signals are perhaps more likely to produce a lasting pro-climate effect. In the coming years, it will be important to evaluate this effect empirically.

Tariffs introduced by the U.S. administration include two parts. Universal 10% baseline tariffs apply to all imported goods, with several exceptions: products already subject to Section 232 tariffs (steel, aluminum, and automotive manufacturing in an expanded version), copper, pharmaceuticals, semiconductors and integrated circuits, energy products, and Canadian and Mexican goods covered by the United States-Mexico-Canada Agreement (USMCA). In addition, as of April 9, 2025, the U.S. further adopted country-specific reciprocal tariffs and rates have been updated in ongoing negotiations. This formula calculates based on the trade deficit between the U.S. and another country, divides the trade deficit by the value of imports from that country, and implements a tariff equivalent to half of the trade barrier value or 10%, whichever is higher. The tariff rates are subject to ongoing negotiation; the European Union negotiated a tariff of 15%, down from 30%, in late July 2025. In addition to these broad-based tariffs, the U.S. Administration expanded Section 301 tariffs exclusively applied to goods imported from China, which cover 94 out of 98 4-digit industries across Agriculture (11), Mining (21), and Manufacturing (31–33). In essence, the Section 301 tariffs penalize many categories of imports from China to the U.S., such as steel, in a manner that is consistent with penalizing CO_2 emissions associated with production. In the case of steel, for example, the CO_2 intensity of production in China is roughly twice that of the United States (see Figure 4).

At the same time, the European Union is moving ahead with the implementation of the CBAM (European Commission 2025c). The CBAM will initially cover emissions-intensive sectors at high risk of relocation: iron and steel, cement, aluminum, fertilizers, electricity, and hydrogen. Importers are required to report the CO_2 intensity of products and purchase CBAM certificates equivalent to the tonnage of embodied emissions at the prevailing EU-ETS CO_2-equivalent price. The CO_2 price paid by an importer in the country of origin can be deducted from their obligations under the CBAM. During the transitional phase (October 2023 to 2025), only reporting of embodied emissions is required. Starting on January 1, 2026, importers will be required to cover their embodied emissions with CBAM certificates. Some developing countries have expressed concern that the CBAM would limit markets for their products, while others have responded by developing plans for their own CO_2 pricing systems (Clausing *et al*. 2024). Proponents of the CBAM point to its ability to play an important role in discouraging GHG-intensive production, while detractors express concern that importers will segment production based on GHG intensity and reroute those with the lowest intensity to the EU, increasing GHG intensity of imports in the rest of the world and offsetting climate benefits (Abnett 2025).

Industrial policy in its broadest sense refers to directed government support for domestic economic activity, although it encompasses a wide range of interventions that have proven difficult to classify and measure (Juhász *et al*. 2022). The term industrial policy has become intertwined with climate change in recent years to the extent that the former targets changes in economic structure and resource allocation to support decarbonization (Flegal 2023). It is often closely related to national security, although it is generally more about competitiveness and leadership than it is about preserving or protecting specific capabilities. Trade policy is often designed to work synergistically with industrial policy, although achieving coordination can be difficult in practice.

Industrial policy is now prevalent worldwide but takes different forms. Industrial policy has been a cornerstone of China's approach to building its economy since the early 1980s. The evolving structure of the economy and direction of technological change was in many ways shaped by economic blueprints and priority research areas enshrined in the country's early science and technology plans. These plans have evolved into nationally-led efforts to cultivate emerging industries over the longer term, using supply-side tools such as public funding for research, development, and demonstration and demand-side tools such as rebates, restrictions on incumbents, and targeted support for exporters. In the United States, industrial policy intersected with the climate agenda in the design of incentives for U.S. manufacturers in the clean energy economy, in particular in the Inflation Reduction Act of 2022, prior to recent policy shifts. In the EU and its member states, industrial policy has many aims, but has included a sustained focus on supporting domestic industry in the energy transition.

4.2 National Security

While industrial policy and national security are related concepts, national security differs in its primary focus on protection of sovereignty, economic stability, and strategic interests, compared to economic competitiveness and transformation in the case of industrial policy. The energy transition is expected to be both positive and negative for national security objectives. Reduced exposure to volatile fossil fuel prices, greater system efficiency and electrification can simplify energy delivery in a conflict, and decentralized systems — such as renewable electricity and distributed energy storage — may be less vulnerable targets compared to centralized energy infrastructure. At the same time, the energy transition implies increased demand for mineral and battery materials, which are currently produced by geographically-concentrated supply chains (Cheng *et al*. 2024a). Electrification will increase energy dependency of many activities on the grid, which with the proliferation of complex, digitized systems may increase attack surfaces (Zografopoulos *et al*. 2023). An increase in nuclear energy for decarbonization will raise concerns about proliferation risk, which must be carefully managed. Policies that attempt to minimize the potential downsides for national security by supporting the onshoring of supply chains include the Critical Raw Materials Act in the EU and the Inflation Reduction Act in the U.S. (European Commission 2025b; Cheng *et al*. 2024b).

National security priorities evolve with global geopolitics. Rising tensions between the U.S. and China and to some extent the EU and China have foregrounded concerns about reliance on supply chains that China controls. Concerns were exacerbated by semiconductor shortages and price spikes in markets for EV battery materials during the pandemic, although for the moment these disruption signals have subsided. However, energy independence arguments for a shift to electricity-based energy systems with generation source flexibility suggest a growing role for wind, solar, EVs, and heat pumps. Managing real and perceived national security risks proactively and effectively can have an outsized effect on building momentum for energy transition.

Table 1: Summary of approximate average borrowing costs in major regions from 2020–2025.

Country / Region	2020–2021 (Pandemic Lows)	2022–2023 (Tightening Peak)	2024–Mid-2025 (Easing / Plateau)	Policy Rate Today (mid-2025)
United States	0–0.25 %	5.25–5.50 %	Easing to 4.25–4.50 %	4.50 %
Eurozone (ECB)	-0.50 % to 0 %	4.00–4.75 %	Cut to 2.00–2.15 %	2.00–2.15 %
United Kingdom	0.10 %	5.25 %	Down to 4.25 %	4.25 %
Canada	0.25 %	4.25 % (late 2022)	Gradual to 2.75 %	2.75 %
Australia	0.10 %	4.35 % (Nov 2023)	Cut to 4.10 % (Feb 2025), easing continues	3.85–4.10 %
Japan	-0.10 % to 0 %	Steady at 0 %	First hike to 0.50 % in early 2025	0.50 %
China	Stable around 3.10–3.50 %	Stayed close to 3.10%	Cut to 3.00 % (May 2025)	3.00 %
India	Repo steady at 4.00 %–4.40 %	Hiked to 6.50 % by late 2023	Cuts to 6.25 % (Feb 2025), then 6.00 % (Apr), then 5.50 % (June)	5.50 %
Brazil	Very low at 2.00 % (Aug ’20)	Sharp rise: 9.25 % (2021) to 13.75 % (end-2022)	Peaked 14.25–14.75 % then rose to 15 % by June 2025	15.00 %

Note: Based on published rates for respective countries/Eurozone: U.S. Federal Reserve, Federal Funds Target Rate; European Central Bank, Main Refinancing Operations Rate; Bank of England, Bank Rate; Bank of Japan, Policy Rate Balance; Bank of Canada, Target for Overnight Rate; Reserve Bank of Australia, Cash Rate Target; People's Bank of China, Loan Prime Rate (1-year); Reserve Bank of India, Repo Rate; Central Bank of Brazil, Selic Rate.

4.3 Macroeconomic Trends

Finally, higher interest rates and rising prices for some forms of clean energy around the world have generated headwinds for the energy transition. Transition requires the deployment of technologies that are capital intensive compared to fossil-fueled alternatives. As shown in Table 1, over the past five years, monetary policy shifted from low rates during the early years of the COVID-19 pandemic to relative tightening to curb inflation. Evidence that inflation was under control prompted a plateau and some modest rate cuts in 2025. Only Japan deviated from this pattern, keeping rates very low through mid-2025.

Evidence of the impacts of higher interest rates and inflation on slowing the energy transition predates recent tariffs and reductions in policy support. Interest rates have been cited alongside a failure to price in inflation as a major factor in the cancellation in 2023 of major wind projects Ocean 1 and Ocean 2 by Ørsted (Ørsted 2023). In late 2023, Avangrid, a subsidy of Iberdrola, terminated PPAs and restructured offshore wind bids in response to higher rates, despite high termination fees (CleanTechnica 2023). Sunnova cited high interest rates among the factors in its decision to file for bankruptcy (Dhumal 2025). High interest rates were also a major consideration in decisions to cancel multiple hydrogen projects in Europe, alongside uncertain economics and reliance on public subsidies (Reuters 2025a). High costs of decarbonized energy, especially electricity, are also a major concern in Europe. ArcelorMittal's announcement in June 2025 that it would turn down $1.3 billion in subsidies to produce steel from hydrogen DRI in Europe cited the price of electricity along with import competition and concerns about CBAM effectiveness (ArcelorMittal 2025; Reuters 2025b).

5. PATHS FORWARD

This paper has described the major opportunities for accelerating decarbonization by sector and taken stock of policies and agendas that influence action on climate change. This final section attempts to weave these threads together to develop a view of potential paths to advance decarbonization. The recommendations attempt to at once address sectoral needs and opportunities (Section 2), the current state of climate change policy and business strategy (Section 3), and exposure to broader institutional and market drivers (Section 4) that influence transition momentum. The main conclusion is that while climate policy in governments and corporate boardrooms can and must continue to align producer and consumer incentives with global goals, broadening the aperture to include complementary levers can reveal many ways to support or accelerate progress. Far from orthogonal to climate policy, these levers may increase the likelihood, ambition, and durability of future efforts to advance the transition.

Three general areas of opportunity could help to build momentum for a global clean energy transition. The first involves preparing for a future that relies much more heavily on electricity, a trend that is strongly aligned with efforts to addressing economic priorities, including the anticipated boom in energy needs for artificial intelligence (AI), as well as electrification of new industrial and residential loads. The second involves managing supply chain risks so that adoption of clean energy technologies can continue to increase in scale. A third area involves pursuing sectoral strategies in which technological advance is aligned with decarbonization, working with philanthropies and governments to increase forgivable loans and grant funding for first-of-a-kind projects and low-interest loans for successive tranches of deployment.

5.1 Invest in the Electricity Grid

The electricity grid is increasingly the lifeblood of the modern economy. Electricity needs for data centers, AI, and computing are expected to soar in the coming decades. Strengthening the grid is also essential to pave the way for electrification across many end uses, including transportation, buildings, and industry. Needed changes involve both modernizing and expanding transmission and distribution, increasing reliability and resilience to service disruption, and increasing flexibility to accommodate variable renewable energy and other distributed energy resources. Achieving these objectives will require substantial capital outlays for new generation and other changes to system operation. Every electricity system faces a broadly similar set of challenges, despite differences in the composition of generation and governance structures. Increasing the efficiency of systems powered by electricity and other energy sources can further complement investments in new generation, transmission, and distribution.

With grid modernization as an overarching strategy, specific and targeted policy actions are needed to support implementation. First, public spending allocated to grid modernization will need to increase. While forming these coalitions has historically been challenging, the confluence of data center energy needs, electrification of other major end uses, strain on aging infrastructure, increasing frequency of storms, and growing sophistication of cyberattacks have strengthened the case for action and brought new stakeholders to the table. In short, the case for strengthening the grid is relatively uncontroversial and directly linked to economic outcomes. Massive spending by China on grid expansion has translated into unparalleled economic advantages and benefits to businesses and citizens. Investing to regain competitive ground may provide a powerful motivator for some governments, while others will continue to benefit from the scale economies of equipment produced in China.

A concerted push to strengthen electric grids could support powerful alignment among business, industry associations, governments, multilateral development banks, and philanthropies with diverse needs and objectives. Developing a common agenda and playbook to accelerate electrification that can be adapted to different contexts and stakeholder needs has the potential to improve coordination and decision effectiveness. The grid is inherently bound by a country or region's borders, helping to elevate the role of national sovereignty and decision authority to shape some system elements in ways that could help to neutralize any opposition to change. At the same time, it allows for flexibility for some governments with climate commitments to move rapidly ahead with the deployment of clean and renewable energy, while reaping security and other non-climate environmental benefits. Public, or public-private, investment in stronger, more responsive infrastructure will make it easier and less expensive to add new generation, integrate distributed energy resources, and consistently meet demand.

5.2 Produce Locally to Improve Relations and Learn

Concern over losing ground in the global clean technology race and facing supply chain disruptions are now more widely cited than cost as a reason not to purchase clean technologies from overseas, and especially from China. These fears are particularly salient in discussions in the European Union and the United States. These concerns set up a tradeoff between security and access to technologies produced in China, which often represent the lowest cost for performance. Concerns center on dependency and mutual trust. Realizing the worst fears of buyers would be a nightmare for overseas suppliers; over time, it would erode business competitiveness and license to operate. Higher trade barriers today are a blunt response to concerns about dependencies; encouraging partnerships with lead developers that involve domestic investment and manufacturing with local workforces is one strategy for allaying concerns. Examples here are Jinko Solar producing solar PV and energy storage in Florida, the Ford-CATL partnership producing EV batteries in Michigan, Gotian producing EV batteries in Illinois and California, and BYD opening a new EV and battery manufacturing plant in Hyderabad, India.

Encouraging or requiring physical production within a country or the formation of a partnership, alliance, or joint venture (JV) with a domestic producer increases the stakes in ways that offer opportunities to mitigate conflict and increase mutual benefit. It can also encourage learning locally and knowledge transfer, much as China's early requirement of JV formation with foreign automotive companies entering the market was intended to do. As some countries struggle with questions of whether to allow imported EVs from China into domestic markets, they can look to this earlier playbook for guidance, recognizing that learning from and building on China's successes may be a viable path forward. While developers may forgo some economies of scale by locating outside of China, they can select locations for other benefits, such as workforce readiness or proximity to customers.

Such a strategy still works in a world with tariffs, because tariffs do not apply to domestic production. In many of China's target export markets, production by companies headquartered in China is already taking place, and this trend may be accelerated by the introduction of tariffs in some countries. The collaboration between CATL and Ford to develop battery production at Ford's BlueOval Battery park in Michigan is expected to begin production in 2026 (Shepardson 2025). CATL is licensing its battery production technology to Ford. So far, the project is still considered eligible for tax credits and funding has not been withdrawn or cancelled (Shepardson 2025). If these investments, and the institutions that scrutinize them, can build in appropriate reporting and safeguards that are not overly onerous while recognizing the potential benefits, not just to reduce cost of production in the near term but accelerate learning in the long term, valuable experience and trust will accumulate and may limit security concerns as a detractor in future rounds of climate policymaking.

5.3 Expand Low-Cost Project Financing

Lowering the barriers to financing for projects aligned with long-term decarbonization goals could help to counter the effects of high interest rates in many parts of the world. Programs offering low-interest financing, especially for first-of-a-kind projects, could help to draw investors. Here, multilateral development banks, programs such as the U.S. Greenhouse Gas Reduction Fund, national development banks, climate funds, and export credit agencies will be central to maintaining access to low-risk sources of capital. The cost of capital associated with each category of finance is shown in Table 2 below.

Table 2: Potential sources of financing that could help to offset the cost of capital.

Source of Finance	Typical Cost	Role
Multilateral development bank loans (e.g., World Bank)	1–3%	Concessional capital, derisking
National development banks	2–5%	Long-term, low-rate loans
Climate funds	Grants/low-rate	De-risking, blended finance
Green bonds	3–5% (varies)	Large-scale project finance, investor access
Export credit agencies	2–4%	Equipment finance

Sources: Climate Bonds Initiative (2023); FinDevLab (2023); World Bank (2024b)

Several factors are essential for continued access to and growth of these low-cost financing options. Outsized influence of individual member countries or stakeholders opposed to addressing climate change must be carefully managed, to counter the possibility that domestic shifts in climate agendas undermine global momentum. In addition, the number and variety of programs needs to be expanded over time, especially if high interest rates persist, to attract a greater number of projects. Finally, industries could become powerful forces in coordinating disparate decarbonization efforts, setting expectations, developing frameworks for measuring and benchmarking effort, and communicating the realm of possibility to national governments and global organizations.

Limiting influence of detractors can be managed in several ways. In power generation, aligning investments with climate action may be more straightforward, given that renewable energy is currently among the lowest cost options for generation. Requirements for clean firm power generation or storage to complement variable renewable energy can be met cost effectively with pumped hydro storage, natural gas, or nuclear, which would either support, or at least not detract substantially from, the path to net zero in the near term. Investments in grid infrastructure may be even more likely to garner support. Emphasizing progress over perfection, especially where the political barriers may be lower, may limit opposition and paradoxically lead to greater progress on decarbonization over time. In the industrial sector, expanding EAF production and with it electricity as an energy source for steelmaking will improve market stability for manufacturers of multiple alternative iron sources, including pathways that use natural gas. In the case of DRI, the cost of new capital equipment required to produce DRI with natural gas and hydrogen is essentially the same, with natural gas proposed by many steelmakers as an intermediate step to net zero. It will be important for financing opportunities to cover a broad range of net zero aligned paths.

6. LAYING THE FOUNDATION FOR STRONGER CLIMATE ACTION

The three strategies outlined are just a few examples that emerged in this analysis as aligned with near-term needs while playing an important role in enabling transition in the longer term. Over the past two decades, support for climate action has waxed and waned at the country and corporate level. While recent ups and downs in support for the transition in the U.S. and in some industries (e.g., steel) have drawn attention, they are typical of policy problems that require collective action to solve and for which solutions imply immediate, concentrated costs and distributed, time-delayed benefits. Focusing on an enabling agenda that capitalizes on the peaks and looks across the valleys can provide much-needed continuity in decisions and routines. At the same time, this agenda could help to ease bottlenecks that can emerge during times of rapid progress — high integration costs for renewables, limits to operational flexibility, permitting headaches, and supply chain shocks — and increase the likelihood that ambition will return after a retreat.

Implementing these strategies may be particularly rewarding at the sector level, recognizing the differentiated technology needs and institutional structures present. The role of transnational governance in enabling particularly industrial decarbonization is currently underdeveloped, with no cohesive sectoral strategy or coordinating mechanism (Oberthür *et al*. 2021). Coalitions of producers have specialized knowledge about the cost and effort required to implement specific technologies or design technologies aligned with deep decarbonization. Many producers already have road maps in place to reach net zero, but implementing them will require de-risking many of the technologies involved. Industries could benefit from alignment on targets, submit proposals for first-of-a-kind demonstrations with large anticipated spillovers, and communicate plans and needs to governments. At the same time, building enabling agendas within institutions of macroeconomic, industrial and trade, and national security policymaking can dovetail with and amplify sectoral approaches.

This paper has developed a case for advancing decarbonization by focusing on cultivating complementary initiatives at the intersection of decarbonization and broader economic goals. The mix of strategies is likely to vary across countries, given diverse public and private sector priorities. For instance, the priorities of improving air quality, strengthening energy security, and promoting industrial upgrading were aligned in the case of China's investment in EVs. Similarly, improving grid operations improves readiness to harness AI and its potential contribution to the economy, while facilitating integration of variable renewable energy sources. For many developing countries, improving energy access and affordability is aligned with deployment of clean energy, but both will benefit from grid investment. Such alignment may be especially powerful as decarbonization faces new headwinds. The strategies outlined here, with appropriate and comprehensive policy support, could help to ensure enablers of decarbonization are durably integrated into national and global economic planning, public policy, and business strategy, with more labels than climate alone.

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Harvard Project on Climate Agreements

79 John F. Kennedy Street
Cambridge, Massachusetts 02138, USA

+1 617 496 8054
www.hks.harvard.edu/hpca

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