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Research Team:

Riandy Laksono
Vrije Universiteit Amsterdam, The Netherlands
Centre for Strategic and International Studies, Indonesia

Via Azlia Widyadi
Centre for Strategic and International Studies, Indonesia

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Green industrial policy in a fragmented world: a view from the Global South

Riandy Laksono[a,b*] and Via Azlia Widyadi[b]

[a]Vrije Universiteit Amsterdam, The Netherlands
[b]Centre for Strategic and International Studies, Indonesia

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Abstract

Green industrialization can be an effective climate change mitigation strategy, and countries can leverage a broad array of green industrial policy (GIP) instruments to promote it. But, in light of current global trade and geopolitical realities, what specific kind of green industrial policy remains feasible for the Global South to pursue? We note a growing consensus in the literature that the uncertain geopolitical climate is reshaping global supply chains and, in the process, creating new strategic opportunities for bystanders, such as the Global South, including in low-carbon sectors. However, the rise of inward-looking green industrial policies in large economies and China's dominance in the global clean-tech supply chain create a new set of external constraints on latecomer green-industrializers. Against this backdrop, we argue that a more realistic GIP approach for the Global South nations must strike the right balance between the short-term imperative of attracting relocating supply chains and the longer-term objective of developing productive capabilities in more complex clean-tech and greener products. Additionally, as China maintains a strong grip across every segment of the low-carbon technology market, the Global South may need to bolster its own domestic renewable energy demand as a catalyst for green industrialization, prompting a reevaluation of green industrial policy beyond China's export model. Our review of Indonesia's GIP model indicates that crafting effective policies and institutions for green industries is challenging, and that inadequate renewable energy deployment can constrain the growth of local green manufacturers. We further contend that a reformed international economic order should allow greater scope for green industrial policy, while being carefully designed to avoid intensifying trade tensions.

JEL codes: L52, Q58, F13, F52, O14
Keywords: Green industrial policy, low-carbon technologies, Geopolitics, supply chain reallocation, Global South, Indonesia

*Corresponding author. Contact information: r.l.edy@vu.nl and riandy.laksono@csis.or.id. We thank Hasran for excellent research assistance. We are also grateful to Praveena Bandara of Boston University for sharing the green industrial policy dataset for Southeast Asian countries. This paper is made possible through funding from the Climate Works Foundation and the Open Society Foundation.

1 Introduction

Efforts to combat climate change are fueling global demand for low-carbon technologies (LCTs) and products. Concurrently, governments are implementing strict regulations to push carbon-intensive industries toward decarbonization, especially at production points where environmental costs are insufficiently internalized and regulatory oversight is lenient. Measures like border carbon adjustment (BCA), which taxes imports based on embedded emissions, and the EU's Deforestation Regulation (EUDR), which limits market access for products linked to deforestation, exemplify this shift. While these developments impose adjustment costs as firms overhaul operations, they also open new growth opportunities within expanding low-carbon supply chains.

To transition into a low-carbon economy and generate associated innovations on the scale needed to deliver both social and climate benefits, a more interventionist approach has its merit, as market alone will likely fail to produce these technologies optimally (Harrison et al., 2017; Rodrik, 2015). This is often referred to as "green industrial policy". Generally, this consists mainly of two elements: (i) building productive capabilities in new low-carbon technology (LCT) sectors, and (ii) promoting the adoption of cleaner production methods to decarbonize existing supply chains (Harrison et al., 2017). But in an increasingly fragmented world, what specific kind of green industrial policies remain feasible?

This paper asks what forms of green industrial policy that countries in the Global South can realistically pursue in the context of a rapidly evolving global environment. Our focus is on countries that do not belong to the main geopolitically competing blocs, but instead function as connector economies linking these rival powers (Gopinath et al., 2025). We also assess green industrial policy framework in Indonesia—one of the connector economies in Southeast Asia—to extract some lessons that could be useful to chart a more effective green industrialization model for the Global South given the new global context.

Drawing on recent studies of supply chain shifts, we note a growing consensus that geopolitical rivalry, especially between the US and China, is creating new opportunities for bystanders as firms reorganize supply chains to avoid escalating tensions (Alfaro & Chor, 2023; Cheng et al., 2025; Fajgelbaum et al., 2024). However, this emerging opportunity is met with two countervailing factors. First, we show that China is poised to retain a dominant position across almost every segment of the LCT supply chain, including less complex products. Second, the deployment of green industrial policies has been steadily intensifying, especially among advanced economies (Bandara et al., 2025). This means that although global demand for green industries is rising, Global South nations will find it increasingly difficult to break into the global low-carbon supply chain as they face not only China's dominance but also an increasingly inward-looking global market.

We argue that, in this global economic landscape, a more feasible green industrial policy model for the Global South must strike the right balance between the short-term imperative of attracting relocating supply chains from global firms, driven by their de-risking strategies, and the longer-term objective of developing stronger productive capabilities to manufacture more complex LCTs and greener products. However, due to changing global landscape, many Global South nations will find export-led green industrialization model, a-la China (Liu & Goldstein, 2013), increasingly hard to emulate. This should compel the Global South nations to look into their own domestic renewable energy demand as a catalyst for green industrialization.

A growing body of literature has discussed general principles and best practice around green industrial policies (Hauge & Hickel, 2025; Lütkenhorst et al., 2014; Rodrik, 2015), including for the case of emerging economies (Harrison et al., 2017; Larsen, 2025; Liu & Goldstein, 2013). However, these studies often miss recent shifts in the global economy and the new constraints and opportunities that these create for countries that want to pursue green industrialization. At the other end of the spectrum, when the latest global context is embedded into industrial policy discussion, it typically revolves around the priorities and innovation agendas of advanced economies, which are narrowly framed through security concerns and great-power rivalry lens (Andrews-Speed & Meidan, 2024; Mazzocco, 2024, 2025). Our paper aims to bridge this gap by examining how the evolving global context shapes the set of realistic green industrial policy options available to Global South economies, emphasizing their potential role as "connector economies" rather than as competing major powers.

The paper proceeds as follows. Section 2 lays conceptual foundation for green industrial policy, while Section 3 discusses how green industrialization agenda and the feasible policy instruments to advance it are increasingly shaped by current global economic dynamics. Then, we examine green industrial policies in Indonesia to derive some policy lessons for green industrialization strategy. Lastly, we conclude the paper by offering a view on what a more effective green industrialization model should look like for the Global South, given the new global landscape.

2 Industrial policy for the green goods

Scope and rationale Green industrial policies generally involve any government interventions aimed at supporting the development of low-carbon sectors and modes of production (Harrison et al., 2017; Rodrik, 2015). By this definition, green industry should not be only limited to cover (i) innovative clean technologies that allow for a greater use of low-carbon energy sources, such as electric vehicles (EV), battery, wind turbine, and solar panel, but it can also cover (ii) traditional industries, including the hard-to-abate ones, that are produced using lower-carbon or generally more environmentally friendly methods, like green steel and sustainable coffee and palm oil.

What distinguishes green industrial policy from climate-focused policies is that the former's ultimate goal is to optimize industrial competitiveness and achieve economic development during the decarbonization process. In contrast, a pure climate policy is typically concerned only with reducing carbon emissions and is often designed to favor no particular sector (Meckling, 2021).[1] This is why a pure taxation on dirty energy, such as through carbon pricing mechanism, is not considered a green industrial policy as it, by definition, must weigh down on the competitiveness of any carbon-intensive sectors, at least in the short-run before innovation kicks in, while a feed-in-tariff that guarantees a fixed price for renewable energy so that it can maintain competitive parity with fossil-based energy is very much among the green industrial policy arsenal (Juhász & Lane, 2024; Meckling, 2021). In this sense, economy-wide carbon pricing and other decarbonization strategies are best understood as instruments in the climate policy realm, but they are analytically distinct from green industrial policy. Meckling (2021) proposes a useful rule of thumb to distinguish the two, by which green industrial policy is associated more with the use of public investment, either through the form of state subsidies or other fiscal support, while climate policy uses more of a pricing system, one way or another, to control emissions. Hence, to foster the competitiveness of green industries, policymakers should design an appropriate green industrial policy package, or at least combine climate policies with compensatory industrial support, to offset the competitive disadvantage inherent in climate policies.

[1]For example, a climate-focused policy may impose regulations that discourage firms from emitting carbon, even at the expense of industrial competitiveness. By contrast, green industrial policy promotes decarbonization by lowering the cost of solar energy through large-scale manufacturing and deployment of solar technologies. As these policies enhance the competitiveness of solar energy, they can advance decarbonization without necessarily undermining industrial competitiveness.

Green industrial policies tackle market failures associated with producing clean technologies and cleaner methods of production in two simultaneous ways. First, through a targeted policy intervention, it can incentivize the production of innovative LCT otherwise undersupplied by the market, as the benefit of new technology typically spills over to other actors in the economy, leaving the original inventor unable to reap the full monetary benefit (Rodrik, 2015). Second, policy measures to support green industries can help level the playing field against carbon-intensive industries, which are often mispriced in the economy. The artificial competitive advantage of the "dirty" sectors might occur due to the subsidy on fossil-based energy or the failure to internalize the costs of climate change within firms' cost structures (Rodrik, 2015).[2]

The efficiency debate Unlike climate policies that reduce emissions directly, green industrial policies advance climate objectives more indirectly by making green technologies and cleaner production methods more ubiquitous and competitive within the economic system. This indirect approach is often viewed as less economically efficient than straightforward carbon pricing, yet pure carbon pricing tends to be more politically unpalatable (Furceri et al., 2023; Juhász & Lane, 2024). The costs of carbon pricing are immediately visible, whereas its climate benefits materialize only in the longer run. By contrast, the benefits of green industrial policies, in terms of job creation and value added, are more immediate, while the economic costs of supporting these industries can be spread over a longer horizon and more broadly across the public (Juhász & Lane, 2024). Owing to their potential to generate new green growth opportunities, green industrial policies can even be viewed as a platform for building coalitions in support of a more ambitious climate agenda in the future by creating new constituencies that stand to benefit from it (Meckling et al., 2015).

Given the urgency of addressing climate change, a multifaceted approach is therefore increasingly compelling: one that does not rely solely on the most efficient price-based instruments, but also incorporates second-best tools, such as green industrial policy, in a complementary role (Blanchard et al., 2023; Juhász & Lane, 2024). In line with this view, Acemoglu et al. (2016) show that the optimal policy path for controlling emissions combines carbon pricing with targeted subsidies to promote the production of LCTs, whereas carbon pricing alone can entail substantial welfare costs. This finding underscores the potentially important role of green industrial policy

[2] The first pertains to the positive externality of knowledge or innovation, while the second relates to the negative externality of climate change.

in tackling climate change, despite its possible inefficiencies.

Our paper proceeds from a similar premise: green industrial policy can enable the Global South to leverage decarbonization objectives for economic development, although it may not be the first-best option to cut emissions in a narrow economic sense.

Instruments and Effectiveness Bandara et al. (2025) outlines six broad categories of green industrial policy that have been devised by policymakers around the world: (i) Export and import policy instruments, (ii) foreign investment policy, (iii) localization policy, (iv) public procurement policy, (v) subsidies and state aid, and (vi) trade defense and other instruments (see Table 1 for a more complete list of instruments within each category). These measures are all similarly designed to enhance domestic capacity and strengthen the competitiveness of green industries. By definition, this involves some degree of preferential treatment for local producers over foreign competitors, though the extent of such discrimination varies considerably across different policy tools.

Table 1: Green industrial policy taxonomy

Policy categories	**Policy instruments**
Export and import policy instruments	• Export bans, licensing requirements, quotas, subsidies, tariffs • Import bans, licensing requirements, quotas, monitoring, tariffs • Internal taxation of imports • Trade finance and trade payment measures
Foreign investment policy	• FDI entry and ownership (including joint venture requirements) • FDI financial incentives • FDI treatment and operations
Localization policy	• Local labor incentive • Local content incentives and requirements
Public procurement policy	• Public procurement access, localization, and other
Subsidies and state aid	• Financial assistance in a foreign market • Financial and in-kind grants • State loans • Interest payment or production subsidy • Tax or social insurance relief
Trade defense and other instruments	• Anti-dumping, countervailing duties, and safeguards • Technical barriers to trade

Source: adopted from Bandara et al. (2025).

As in the broader industrial policy literature, rigorous causal evidence on the effectiveness of these green industrial policy instruments remains in the early stage of development. Nonetheless, qualitative studies of green industrial policy implementation in various emerging economies suggest that policy effectiveness depends critically on how closely instruments are matched to the underlying market failures (Harrison et al., 2017). In particular, policy measures that do not directly help ameliorate either spillover or environmental externalities are more likely to fail to achieve their intended objectives.

Local content policy is a case in point (Harrison et al., 2017). Although increasingly popular as a green industrial policy tool, particularly among lower-income nations in the Global South (Bandara et al., 2025), local content regulation in renewable energy technologies, such as solar panels and wind turbines, does not address the low-innovation problem associated with knowledge externality, nor does it help lift their competitive parity with mispriced carbon-intensive technologies. If at all, it may even raise the price of renewable energy as local producers of those clean technologies have to use relatively more inefficient local components (Bazilian et al., 2020; Probst et al., 2020). This will, in turn, slow down the energy transition process and is counterproductive to the overall climate goals. The cross-country evidence by Scheifele et al. (2022) further suggests that local content policies have rarely led to increased export competitiveness in solar and wind products, contrary to the core objective of green industrial policy, which is to strengthen industrial competitiveness in clean technology to counteract artificially cheap dirty technology. A more targeted subsidy to clean technology production, in this context, can be a much more direct policy instrument, as it could help solve both market failure problems, albeit still a second-best alternative to carbon price system in cutting down emission.

This paper will discuss what type of green industrial policy instruments are likely to be effective in driving green industrial development, given the emerging opportunities and constraints provided by the contemporary global economic landscape.

3 How evolving global landscape will shape green industrialization prospect in the Global South

The range of tools the government could implement to transform economic sectors depends not only on the type of market failures that need solving but also on the context in which policymakers operate. Juhász and Lane (2024) showed how politics can constrain the range of policy options that the government could devise in greening the industry, in that policymakers often end up not choosing the first-best solution, such as carbon pricing policy, and instead resort to less direct intervention through local content requirements or production subsidies. This section considers the rapidly changing global landscape as an additional context that can shape the prospects for green industrialization and, in turn, the set of viable green industrial policy instruments available to aspiring latecomer countries in the Global South, particularly those seeking to catch up with early green industrializers such as China.

3.1 The great supply chain reallocation

One of the major global economic shocks that may shape industrialization prospects for the Global South economies, including in green industries, is the substantial reshuffling of global trade and investment patterns driven by heightened geopolitical tensions. The US-China trade tension and broader power rivalry, the war in Ukraine, and the need to have a more resilient and diversified supply chain have all played their part in altering global trade and production networks, in which firms' sourcing and investment decisions are becoming gradually structured around axes of geopolitical proximity rather than on pure economic efficiency grounds. Yet, this has created a tailwind for economies outside the main rival blocs, as businesses seek new connections that can link competing powers.

Trade reallocation The US-China trade war, which started in 2018, has seen China's much-reduced role in the US's supply chain (Alfaro & Chor, 2023; Freund et al., 2024; Gopinath et al., 2025). The share of China in US goods imports fell from 22 percent in 2017 to 14 percent in 2023, with a clear market share loss in products heavily organized around global value chain (GVC) networks, such as auto parts, electronics, and semiconductors (Alfaro & Chor, 2023; Gopinath et al., 2025). This trend likely reflects the worsening of a broader geopolitical climate, as trade and investment between groups of countries belonging to different geopolitical alliances (Western and Eastern blocs) have also shrunk by 11 and 12 percent, respectively, suggesting that the decoupling has gone beyond US-China's rivalry issues alone. Despite all this shrinking trade relationship between groups of countries, the share of global trade to GDP remains stable, even climbing to a new record in 2022 (Freund et al., 2024; Gopinath et al., 2025).

Behind this stable trade share lies the "great reallocation" in the supply chain unseen in the last few decades, where developing countries in Asia and those bordering the US, particularly Mexico, emerge as growing nodes connecting the competing powers. Vietnam has been the largest beneficiary of China's loss of market share in the US, replacing almost half of market share that China has lost since the start of the trade war episode. Many of these trade reallocations to Vietnam are occurring in the more upstream stage of the US's supply chain, like auto parts, electronic parts and components, as well as semiconductors (Alfaro & Chor, 2023). Trade also shifted to other lower-income Asian economies, such as India, Thailand, Cambodia, and Indonesia, but to a much smaller extent (Freund et al., 2024). Mexico, on the other hand, albeit not experiencing as great trade reallocation as Vietnam did, prevails as an important interlocutor for a more downstream stage of production for the US market, particularly the final assembly of motor vehicles, indicating evidence of "nearshoring" (Alfaro & Chor, 2023). Fajgelbaum et al. (2024) further finds that the trade war did not simply take away exports from the rest of the world, but, instead, creates net trade opportunities for the bystanders, as exports from connector economies in products targeted by US-China tariffs not only increase towards the US market but also to all other nations.

Beyond rerouting This "great reallocation" represents something more than just evasive trade rerouting, where exporters evade U.S. tariffs on China by redirecting goods through third countries—a form of illegal transshipment that U.S. officials say has increased since the first tariffs in 2018 (The White House, 2025). Rather, it involves legitimate production relocation and scaling up of industrial capacity in the non-aligned connector economies of the Global South, while remaining deeply linked with China-centered supply chains.

Two pieces of evidence corroborate this argument. First, countries that experience the more pronounced increase in their exports to the US market post-2018 are those that receive more of China's greenfield investment (Gopinath et al., 2025). Relatedly, since the onset of Ukraine's war in early 2022, greenfield FDI into the connector economies, especially from China, has increased as much as the within-bloc investment (Cheng et al., 2025). The greenfield FDI between blocs, however, has seen a dramatic drop of around 30 percent. Vietnam, one of the largest recipients of China's investment during this war period, has seen its average number of investment projects from China increase by almost a factor of four relative to the pre-war period. Mexico, Thailand, Malaysia, and Indonesia are also among the beneficiaries of China's growing overseas investment in the connector economies of the Global South. Outward FDI from the US, on the other hand, has been directed more towards India as the US looks for a large, labor-abundant country that can replace China for the assembly of finished manufacturing goods (Cheng et al., 2025).

Investment in low-carbon sectors also follows this general pattern of FDI restructuring. Cheng et al. (2025) finds that since early 2022, clean technology investment in the connector economies has increased much more than in other countries in the control group.[3] The increase in clean-tech FDI in the connector economies is comparable in magnitude to that in the US itself. However, this effect was driven mainly by Inflation Reduction Act (IRA) incentives that subsidize clean technologies using domestically sourced inputs or inputs from US trade agreements' partners, rather than by the broader geopolitical climate, even though the IRA itself was partly designed to strengthen US leadership in the strategic race for dominance in clean technologies against China. Sustainability-related investment in key connector regions, particularly ASEAN, has also been increasing, with member countries such as Singapore, Indonesia, and Vietnam emerging as top destinations amid geoeconomic fragmentation (Liu & Sengstschmid, 2024).

The second piece of evidence examines a more specific case in Vietnam and whether it has been used as a hub for tariff evasion. Building on the findings of Iyoha et al. (2024), the incidence of rerouting Chinese exports through Vietnam has indeed risen in response to the imposition of US tariffs on Chinese goods. However, this mechanism accounts for only a small share of the observed trade expansion: of the total $52.8 billion increase in Vietnam's exports to the US, less than 9 percent can be credibly attributed to rerouting, suggesting that the bulk of the increase reflects a genuine domestic value addition process. These two pieces of evidence suggest that the great supply chain reallocation may present the Global South with real economic development and industrial upgrading opportunities, as multinational firms look for new hubs to reduce risk and link rival great powers, including in the low-carbon sectors.

Domestic preconditions However, the benefits of the great supply chain reallocation tend to concentrate in a few countries with certain preconditions. First, countries that are able to replace China in the US market are those that already have specialization or comparative advantage in tariffed products (Dang et al., 2023; Freund et al., 2024). This helps explain why Vietnam tends to dominate the electronics and parts and components segments, whereas Mexico is increasingly

[3] The clean-tech investment includes projects in the battery supply chain, carbon capture, critical minerals, electric vehicles, hydrogen, lithium, solar photovoltaic technology, waste to energy, and wind power technologies.

a more important player in the US's vehicle markets, as these two countries already have strong comparative advantage in those categories of products even before the trade war period (Alfaro & Chor, 2023).

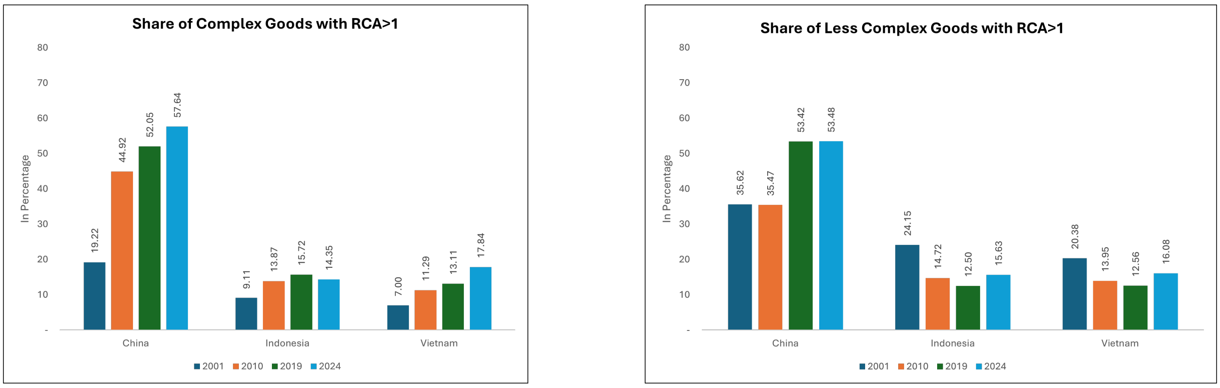
Second, countries that were initially more closely linked with China supply chain tend to experience faster export growth to the US later on (Freund et al., 2024), again rationalizing why Vietnam and other developing countries in the ASEAN region are among the beneficiaries of the trade war, as ASEAN member states are already relatively more integrated with China's supply chain compared to other areas. This means that to replace China's position in the US market, countries need to embrace China's supply chain rather than turning away from it.

Third, the reorganization of the supply chain is transmitted mainly through multinational enterprises (MNEs) that are participating actively in the GVC (Utar et al., 2025). This helps explain why Mexico, with a dynamic presence of MNEs and linkage with its US counterparts, is among the biggest beneficiaries of the US-China trade war. Utar et al. (2025) shows that the increase in exports from Mexico to the US following the 2018-2019 US-China trade war episode comes virtually from the firms that participate in GVC networks, especially foreign MNEs. This suggests that the presence of MNEs can play an essential role in determining whether a country can benefit from supply chain reallocation amid heightened geopolitical tensions.

All of this evidence points to a suggestion that green industrial policy instruments that tend to be inward-looking and discriminating against foreign investment and trade might not be the most effective instrument around, given the great reorganization of the supply chain that is underway at the global level, including in the clean technology sector. Instead, the patterns given by the previous studies suggest that the classical policies that are generally aimed at fostering countries' participation in the GVC, such as through improving investment climate to better attract foreign firms and facilitating linkage with foreign supply chain may turn out to be a more effective policy approach in today's more turbulent times, especially in the context of connector economies among the Global South that do not participate in one of the competing blocs.

3.2 China's dominance in the global LCT supply chain

China's dominance Although China has been at the centre of supply chain reorganization, it has also become a key obstacle for many Global South countries seeking to enter global low-carbon technology production networks. In the early 2000s, China had already dominated the large-scale production of the relatively simple downstream stage of solar PV modules (Liu & Goldstein, 2013). Since then, it has climbed the clean-tech ladder and become a major player in more complex technologies such as electric vehicles and wind turbine components (see Figure 1). As a result, China has become one of the most important actors—if not the most important—in global low-carbon technology, helping to accelerate the world's transition to cleaner energy sources.



((a)) ((b))

Figure 1: Capability in green products

Notes: The definition of green goods is taken from three main sources: (i) Greenplexity platform of the Observatory of Economic Complexity, which combines various Harmonized Codes (HS) under one clean-tech supply chain, (ii) OECD environmental goods list, and (iii) APEC environmental goods list. Product complexity index (PCI) > 0 indicate more complex goods, while PCI < 0 indicates less complex goods. RCA suggests whether or not a country has a comparative advantage in producing a particular product, relative to the global export pattern.
Source: Authors' calculation based on WITS database.

However, as China acquires new productive capabilities in the more complex green sectors, it does not relinquish its ability and market share among the less complex green goods. If anything, China's grip in the less complex green sectors has become even stronger, where it possesses a comparative advantage in more than half of the green products considered as less complex in 2024, compared to only around one-third in 2010. This could narrow the options for lower-income nations in the Global South to pursue green industrialization through an export model, as they will likely have to start from less complex LCT products and work their way up, but will find it difficult to challenge China's dominance in that market segment. Additionally, the Chinese dominance in clean technologies may also put domestic industrialization goals at odds with climate objective, as nations may increase reliance upon China's competitive clean technologies in attaining decarbonization goals (Matsuo & Schmidt, 2019).

Ideally, economies in the Global South could benefit from China's dominance by inserting themselves into the China-centered supply chain in low-carbon technology. This could either involve supplying materials, parts, and components to China's lead firm or serving as the assembly base for a Chinese brand. These two strategies, however, increasingly seem rather unlikely. One of the biggest reasons for that skepticism is that China looks set to become the dominant player across all stages of the supply chain, with the exception of minerals used in renewable energy technology production, which still mainly come from mineral-rich lower-middle-income countries (see Figure 2 and 3). In two key renewable energy technologies, batteries and solar panels, China's role is not only dominant in the more downstream final-goods exports but is also becoming ever more important in the export of industrial raw materials, parts, and components, which are among the more upstream stages in these LCT supply chains.

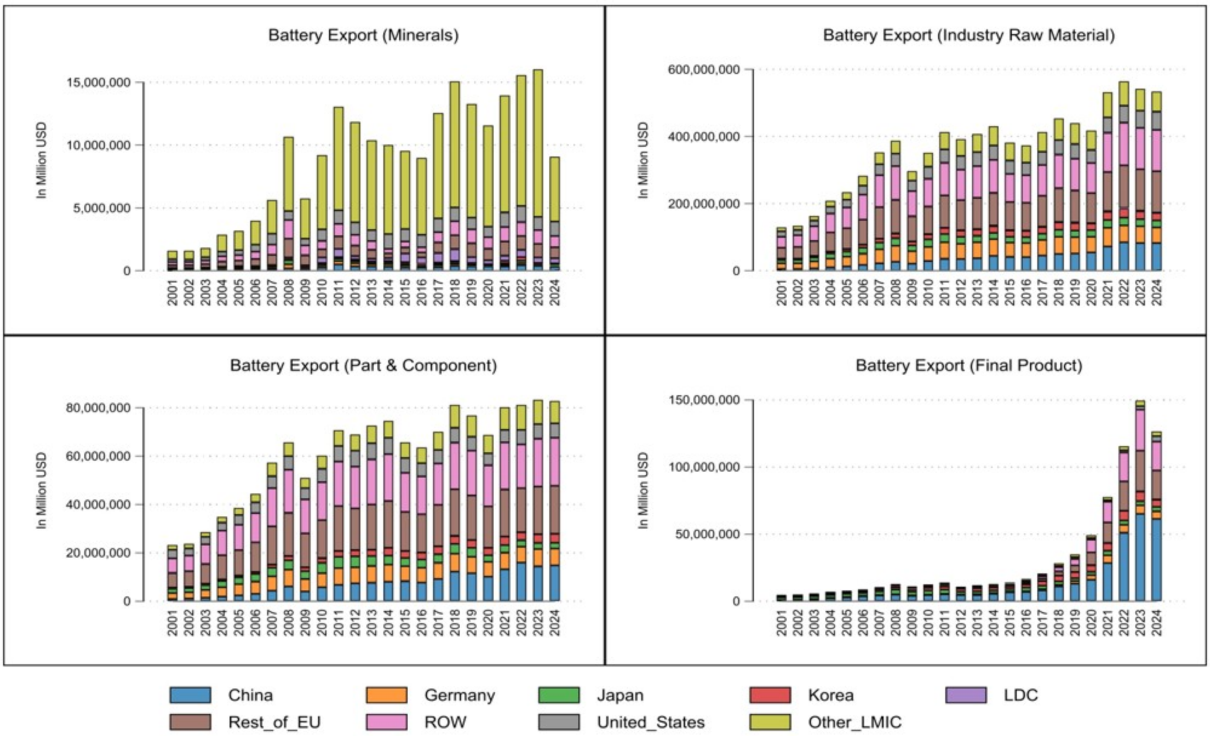


Figure 2: Battery export, various supply chain stages

Notes: We borrow battery supply chain definition from Greenplexity. We then delineate that supply chain into four different parts, suggesting their different role in the clean-tech production process: (i) minerals, (ii) industrial raw materials, (iii) parts and components, and final products. We follow broad economic category (BEC) to identify parts and components, while minerals can be straightforwardly detected from HS classification. Final products are taken from the definition used by Mazzocco (2024), where it uses HS code 850760 from 2022 onwards, and 850780 between 2001–2021. Industry raw materials are then simply the remaining HS codes not classified under any of the groups above.
Source: Authors' calculation based on WITS database.

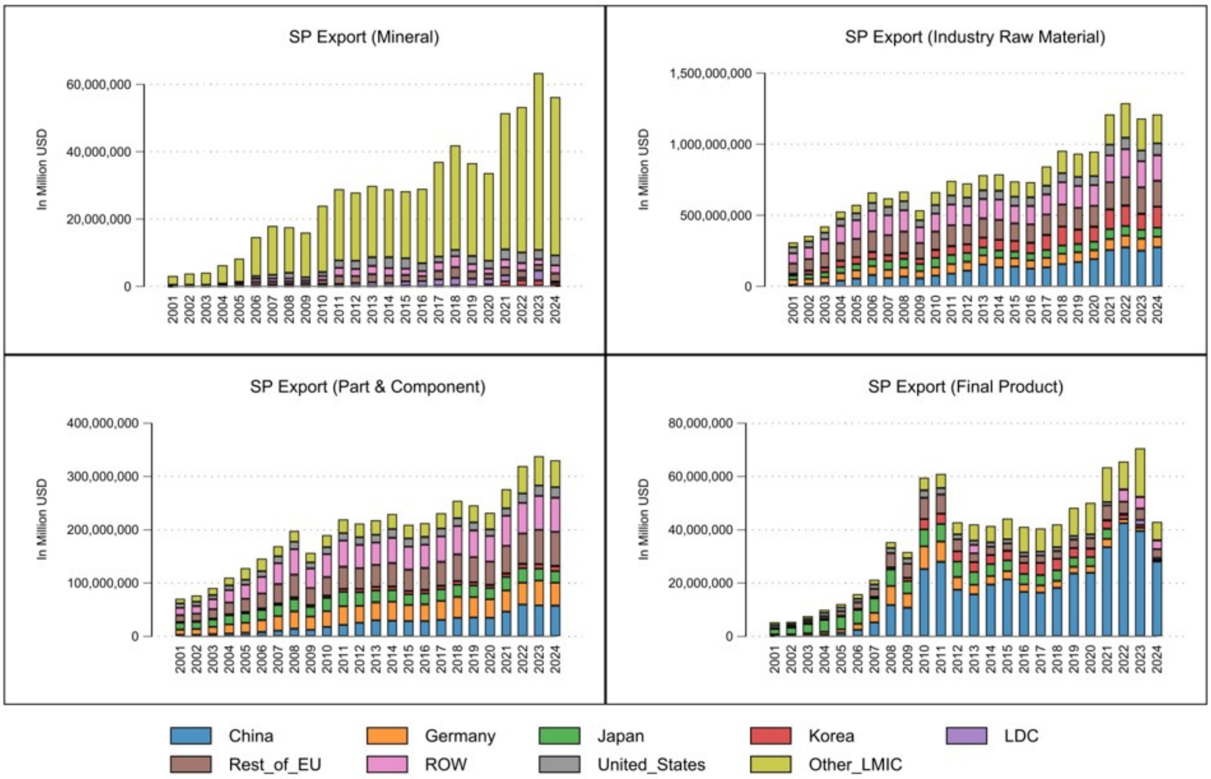


Figure 3: Solar PV export, various supply chain stages

Notes: We borrow solar PV supply chain definition from Greenplexity. We then delineate that supply chain into four different parts, suggesting their different role in the clean-tech production process: (i) minerals, (ii) industrial raw materials, (iii) parts and components, and final products. We follow broad economic category (BEC) to identify parts and components, while minerals can be straightforwardly detected from HS classification. Final products are taken from the definition used by Mazzocco (2024), where it uses HS code 854143 from 2022 onwards and 854140 between 2001–2021. Industry raw materials are then simply the remaining HS codes not classified under any of the groups above.
Source: Authors' calculation based on WITS database.

A second, closely related reason why it will be challenging to participate in China-centered LCT supply chains at the current pace is that, although China's outward investment in green industries has begun to increase—over 75 percent of which is located in countries of the global South(Xue & Larsen, 2025) and has indeed provided a boost to countries that meet certain preconditions for success in the ongoing supply chain reorganization, such as Vietnam—considerable uncertainty remains as to whether China will actually relinquish parts of LCT value chains. This is evident in China's leadership statement, which underscores the importance of preserving manufacturing as a core pillar of the economy across all stages of production to strengthen and sustain the resilience of the domestic supply chain (Central Committee of the Communist Party of China, 2025). Consistent with this, International Energy Agency (2024) projects that China

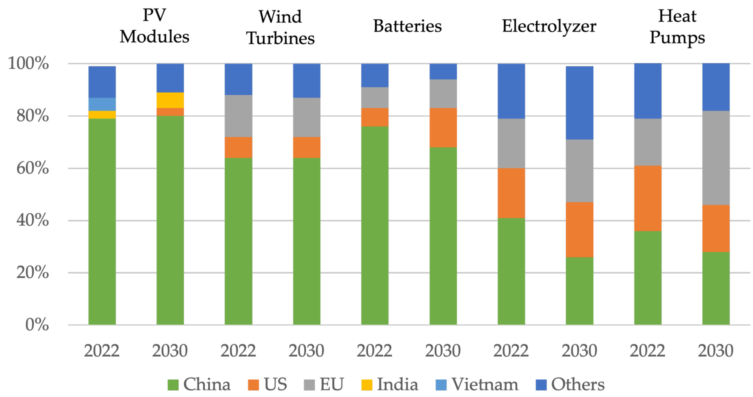


Figure 4: Clean Technology Production Capacity Share (IEA, 2023)

will continue to dominate the LCT market by 2030 (see Figure 4).

A third constraint on wider involvement in China-focused LCT supply chains is that, when China does relocate portions of LCT manufacturing abroad, this offshoring tends to be centered in the most capital- and energy-intensive stages, notably mineral refining and the production of battery-related materials. Evidence from Xue and Larsen (2025) suggests that close to one-third of Chinese firms' overseas investments in clean technology, or around $62 billion, are directed toward battery-materials processing activities. The bulk of this investment went to the ASEAN region, particularly Indonesia, which has abundant reserves of nickel that are used for batteries. Thus, even as opportunities to participate in low-carbon industrial supply chains expand, many Global South countries—particularly those rich in energy-transition minerals—may still find themselves confined to exporting raw minerals or, at best (with some luck in the form of Chinese investment), processed minerals. Yet these activities are typically more capital- and energy-intensive, and they do not generate substantial employment (Bosker et al., 2025). For other countries that lack significant mineral endowments, the scope for meaningful participation is likely to be even more constrained.

China has indeed made substantial outward investments in solar panel manufacturing across the Global South, particularly in ASEAN and MENA countries. These activities tend to be more downstream and labor-intensive. Yet the scale of solar panel investment (about $57 billion) is overshadowed by China's investment in battery-related sectors—around $111 billion in total—covering both battery-material processing and battery manufacturing (Xue & Larsen, 2025) (see Figure 5). Crucially, the geography of these investments differs. While solar panel production is pushed into Global South locations, most Chinese investment in battery manufac-

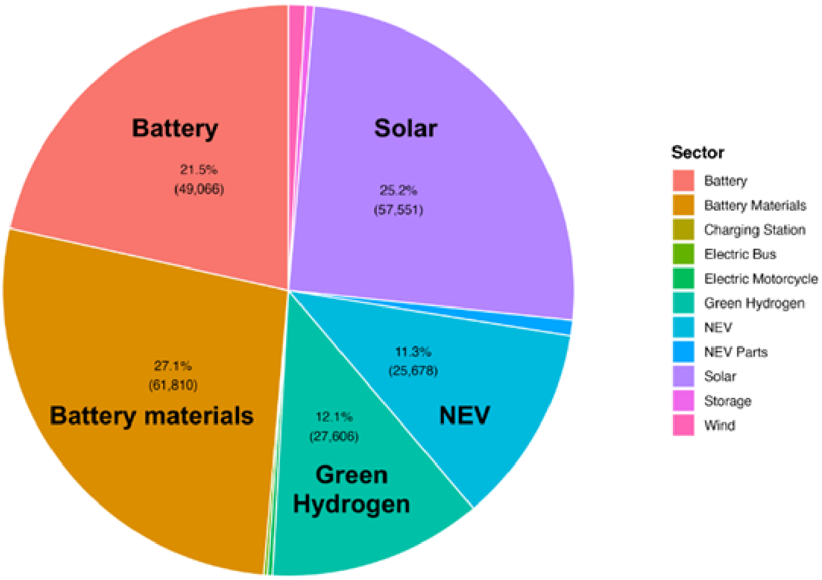


Figure 5: China's outward investment in clean-tech manufacturing, 2013-2025 (million USD)

Source: Taken from Xue and Larsen (2025).

turing is located in Europe. This reflects the need to serve large European markets that Chinese firms can no longer fully access through direct exports, due to increasingly security-driven trade protection in the EU.

Taken together, these patterns indicate that China's outward investment is still shaped primarily by resource-seeking and geopolitical motives, rather than by a genuine, broad-based unbundling of the LCT supply chain. In a classic unbundling process, more labor-intensive stages—such as assembly—would typically migrate to lower-income, low-wage countries as the lead economy advances, which we might expect given China's current position (Baldwin, 2013). Because China now dominates the global clean-tech industry, the extent to which other countries, including those in the Global South, develop similar productive capabilities will depend in part on how rapidly China transfers the knowledge typically embedded in direct investment.

The concern about China's dominance is less about the notion of static comparative advantage, which holds that even a country with an absolute advantage in all traded goods can still conduct mutually beneficial trade with other trading partners. In fact, studies overwhelmingly suggest that the world benefits substantially from more integration with a highly competitive China (Caliendo et al., 2019; di Giovanni et al., 2014; Fan et al., 2021). Rather, the issue has more to do with a dynamic comparative advantage perspective: China's control over all stages of key supply chains narrows the opportunities available to its trading partners to upgrade and diversify their productive capabilities (Atkin et al., 2025). As a result, lower-income countries may remain stuck on the lower rungs of the development ladder, since China's continued dominance and reluctance to cede segments of the LCT supply chains contribute to restricting their ability to develop more complex and greener production structures and advance economically.

The relevance of export-led model China's early emergence in the global low-carbon technology market, especially for solar PV, was propelled, for the most part, by the rising use of renewable energy for electricity generation in advanced countries in the 2000s, notably the EU. During that period, Germany implemented a generous feed-in-tariff policy which stimulated large-scale installation of solar panels. This policy was soon also adopted by other European countries, such as Spain and Italy, resulting in a substantial increase in demand for China's solar PV exports (Liu & Goldstein, 2013) (see Figure 3 and 6). China's domestic solar energy deployment, on the other hand, plays very little, if not negligible, role in driving those export values. This is because in the early to mid 2000s, China's share of solar energy in its electricity generation was essentially non-existent, while its solar PV exports was already dominating global market in 2008, and even overtook Germany and Japan, once global market leaders in that product (see Figure 3 and 6). Relying on China's domestic solar energy demand alone would not have been possible in fueling such growth in its solar panel exports.

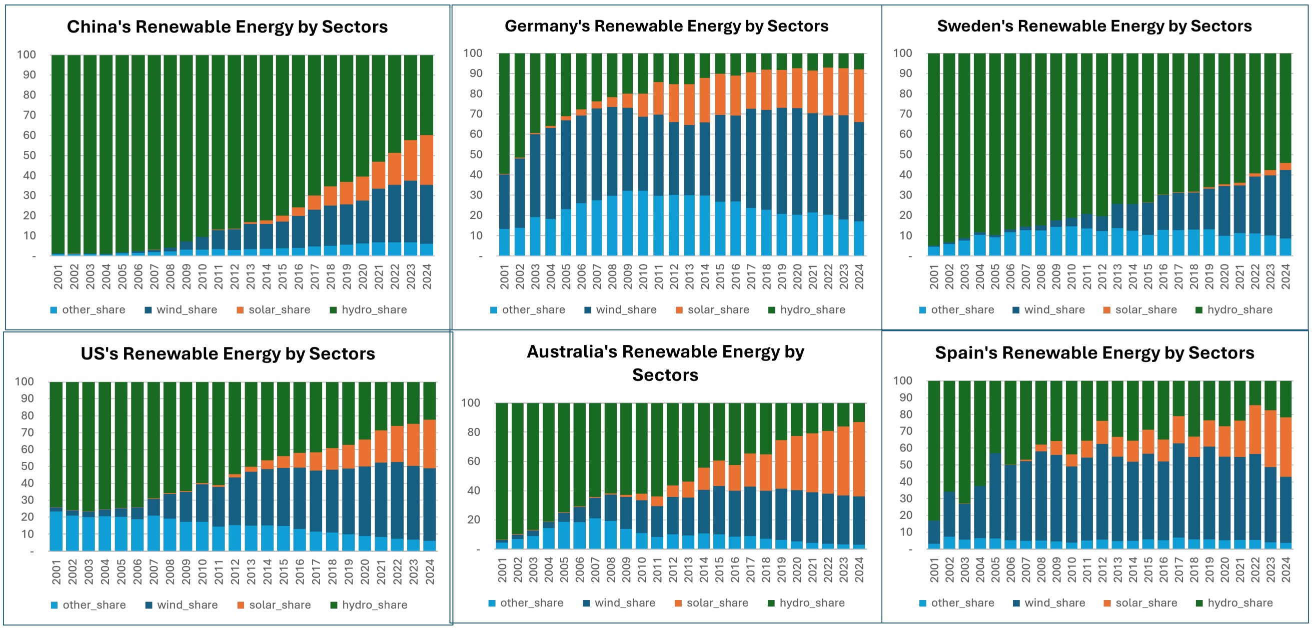


Figure 6: Share of renewable electricity generation by sources

Source: Authors' calculation based on Our World in Data dataset.

It has been argued that the role of state subsidy is rather limited here, as China's export is mostly concentrated on the more downstream solar PV modules, which are more labor-intensive and do not require high technological capability to produce (Liu & Goldstein, 2013). These characteristics of the solar PV module are considered to be relatively aligned with China's pattern of industrial specialization then, thus making subsidy rather redundant. The dovetailing between China's supply-side scale and policy-induced demand in the EU has been the primary driver of the rapid reduction in solar PV costs since the early 2000s (Kavlak et al., 2018).

But is export-led model the only feasible route towards green industrialization? History of China's wind turbine generation system suggests otherwise: strong domestic demand in renewable energy can be a promising catalyst for green industrialization.

Unlike solar PV, wind turbines in China have a much robust demand domestically, where the uptake of wind energy in China's energy system has started much earlier than in solar energy (see Figure 6). Public procurement that favors local wind energy generation, coupled with price guarantees and tax breaks, has provided China with a steady stream of consistent demand for wind energy, which has attracted a large wave of FDI into wind turbine manufacturing (Liu & Goldstein, 2013). This, however, does not quickly translate into strong export performance as the wind turbine industry was still dominated by the European countries, such as Denmark and Germany, during the 2010s and even 2020s. However, this robust domestic demand for wind energy has allowed gradual technological learning and catch-up with foreign producers, and China's wind turbine exports recently show a substantial upward trend, although still in a relatively low base (Liu & Goldstein, 2013) (see Figure 7). The difference in technological capability prerequisite is the key differentiating factor here, where in solar panels, China's producers can more easily acquire turn-key production facilities and necessary capital goods to leverage domestic manufacturing capabilities, while in the wind turbine sector, the technological barriers were rather prohibitive (Liu & Goldstein, 2013). As a result, in the wind turbine industry, this higher technological threshold, combined with the dominance of European producers in the global market, has compelled China to prioritize the development of its domestic wind energy market as an essential stepping stone toward eventually building robust global competitiveness.

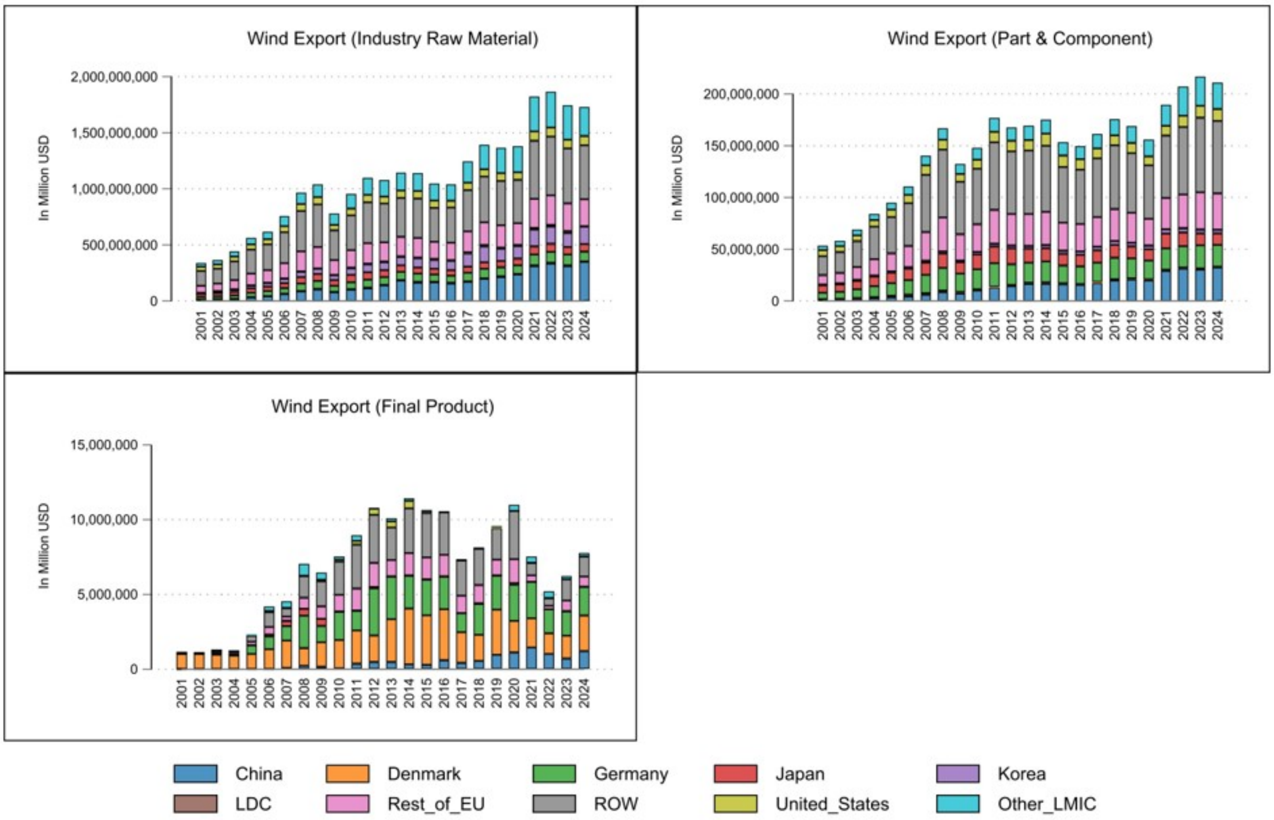


Figure 7: Wind Turbine export, various supply chain stages

Notes: We borrow wind turbine supply chain definition from Greenplexity. We then delineate that supply chain into four different parts, suggesting their different role in the clean-tech production process: (i) minerals, (ii) industrial raw materials, (iii) parts and components, and final products. We follow broad economic category (BEC) to identify parts and components, while minerals can be straightforwardly detected from HS classification. Final products are taken from the definition used by Mazzocco (2024), where it uses HS code 850231. Industry raw materials are then simply the remaining HS codes not classified under any of the groups above.
Source: Authors' calculation based on WITS database.

3.3 The surge in green industrial policies

GIP landscape The next major force that might prevent the connector nations in the Global South from participating more meaningfully in the low-carbon supply chain is that, around the same period of increased geopolitical tension and the resulting reorganization of the supply chain, the use of industrial policy intervention aimed at promoting the domestic competitiveness of specific sectors has accelerated rapidly (Evenett et al., 2025). The need to mitigate climate change problems has been one of the dominant drivers behind that surge, including, to some extent, the ambition to develop domestic capabilities in the LCT sectors, such as solar panels and wind turbines (Evenett et al., 2025) (see Figure 8).

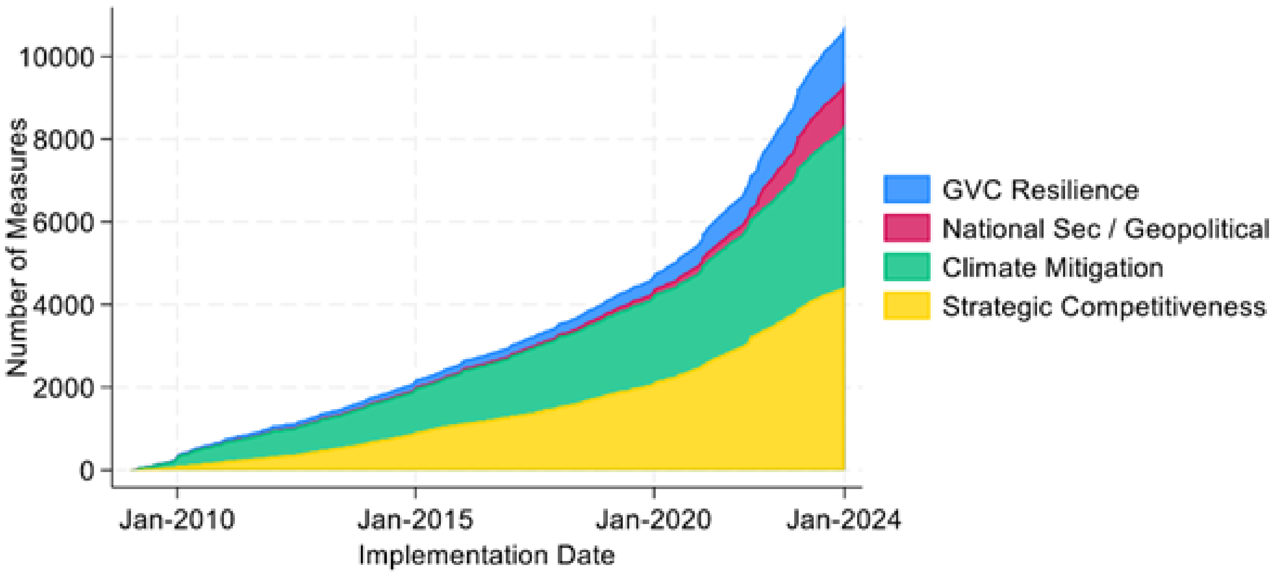


Figure 8: Industrial policy, by motives

Notes: Number corresponds to the cumulative stock of industrial policy measures distinguished by stated policy motivations.
Source: Taken from Evenett et al. (2025).

Bandara et al. (2025) provides a detailed analysis of green industrial policy trends and finds that, in 2023, such measures accounted for approximately 20% of all industrial policies adopted across the countries in the sample, up sharply from just 7% in 2019. Similarly to the general pattern across all types of industrial policies found in Evenett et al. (2025), Bandara et al. (2025) also discovered that the subsidy policy is the most dominant measure used by countries in their goal to develop competitiveness in the green industries and help them tackle climate change issues. However, there is important heterogeneity in term of policy instruments between advanced countries and the lower-income nations. Whereas high income nations as well as China tend to use some kind of state-backed subsidy and financial assistance to support their green industries, the main policy instrument for lower-income nations tends to be in the form of trade and localization policy, which not only tend to be more discriminatory against foreign competitors, but also more prone to trade disputes (Bandara et al., 2025) (see Figure 9). This gap in policy instruments may well reflect the difference in fiscal space and state capacity in administering industrial policy (Evenett et al., 2024). However, although the dominant tools are subsidies rather than direct trade protection in the advanced countries, they still have a discriminatory effect precisely because subsidies are generally designed to favor domestic producers, hence still putting green industries produced in the Global South nations at a competitive disadvantage (Aldaz-Carroll et al., 2024; Espa & Marín Durán, 2018).

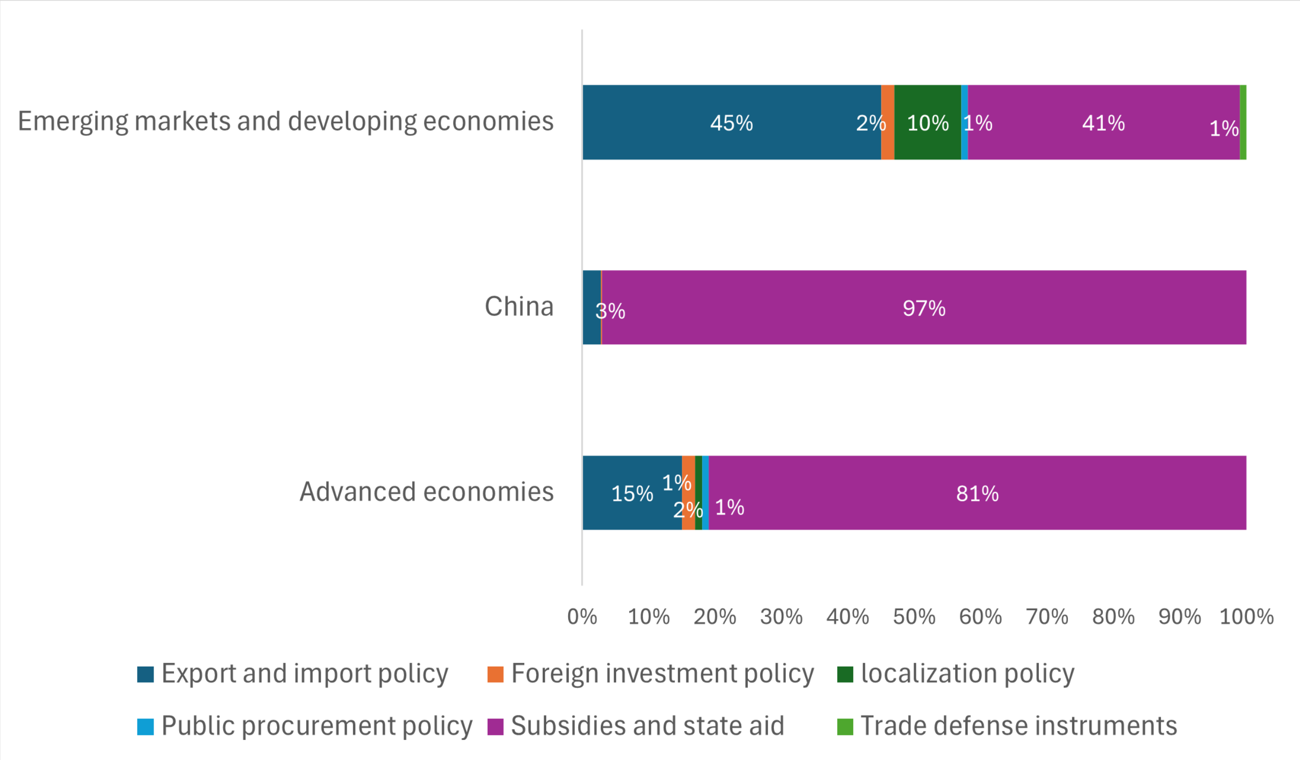


Figure 9: Green industrial policy pattern

Notes: Table 1 provides More mdetailed instruments for each policy category
Source: Reproduced from Bandara et al. (2025).

Fractured Trade Governance The erosion of the rules-based trading system has played a significant role in this development. Trade-restrictive green industrial policies have proliferated in the wake of a paralyzed WTO Appellate Body, as the WTO can no longer effectively enforce the relevant provisions or definitively resolve trade disputes (Bandara et al., 2025; Gulotty, 2022). Major economies are increasingly developing and using border measures to protect domestic competitiveness while pursuing decarbonization. The EU's Carbon Border Adjustment Mechanism (CBAM) exemplifies this by imposing costs on the embedded emissions of imports (cement, iron and steel, aluminum, fertilizers, power, hydrogen) in accordance with the EU Emissions Trading System (EU-ETS) (European Commission, 2023). CBAM is presented as WTO-compliant by applying exact carbon pricing to both domestic and imported goods. However, some argue that it undermines the principle of Common but Differentiated Responsibilities and Respective

Capabilities (CBDR-RC) under the United Nations Framework Convention on Climate Change (UNFCCC) (Cosbey et al., 2019; Durel, 2024).

Beyond the EU, the consideration and adoption of carbon border adjustments (CBAs) by several major economies point to a broader trend towards the unilateralism of climate-trade governance. The United Kingdom's plans to introduce a CBA, Canada's formal consultations on border carbon adjustments, and ongoing legislative debates in the United States reflect a growing convergence around the use of trade-related instruments to address carbon leakage and competitiveness concerns(CRS, 2024; European Commission, 2023; HM Government, 2025). Although differing in design and institutional status, these initiatives signal an emerging policy norm in which carbon pricing and industrial policy objectives are increasingly incorporated into border measures, with potentially significant spillover effects for developing-country exporters of emissions-intensive goods such as steel, aluminium, and chemicals. Australia's early exploration of a CBA in the context of reforms to its Safeguard Mechanism further reinforces this trajectory, suggesting that CBAs are evolving from an exceptional EU instrument into a more widely contemplated feature of contemporary climate–trade policy(Australian Government, 2022).

Another example is the EU Deforestation Regulation (EUDR), which conditions market access on proof that commodities, such as palm oil, coffee, cocoa, rubber, timber, and derived products, are deforestation-free based on geolocation tracking. Although it does not impose a carbon border price, the regulation establishes a rigorous compliance system that can affect smallholders in the Global South, many of whom may face challenges and costs in meeting EU-level traceability standards (Zhunusova et al., 2022).

These trends indicate a significant reconfiguration of global trade governance, with carbon border adjustments and environmental due diligence measures emerging as dominant regulatory tools that can potentially restrict trade. Consequently, the challenge for the Global South countries lies in navigating this fragmented trade landscape where market access and green industrialization prospects increasingly depend on compliance and complex environmental standards, whilst often without adequate financial or technological support.

3.4 Implications for green industrialization in the Global South

Some trade-offs Green industrial policies pursue decarbonization objectives while simultaneously fostering the development of new productive capabilities across clean-technology supply chains. These innovation activities are typically oriented toward championing domestic production and firms, rather than foreign producers. These three objectives, in vacuum, already inherently involve some trade-offs, as pursuing some goals might come at the expense of other objective(s) (Rodrik, 2015). Yet, as we will show below, the current global landscape identified above amplifies these policy trade-offs in important ways.

Figure 10 illustrates how Global South nations may face a trilemma in their green industrialization ambitions. By committing to using green industrial policy to propel green industrialization objectives, aspiring nations may connect only two nodes (objectives) at a time and will find it very challenging to connect all three simultaneously. In other words, any green industrial policy mix that policymakers choose to pursue will likely leave at least one objective (node) unattainable.

The most significant trade-off lies in balancing large-scale renewable energy deployment to achieve decarbonization, on one hand, with the goal of developing a dynamic local clean-tech industry, on the other hand. Aspiring nations may achieve deep decarbonization by harnessing renewable energy potential, particularly by leveraging Chinese cost-effective clean technologies, such as solar PV, EVs, and batteries (connection between node A and C). However, it entails a risk of de-localization for domestic LCT industries, as China's highly competitive LCT sectors may undermine the growth prospects of local firms.

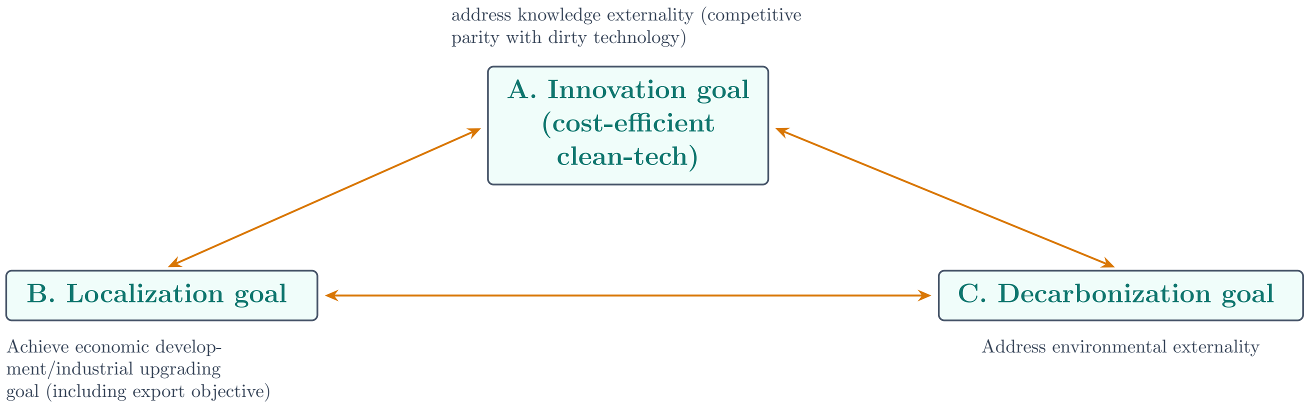


Figure 10: GIP trilemma in an evolving global landscape

China's competitive advantage in clean-technology is argued to have come from state subsidies in the form of state expenditure (Bandara et al., 2025). In the EV sector alone, China's industrial support is estimated to exceed$230 billion or close to 20% of total EV sales between 2009 and 2023 (Kennedy, 2024). Given the fiscal space constraints many low-income nations face, it is almost impossible to match the sheer scale of China's industrial policy support to compete with China's LCT domestically or globally. This makes it difficult for domestic LCT industries in the Global South to compete with imported Chinese clean-tech products, hence creating a serious de-localization risk to domestic players.

The fiscal space issue is likely also the reason why a big chunk of green industrial policy in lower-income nations tends to be in the form of trade protection and localization policy. These instruments are seen as capable of fostering domestic champions in clean-tech while creating much less fiscal burden compared to subsidies. However, the broader economic cost is ultimately borne by consumers and downstream industries in the form of higher overall prices (Bazilian et al., 2020; Probst et al., 2020).

On the other end of the spectrum, linking node A to node B is also possible, but in doing so, it may come at the expense of node C. Aspiring nations can still plausibly pursue localization objectives while simultaneously developing robust home-grown capabilities in innovative and cost-efficient clean-technology products that can maintain competitive parity with emissions-intensive alternatives (from node A to B). However, it will take considerable time to jump into the technological frontier in the clean-tech industry, and the scale of economic resources required to challenge China's dominance in this domain would be so substantial that it would likely divert funding away from policies that could otherwise incentivize the broader deployment of clean energy during the protracted innovation process. Connecting localization and innovation goals (node A and B), in other words, may come at the expense of decarbonization objectives, at least in the short term, while innovation is underway.

The final aspect of the trilemma in implementing green industrial policies is that policymakers may need to forgo node A when attempting to connect nodes B and C. When policymakers ambitiously want to achieve localization and decarbonization simultaneously, it means that it has to be done through breeding local champions, even though that could most likely mean denying access to a more cost-efficient Chinese clean-tech. In principle, doing this may still help achieve the decarbonization goal, but it might mean a slower transition than would otherwise be possible using more efficient Chinese clean technologies.

In summary, due to inherent trade-offs caused by the multi-objective nature of green industrial policy, aspiring nations may be left with only two out of three possible green industrialization outcomes, and the current global economic landscape, especially China's dominance in the LCT supply chain, heightens those tensions.

Policy space In a world where the WTO can no longer effectively enforce its rules, it is unsurprising that the available policy space appears to be expanding. This is indeed the case with green industrial policies, as noted by Bandara et al. (2025), whose use has increased rapidly over time during the decline of WTO effectiveness. Countries now seem able to adopt more interventionist and discriminatory measures without facing the serious consequence that once loomed large: having to roll back such policies when the WTO dispute settlement body issued a final and binding ruling, as it did during its heyday. Yet in today's turbulent world, the global economic and geopolitical order often functions as the de facto rule-setter, tightening the boundaries of the policy space that the Global South can realistically expect to command.

Based on the discussion above, we have identified several ways in which the current global economic landscape has shaped policy space, particularly for Global South nations that are caught between competing powers but still actively seeking to develop their green industrial capacity within this enclave of opportunity. This revised policy space will, in turn, determine the types of green industrial policies that are both realistic and likely to be effective given the global context they are in.

First, we acknowledge that the current situation around global trade governance does present countries in the Global South with greater opportunities to pursue industrial policy, including in the green sectors. After all, a more hands-on approach to green industrial policy is essential for building domestic productive capabilities in low-carbon technologies, especially the more complex ones, and for greening existing production methods. Yet this support should be carefully targeted at those segments of the low-carbon supply chain where technological requirements do not naturally match a country's existing capabilities and areas of specialization. Such precise targeting is particularly critical for countries in the Global South. Even though policy space may appear more flexible today—partly due to the weakened effectiveness of the WTO—most of these countries lack the fiscal resources to match the scale of green industrial subsidies deployed by advanced economies and China, and must also contend with other urgent socio-economic priorities.

China's industrial policy in solar PV and wind turbine generation systems illustrates this point very well (Liu & Goldstein, 2013). Industrial subsidies play a limited role in the success story of China's solar PV exports, as the downstream stage of solar PV production, which China focused on in the early 2000s, does not require advanced technological capabilities and thus aligns well with China's pre-existing specialization at that time. The huge renewable energy demand from the EU in the 2000s was the one that allowed China to rapidly scale up the production of solar PV, not the subsidy.

The case of wind turbine manufacturing in China, on the other hand, is an example of a sector where more active intervention is needed, as the technological prerequisites for producing it are much higher than those for downstream solar panels. Demand-side incentives in wind energy implementation have indeed served as green industrial policies that help build capabilities in China's wind turbine manufacturing. The steady stream of wind energy demand generated by the incentive has enabled wind turbine manufacturing FDI to flourish in China, thereby allowing it to learn from the technological frontier and subsequently boost its exports.

At the same time, any intervention must be calibrated carefully. As global supply chains reorganize away from China, countries that make it easier to host turn-key production facilities relocating from China will be relatively better positioned. Freund et al. (2024) finds that economies more open to integrating with China's supply chains tend to benefit more from this reallocation.

This brings us to our second key consideration regarding the policy space in green industrialization: policies that support foreign investment and imported capital are likely to be more effective in helping countries tap into emerging opportunities in low-carbon supply chains. By contrast, inward-looking measures—such as stringent local content requirements and import restrictions—may run counter to the logic of supply chain reorganization, since relocating firms need flexibility to reconfigure their networks across new locations in order to quickly connect competing powers in an uncertain geopolitical environment.

Third, given China's dominance and the growing tendency of advanced economies to turn inward through subsidies and other forms of support for domestic producers, replicating China's export-led green industrialization model—as exemplified in the case of solar PV, batteries, and electric vehicles—will be considerably more difficult.

A more realistic green industrialization strategy for the global South will likely need to place a stronger emphasis on cultivating robust domestic demand for renewable energy than China did in the early stages of its own green industrialization, which initially depended heavily on clean energy demand from Europe and other advanced economies, especially true in the success story of solar photovoltaics and, later, in electric vehicles exports. Evidence from China's wind turbine industry can be taken as a source of inspiration for the domestic market-oriented green industrialization model: generous incentives to expand the domestic wind market were a pre-condition for attracting FDI into the turbine sector and provided a stepping stone for building export capabilities in China (Liu & Goldstein, 2013).

This does not mean that exporting is no longer useful. In contrast, exports remain an effective instrument for exerting some discipline on domestic firms. By tying industrial support to export performance, for example, governments can compel domestic firms to enhance their competitiveness through exposure to more efficient global producers. This helps ensure that the industrial support delivers the greatest possible impact for its investment. This approach aligns with the findings of Aghion et al. (2015), who show that industrial policy yields the greatest productivity gains when it targets already competitive sectors or is explicitly designed to foster competition within the supported industries.

Based on this revised policy space and the lessons derived from Indonesia's case that will soon be discussed in the following section, we will then attempt to build a conjecture on what we argue to be the likely more effective green industrialization model for the Global South, taking into considerable account what has happened recently in the global economic landscape.

4 Overview of Green Industrial Policies in Indonesia

The previous section has discussed at length how green industrial policy instruments have been shaped by geopolitical and trade realities. Yet state capacity is a crucial determinant of whether a country can implement industrial policy effectively, regardless of its form, thereby shaping the nature of its industrial outcomes (Juhász & Lane, 2024; Rodrik, 2015). Therefore, how green industrial policies will unfold in practice will depend on whether the government has put in place appropriate regulations and institutional arrangements around them.

This section will use Indonesia as a case study to examine how green industrial policy is being incorporated into the national strategy and how it is being implemented to achieve both climate and industrial objectives. To do that, we examine Indonesia's national legislation around green industrial policies and evaluate whether the regulatory framework and institutional settings have been designed in a way that optimizes the ability of the Indonesian government to actually deliver them effectively. We then also examine how green industrial policies are being carried out to support two major sectors that embody the very goal of green industrialization: (i) solar PV that represent the goal of building capability on low-carbon technology, and (ii) green steel, which reflects the goal of decarbonizing existing industries.

Like other Global South 'latecomer' countries attempting to reconcile economic development agenda with climate action, Indonesia, too, faces the dual challenge of sustaining industrial competitiveness while responding to growing domestic and international decarbonization pressures. Therefore, in this section, especially in the following regulatory part, we also ask whether green industrial policy design in Indonesia has effectively linked these two objectives together

4.1 Regulatory framework

Indonesia is an emerging hub in global clean technology value chains. As a leading producer and major holder of mineral reserves essential for the energy transition, particularly nickel, Indonesia is advancing a series of strategies and roadmaps to attract investment in downstream industries and modernize its manufacturing base (IEA, 2021). In addition, it articulates increasingly ambitious commitments to emissions reduction and climate resilience. However, the extent to which these parallel agendas are aligned within the country's industrial policy framework remains unclear. Our analysis below highlights a disconnect between Indonesia's climate ambitions and its industrial policy framework, despite the country's stated aspiration to play a larger role in global clean technology supply chains, a pattern that is also identified by Massagony et al. (2025).

While national climate commitments, such as the NDC and the Long-Term Strategy for Low-Carbon and Climate Resilience (LTS-LCCR) articulate emissions-reduction pathways, these are not systematically translated into an industrial policy that explicitly supports low-carbon technology (LCT) development. Instead, green industry remains largely oriented towards greening existing industries through efficiency improvements and emissions reduction. This results in a clear gap between decarbonization plans and the policy instruments required to support a structural transformation towards green industry. Our analysis of the relevant policy documents is summarized in Table 2, with the full analysis presented in the Appendix A1.

This policy disconnect is rooted in the legal foundations of industrial development. Law number 3/2014 on Industry narrowly defines "green industry" in terms of resource-efficient and

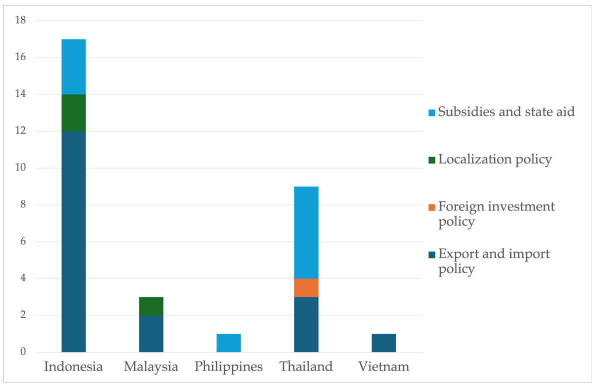
Table 2: Indonesia policy document analysis

Policy document	Decarbonisation strategy	Industrial policy strategy
Long-Term National Development Plan (RPJPN) 2025–2045	93.5% reduction in GHG intensity by 2045, embedded in economic transformation and socio-ecological resilience agenda	None
National Medium-Term Development Plan (RPJMN) 2025–2029	45.17% emissions reduction by 2029 across five sectors	Resource-based downstreaming prioritised (National Priority 5)
Low Carbon Development Strategy and Phases in RPJPN (LCDI) 2025–2045	Multisector modelling (energy, transport, industry, AFOLU) and indicative investment needs for 2025–2029	None
Second Nationally Determined Contribution (NDC)	Low Carbon and Climate Resilience Pathway scenarios (LCCP-Low/High), with emissions projected 8–17.5% below BAU by 2035	None
Long-Term Strategy for Low Carbon and Climate Resilience (LTS–LCCR) 2050	Economy-wide net zero by 2060 and industrial sector net zero by 2050	None
National Industry Development Master Plan (RIPIN) 2015–2035	Long-term industrial masterplan with limited reference to decarbonisation or green transition	Traditional industrial policy with sectoral priorities, spatial planning, and value-addition focus
Industrial Decarbonization Roadmap	93.5% emissions reduction by 2045, based on sectoral modelling of nine energy-intensive industries	None
National Energy Policy (KEN) 2025	Renewable energy targets (19–21% by 2030 and 58–61% by 2060), energy efficiency, and conservation measures	None
National Electricity General Plan (RUKN) 2024–2060	Approximately 73.6% renewable energy target in electricity supply	None
Strategic Downstreaming Framework	None	Large-scale resource-based downstreaming across eight priority sectors and 28 commodities

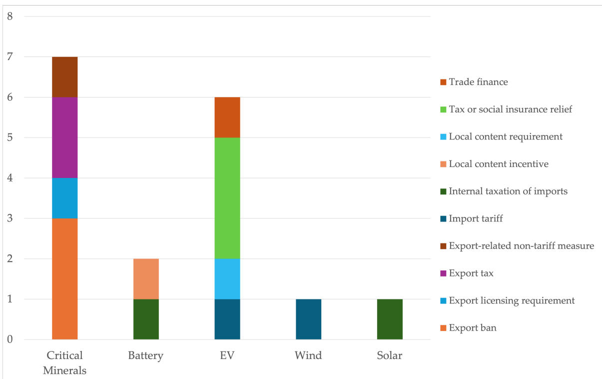
Note: More detailed assessment of policy instruments is provided in Appendix A1.

environmentally sustainable production processes, without recognising LCT development as a strategic industrial objective.[4] Crucially, because the law does not recognize LCT as a strategic industrial objective, the implementing regulations and policies result in institutional arrangements and regulations biased toward the decarbonization of industries only, leaving the goal of productive capability in LCT untouched. Green industrial policy instruments—such as targeted R&D support, tax incentives, localized public procurement, and export-promotion support for LCT firms, all of which would help build domestic technological capabilities in LCT—are largely missing from the more detailed implementing regulations.

However, where a vision for LCT industries does exist, it is largely confined to resource-based downstreaming. The mineral downstream policy agenda, which is one that focuses on the development of processed minerals that will be used to produce LCT, has so far remained the main target of the Indonesian government with regard to the green industrialization strategy and therefore has detached itself from formulating the broader LCT-oriented industrialization strategy, including in key renewable energy technologies such as solar panels and wind turbines. The Industry Development Master Plan (RIPIN), which serves as guidance for industrial development agenda in Indonesia, for example, has placed excessive emphasis on mineral processing and relegated LCT to the sidelines.



((a))



((b))

Figure 11: Green industrial policy instrument

Notes: Figure 11(a) presents the distribution of green industrial policy (GIP) instruments across Southeast Asian countries, while Figure 11(b) illustrates how GIP instruments in Indonesia are used by sectors
Source: Authors' illustration based on data from Bandara et al. (2025)

[4]Article 1 No. 3 "Green Industry is an industry that, in its production processes, prioritizes efforts to improve the efficiency and effectiveness of resource use in a sustainable manner, thereby aligning industrial development with the preservation of environmental functions and delivering benefits to society." (GoI, 2014)

Based on Figure 11(a), Indonesia clearly has the largest number of industrial policy instruments compared to other Southeast Asian countries. By contrast, Thailand exhibits a smaller but more balanced policy mix, however without explicit localization policies. Malaysia relies on selective localization tools, whereas Vietnam and the Philippines show minimal industrial policy intervention. However, the sectoral evidence further clarifies that these interventions are concentrated on critical mineral downstreaming, primarily implemented through export restrictions and local content requirements (TKDN), which are also linked to tax incentives in the EV sector (Figure 11(b)).

EV sector is on a secondary position, characterized by a more incentive-based mix of tax relief, local content requirements, import tariffs, and trade finance. Battery related policies remain fragmented despite the sector's strategic importance for both EVs and renewable energy integration, pointing to weak value-chain coordination. This is further reflected in Indonesia's downstreaming trajectory, which has largely produced intermediate inputs for stainless steel manufacturing, underscoring the limited translation of downstreaming efforts into battery-related value chains (Bosker et al., 2025). Moreover, while many EV manufacturers increasingly rely on lithium iron phosphate (LFP) batteries (IEA, 2024a), Indonesia's downstreaming strategy remains centered on nickel manganese cobalt (NMC), which higlights a potential mismatch between industrial policy priorities and evolving global LCT trends.

On the other hand, wind and solar technologies are almost entirely excluded from industrial policy intervention, each registering only a single trade-related measure. This stands in sharp contrast to their central role in decarbonization pathways and underscores a structural misalignment between Indonesia's industrial policy instruments and its climate objectives.

This excessive focus on the mineral downstream agenda is considered too narrow a policy goal given the wide range of LCTs that are within grasp of Indonesia's preexisting specialization, especially the assembly of less technology-intensive products, like solar modules. In addition, the mineral-downstreaming strategy has created structural conditions conducive to the expansion of coal-fired power plants. Because mineral processing industries are typically highly energy-intensive, coal has emerged as the cheapest and most readily available energy source to meet their substantial power demands, as illustrated in the case of nickel (Bosker et al., 2025). Continued reliance on coal further complicates the transition, as coal use has historically been framed as a means of poverty reduction, industrialization, domestic value creation, and regional development in areas that might otherwise face limited economic opportunities (Ordonez et al., 2021), which created path dependency. Reliance on coal-based energy is at odds with the green industrialization strategy, which still carries an environmental improvement spirit in its grand vision. A better alternative that is more aligned with green industrial policy objectives would be to build an incentive system that can promote the rapid and scaled-up deployment of renewable energy, including one to support mineral processing companies. This can reconcile mineral-downstreaming ambition with environmental goals.

Another big gap in Indonesia's high-level planning documents on green industrial policy is that the climate objectives outlined in the national development plan and LTS-LCCR are not paired with concrete measures to help firms manage the short- to medium-term loss of competitiveness they are likely to face as they undertake decarbonization, at least until innovation-driven productivity gains materialize. Without complementary measures, climate-focused policy may likely undermine the competitiveness of the industry, contradicting the core competitiveness objective of any green industrial policy.

Overall, our review of Indonesia's policy landscape suggests that policy efforts have focused primarily on achieving climate and emissions-reduction goals, rather than on systematically building domestic productive capabilities in low-carbon sectors, such as renewable energy technologies. Without coherent policies, as our analysis shows, firms may see current green-industry regulations as uncertain, discouraging investment in low-carbon technologies and risk undermining green industrialization strategies (CSIS, 2025b).

4.2 Institutional Arrangement

Fragmented Governance and Coordination Challenges Understanding Indonesia's institutional architecture is fundamental to assessing the policy context and implementation dynamics of its Green Industrial Policy (GIP). As summarised in Table 2, key policy documents are distributed across multiple ministries with differing mandates and degrees of legal authority.

At the strategic planning level, the Low Carbon Development Initiative (LCDI), which stipulates the overarching low-carbon economic strategy, is led by the Ministry of National Development Planning (Bappenas). Climate-focused strategies such as the Long-Term Strategy for Low-Carbon and Climate Resilience (LTS-LCCR) and the Second Nationally Determined Contribution (NDC) are led by the Ministry of Environment, which serves as the national climate focal point. In the industrial domain, the so-called "Industrial Decarbonization Roadmap" is coordinated by the Ministry of Industry, while the downstreaming framework falls under the Ministry of Investment and Downstream Industry (BKPM). In the energy sector, the National Energy Policy and Electricity Policy are governed by the Ministry of Energy and Mineral Resources (MEMR) and, unlike several of the aforementioned strategies, constitute legally binding documents.

These strategies and policies have largely been developed by multiple ministries with distinct objectives and policy instruments. They are translated into varying degrees of government programmes, depending on each institution's formal authority and mandate. This gives rise to policy inconsistencies and overlaps rooted in the difficulty of arranging an effective horizontal (across ministries) and vertical (across levels of government) coordination, and ultimately results in ineffective implementation across policy domains (Massagony et al., 2025).[5]

While this institutional arrangement reflects the cross-cutting nature of GIP, the sectoral ministries responsible for green industrial policy instruments mainly operate in silo rather than in coordination. At the core of strategic planning, Bappenas (Ministry of National Development Planning) plays a central role by embedding GIP-related objectives within the Low Carbon Development Initiative (LCDI) and in medium- and long-term national development plans. However, Bappenas lacks direct enforcement authority over line ministries responsible for policy execution, reinforcing a persistent disjunction between planning and implementation. For example, mineral-downstreaming initiatives have spurred the expansion of coal-powered smelting capacity, even as energy-transition strategies emphasize the phasedown of coal. This weakness reflects broader governance challenges in Indonesia, where fragmented institutional arrangements and competing policy priorities have constrained effective alignment between long-term climate objectives and sectoral policy implementation Massagony et al. (2025). As a result, policymaking remains fragmented and poorly integrated across key domains, weakening the effectiveness of green industrial policy implementation, and hence may risk undermining the prospects for a more rapid green transition. Details of the institutional mapping are provided in Appendix A2.

Institutional restructuring Under the new administration of President Prabowo Subianto, the institutional landscape for green industrial policy has been significantly restructured and

[5] Further details on the institutional landscape and stakeholder mapping are provided in Appendix A2.

expanded. This proliferation and reallocation of mandates has made coordination more complex, as no single champion or lead agency has emerged to steer and align overall green industrial policy implementation.

A key change was the dissolution of the Coordinating Ministry for Maritime Affairs and Investment (Kemenko Marves), whose functions were split among several newly created coordinating ministries, including the Coordinating Ministry for Infrastructure and Regional Development and the Coordinating Ministry for Food Affairs. While these bodies absorb parts of the former ministry's portfolio, the division of responsibilities has fragmented what was previously a more consolidated coordination function. Under previous administrations, Kemenko Marves played a central leadership role in driving green industrial policy, particularly in nickel downstreaming and EV industrialization. It led inter-ministerial coordination on the nickel export ban, domestic smelting, and large-scale nickel industrial estates, overseeing permitting, infrastructure, and strategic project task forces. Kemenko Marves also served as the primary coordinator that oversee the project of an integrated EV and battery industrial complex, uniting key sectoral ministries and acting as the main political and negotiating hub with major foreign investors. Institutionally, this more concentrated mandate made Kemenko Marves the key coordinator for Indonesia's nickel and EV-related green industrial strategies before its later dissolution and the fragmentation of its portfolio.

The Ministry of Environment and Forestry (KLHK) has also undergone restructuring into two different sectoral ministries. The Ministry of Environment, on one hand, now holds a broader mandate for environmental and climate change policy, while the Ministry of Forestry, on the other hand, is in charge of forestry-related issues only. This may contribute to a slower policymaking process for decarbonization goals, as it introduces an additional layer of bureaucracy.

At the same time, new roles such as the Presidential Special Envoy for Climate and Energy and the Energy and Green Economy Transition Task Force signal heightened political attention to climate and energy issues. However, these additions have not clearly consolidated authority or strengthened enforcement capacity. The Task Force, established in 2025, remains largely advisory and lacks executive powers over line ministries, limiting its ability to resolve inter-ministerial conflicts or drive policy alignment around green industrial policy.

Horizontal coordination challenges are further compounded by vertical fragmentation between national and subnational levels. Centralized and decentralized authority over permitting, land use, and aspects of energy and industrial development is often weakly aligned with subnational governance Marquardt (2014). Limited local capacity, uneven awareness of national policy intentions, and insufficient consultation during policy formulation further constrain implementation at the local level (Marquardt, 2014).

Together, the dissolution of existing institutions, the creation of new agencies and roles, and persistent horizontal and vertical gaps have produced a fragmented governance landscape for green industrial policy, without a clear lead institution to orchestrate a coherent transition.

Overall, Indonesia's institutional landscape for green industrial policy has become increasingly complex, characterised by a proliferation of various actors and recent ministerial restructuring. Nevertheless, this expansion has not necessarily translated into more effective governance around the green industrialization agenda. Indonesia remains without a clear lead institution to orchestrate a coherent green industrial policy measure. The weak institutional design may therefore risk undermining the state's capacity to formulate, coordinate, and implement effective green industrial policy measures (Juhász & Lane, 2024; Rodrik, 2015).

The following sections will discuss how this regulatory and institutional framework plays out in the two sectors that embody the goal of green industrial policies, namely the solar panel industry, which represents the goal of developing productive capability in low-carbon technology, and green steel, which represents an effort to decarbonize the existing industrial supply chain.

In the case of solar panels, we highlight how regulatory and institutional designs for renewable energy impede solar deployment, thereby further constraining the development of domestic solar panel manufacturing. Similarly, in the case of green steel, the failure to break away from coal dependence and promote rapid deployment of renewable energy has stymied the prospect of domestic steel made with a greener method of production. We contend that boosting the domestic renewable energy market can serve as a powerful catalyst for strengthening productive capacities in these two sectors in Indonesia, similar to the role it played in the development of China's wind turbine manufacturing industry (Liu & Goldstein, 2013).

4.3 Case study 1: Solar PV

Indonesia's energy transition is unfolding under a striking paradox. The country has set ambitious decarbonization targets, yet its power system remains dominated by coal, which continues to underpin around 72% of the energy mix while renewables account for only about 11% (IEA, 2024b; MoEF, 2024). At the same time, Indonesia is endowed with abundant renewable resources—particularly solar, which represents roughly half of its total renewable energy potential, of which less than 1% is currently harnessed (Pambudi et al., 2023). This mismatch between resource potential and actual deployment signals that the key obstacles to change lie less in physical scarcity and more in how markets, policies, and institutions shape both demand and supply.

Crucially, policy planning for solar energy uptake has not translated into strong, predictable market demand that could sustain investment and learning in the domestic solar panel manufacturing industry. Indonesia has adopted a range of regulatory instruments to promote renewable energy, including National Energy Policy, RUKN, RUEN, and the RUPTL 2025–2034, which outlines the national electricity development pathway, and the Just Energy Transition Partnership (JETP) Comprehensive Investment and Policy Plan, which commits concessional finance alongside policy reforms. In addition, Presidential Regulation No. 112/2022 on the acceleration of renewable energy development signals clearer policy commitment, particularly in constraining the expansion of coal-fired power plants and establishing a pricing framework for renewable electricity. While various strategies and regulations have signaled support for renewables in general, they have fallen short of generating the stable, large-scale deployment necessary for solar firms to scale, innovate, and compete. Instead, weak and volatile demand for solar power interacts with shallow industrial capabilities and coal-favouring regulatory arrangements, constraining both market formation and technological upgrading.

Hansen et al. (2026) characterizes the evolution of Indonesia's solar PV module manufacturing through three phases. The first two phases were marked by limited technological upgrading and weak market coexistence with incumbent producers, while the third phase represents a missed catch-up opportunity in which domestic firms failed to consolidate capabilities, upgrade production technologies, or secure durable market positions. This pattern is summarized in Table 3.

Across these phases, misalignment between industrial and energy policies, combined with policy instability, has resulted in a insufficient demand to support domestic capability building in solar PV manufacturing. This constraint became particularly evident during the second phase, when favourable industrial policy instruments, notably local content requirements, helped sustain domestic manufacturers in the absence of complementary energy policies capable of generating a sizeable and reliable market (Burke et al., 2019; Hansen et al., 2026). Although the government, through PLN, sought to stimulate demand via state-led project development, both foreign and domestic manufacturers perceived the domestic market insufficient and unpredictable to justify investment in local production.

During the third phase, which cover the more recent period of 2018-2023, energy policies start to shift towards solar PV deployment through rooftop and Independent Power Producer (IPP) projects, while industrial policy targets an export-oriented approach by postponing and ultimately phasing out local content requirements. However, since there is no adequate industrial assistance, low capacity utilization, and outdated manufacturing equipment, there has been a wave of firms exiting the industry and a strategic reorientation of surviving firms towards module imports and service provision rather than manufacturing (Hansen et al., 2026).

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Recently, revisions to domestic content requirements (TKDN) under MEMR Regulation No. 11/2024 from 40% to 20% sought to ease deployment constraints while continuing to signal support for domestic industry. However, this adjustment has taken place in a context where domestic demand for solar PV remains insufficient and unpredictable, limiting the extent to which such policy signals can translate into sustained industrialization. Without stable, long-term demand anchored in procurement mechanisms, pricing frameworks, and assured grid access, domestic firms face limited opportunities for learning-by-doing, capacity utilization, and the realization of scale economies—conditions that local content requirements alone could not substitute.

These combined demand and structural constraints translate into persistent cost disadvantages. Domestically produced solar PV module are estimated to be 30–40% more expensive than imported module, reflecting limited economies of scale, technological gaps, and incomplete upstream supply chains (Hansen et al., 2026; IESR, 2025). In turn, these disadvantages undermine competitiveness, constrain opportunities for industrial upgrading, and weaken the sector's capacity for sustained expansion.

In addition, coal-supportive measures such as the Domestic Market Obligation (DMO) and coal price caps have reinforced path dependency and prolonged reliance on coal (Ordonez et al., 2021). The new RUPTL continues to signal prioritization of existing coal assets, creating inconsistencies between long-term decarbonization commitments and short-term planning. The DMO, in particular, artificially lowers coal prices for domestic power plants reducing operational costs

Table 3: Evolution of energy and industrial policy for solar PV in Indonesia

Period	**Energy policy**	**Industrial policy**	**Policy alignment and firm-level response**
2008–2012	High renewable ambition, including a 15% target by 2025, and the introduction of feed-in tariffs, though market formation remained limited and installed capacity very small.	Early industrial policy focused on domestic capability-building through state-owned enterprises, public–private coordination via APAMSI, and the introduction of local content requirements.	Energy and industrial policies were broadly aligned, encouraging firm entry into domestic PV manufacturing, although production volumes remained low and imports dominated the market.
2013–2018	Ambitious solar targets persisted, but frequent policy reversals—including cancelled auctions and the replacement of feed-in tariffs with the BPP price cap—created regulatory uncertainty and constrained market growth.	Solar PV was prioritised in industrial strategy, with strengthened local content roadmaps and active support from the Ministry of Industry, reinforcing commitment to domestic manufacturing.	A growing misalignment emerged as supportive industrial policies were undermined by unstable energy policies, leading firms to expand capacity in anticipation of demand that largely failed to materialise.
2018–2023	Energy policy supported market expansion through rooftop and IPP projects under continued price caps, enabling growth in utility-scale projects such as Cirata, while off-grid deployment remained limited.	Industrial policy shifted towards an export-oriented strategy, with relaxed local content enforcement and exemptions for large and rooftop projects, signalling reduced emphasis on import substitution.	Partial realignment occurred through market growth, but limited support for upgrading domestic manufacturing led to firm exit, diversification into imports and services, and the emergence of export-oriented producers.

Source: This table is adopted from Hansen et al. (2026).

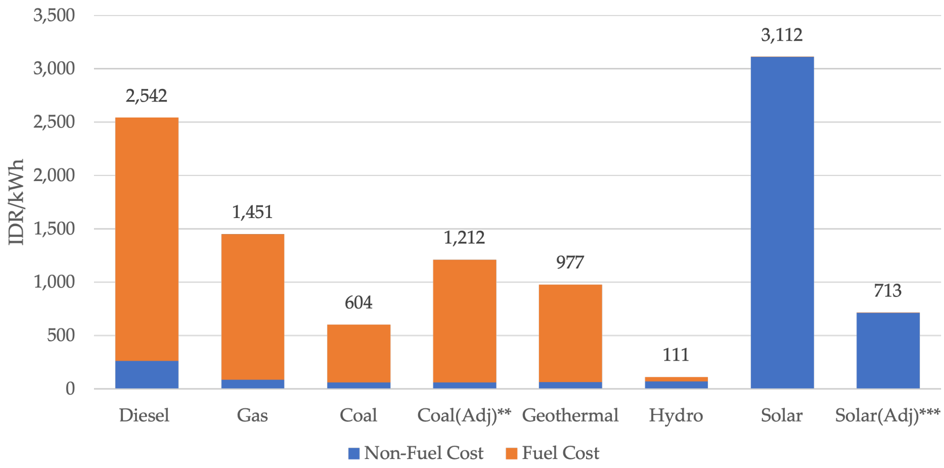
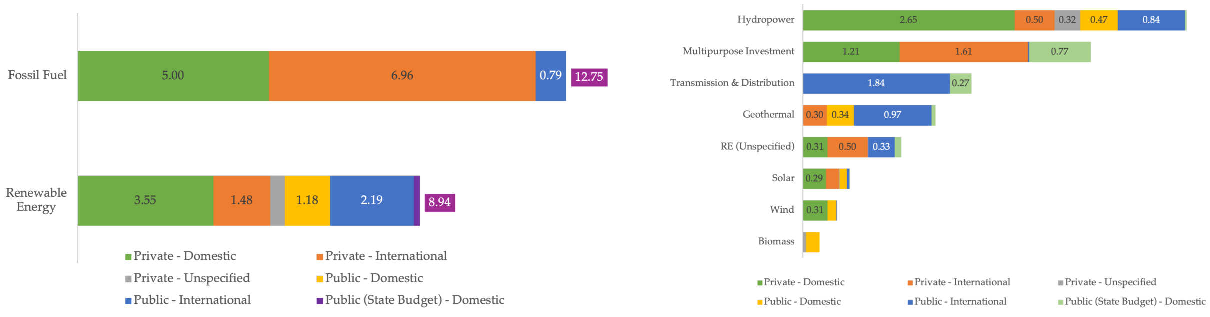


Figure 12: Operational Cost Per Unit Production (by Type) 2019-2024 (CPI, 2025)

*Notes: *Exclude Depreciation Cost. **Coal(adj) adjusts Coal fuel costs into the Coal Indonesia Export Prices based on MEMR Statistics Report in 2023. ***Solar (adj) adjusts operational costs using average of Southeast Asian Solar PV capacity factors.*
Source: Reproduced from CPI (2025)

for coal-fired generation and widening the competitive gap between fossil fuels and renewables (CPI, 2025; Ordonez et al., 2021). This measure risks weakening the investment case for solar energy, reducing deployment volumes, and reinforcing the low-demand conditions that constrain domestic manufacturing of solar PV in the first place (see the cost gap in Figure 12).



((a)) ((b))

Figure 13: Power sector investment flow 2019 - 2023 (in USD billion)

Notes: Fossil fuel, renewable energy, and supporting infrastructure reported investment
Source: Reproduced from CPI (2025)

Limited access to financing also constrains the growth of solar energy projects in Indonesia, where renewable energy investment remains low compared to regional peers, at only USD 1.5 billion in 2023 (see Figure 13) (CPI, 2025; IEEFA, 2024). Tariff caps restrict bankability, while the absence of complementary market instruments, such as feed-in tariffs, feed-in premiums, time-of-use pricing, or green certificate schemes, limits incentives for private developers. High upfront capital requirements, combined with slow disbursement of concessional finance under the JETP, further restrict capital mobilization. This, in turn, slows solar energy deployment, which could otherwise become a source of steady demand for domestic solar PV manufacturers.

Furthermore, a range of institutional and structural limitations significantly raise the obstacles to expanding solar power adoption. PLN's role as the dominant utility and a single off-taker creates procurement and grid-access bottlenecks, while long-term coal power purchase agreements and sunk investments reinforce carbon lock-in (Ordonez et al., 2021). Thus, the new Presidential Regulation 112/2022, which continues to reflect a centralized power system, risks limiting market-driven energy transformation and, in turn, suppressing what could otherwise be a much greater demand for solar energy.

On the back of that institutional arrangement, the recent regulatory changes have further heightened uncertainty. MEMR Regulation No. 2/2024 abolished net metering and introduced five-year rooftop PV quotas, reducing the financial attractiveness of rooftop solar while reinforcing system control and aligning deployment with PLN planning framework. As reflected in the responses of solar PV market players, such frequent policy and regulatory changes generate uncertainty and undermine firms and investors confidence (Burke et al., 2019; Hansen et al., 2026).

Taken together, these barriers reveal that Indonesia's solar PV sector trajectory is constrained by weak and uncertain domestic demand, which in turn discourages investment, local capability building, and innovation. The core challenge is therefore not only on the supply side, but in creating a strong, predictable market pull for renewable energy. Overcoming this demand constraint will require coherent green industrial policies that deliberately expand and stabilize domestic renewable energy demand while aligning energy policy, solar industry capability development, and the decarbonization strategies of the power and industrial sectors (Hansen et al., 2026).

4.4 Case study 2: Green Steel

In Indonesia, steel represents a critical test case for green industrial policy, as it sits at the intersection of coal-dependent energy systems, downstreaming-led industrial expansion, and rising exposure to climate-conditioned trade. The manufacturing sector contributed 19% to Indonesia's

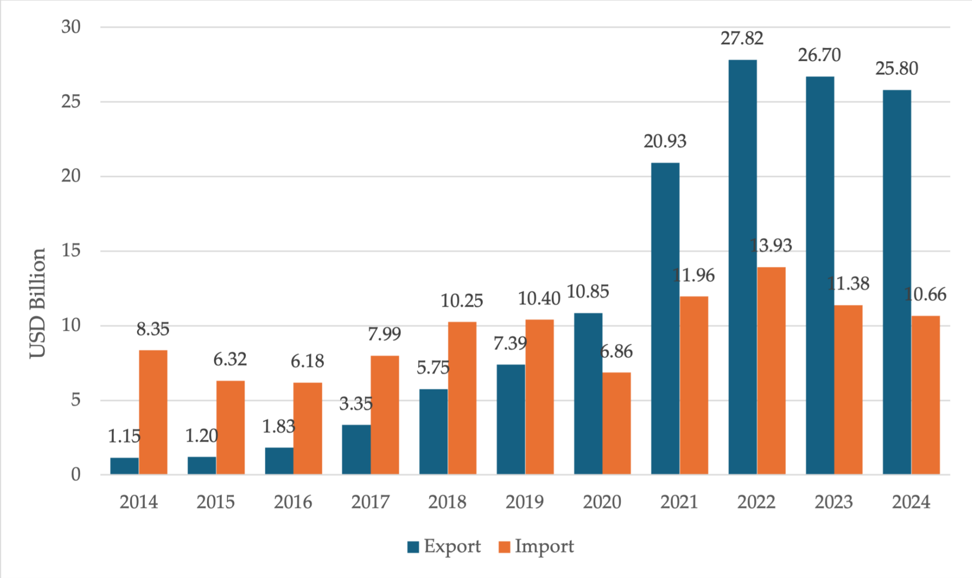


Figure 14: Export Import Iron and Steel (HS72) (ITC, 2025)

GDP in 2024, with basic metals accounting for 5% of total manufacturing output (BPS, 2025). Yet, the iron and steel sector alone is responsible for roughly 18% of Indonesia's industry-related emissions (MoEF, 2024). This asymmetry suggests that steel decarbonization could deliver high emissions abatement relative to economic output, but also raises political economy challenges given the sector's concentration in high capital firms and resource-dependent regions.

Figure 14 shows the export and import trend in Indonesia for the last ten years from 2014-2024. Based on data, Indonesia's iron and steel trade balance, which was previously in deficit until 2019, began to record a surplus in 2020, with a significant increase in exports in 2021. This trend aligns with Indonesia's downstreaming strategy, especially in nickel-based intermediate products used in iron and steelmaking. Indonesia has since become the world's fourth-largest steel exporter, with China as the primary destination in 2024 (62.3%), followed by Taipei (8.1%), India (7.2%), and Vietnam (4.8%) (ITC, 2025).

Indonesia's main export destinations are moving towards a low-carbon future. To maintain competitiveness, decarbonizing Indonesian steel is crucial. Beyond the EU CBAM, Taiwan has announced plans to introduce Carbon Border Adjustment for steel imports. Meanwhile, China is implementing the Green Steel Standard and India has its Green Steel Taxonomy, although both countries are still implementing it domestically. These developments signal a tightening global trade environment in which carbon intensity is increasingly embedded in market-access conditions, raising the risk of reduced competitiveness for carbon-intensive exporters such as

Indonesia.

The policy landscape governing industrial decarbonization in Indonesia has expanded over the past decade, yet it remains comparatively underdeveloped relative to major steel-producing countries. Indonesia is among countries that has the largest increase of coal-based steel production, 2,5 times from 2007-2018 period (Arens et al., 2021). Since then, Indonesia has continued to expand coal-based steelmaking capacity, while lacking sufficiently ambitious climate and renewable energy targets, resulting in a widening gap between production expansion and decarbonization readiness (Arens et al., 2021).

Key regulatory instruments for steel include the Green Industry Standard (Standar Industri Hijau, SIH) under Ministry of Industry Regulations No. 12/2023 and 41/2024. However, many firms struggle to comply due to limited technical and financial capacity. Moreover, SIH operates alongside other voluntary environmental standards, including the PROPER (Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup) rating system (PermenLHK No. 1/2021). The coexistence of SIH and PROPER without functional integration increases compliance costs and limits firms' incentives to invest beyond incremental improvements. In addition, SIH certification remains voluntary and its implementation is not supported by a compensating industrial policy mechanism such as fiscal incentives. Additionally, misalignment with international green steel standards within Indonesia's existing standards system will limit its competitiveness in emerging climate-sensitive export markets.

More recently, Indonesia has launched decarbonization roadmaps consisting of 9 priority sectors, including iron and steel. In this document, there are some strategies outlined for decarbonize steel industries (MoI, 2025). However, the roadmap does not clearly specify the industrial policy instruments—such as investment support, risk-sharing mechanisms, or demand-side incentives required to operationalize these pathways. These complementary measures are crucial if Indonesia is to maintain industrial competitiveness, as firms will experience downward pressure in their competitiveness while undertaking such a decarbonization process. However, this case echoes Indonesia's overall regulatory framework, which puts too much emphasis on decarbonization measures but lacks necessary support to help firms adjust during the process.

Firm level evidence from CSIS (2025b) indicates that while awareness of energy efficiency and emissions reduction has improved among steel producers, decarbonization efforts are primarily driven by external pressures, particularly from international markets. Domestic policy signals, on the other hand, remain comparatively weak. Firms also emphasize the constraints posed by long asset lifetimes, high capital costs, and uncertain market demand. Persistent concerns over limited domestic demand for green steel and the absence of a supporting ecosystem further dampen investment incentives, especially given that green steel is estimated to be 30–50% more expensive than conventional alternatives(CSIS, 2025a). This dynamic reduces the incentives for private sector to invest in low-carbon technologies and hinders the formation of a viable domestic green steel market.

Technologically, Indonesia's steel sector is constrained by several structural barriers. The continued dominance of coal-based power limits the feasibility of shifting to low-carbon production routes. Although several technological pathways identified by MoI (2025), including scrap-based Electric Arc Furnaces (EAF), green hydrogen-based Direct Reduced Iron (DRI), and Carbon Capture and Storage (CCS), have begun to emerge, these upgrades also face substantial challenges. These include the need for sufficient renewable energy supply, which Indonesia is currently lacking, high upfront capital investment requirements, and the developed enabling infrastructure (Arens et al., 2021). The reliance on coal-fired captive power also undermines attempts to integrate low-carbon technologies in the steel industry (Ordonez et al., 2021).

Demand-pull policies are also largely missing, undermining the creation of a robust market for low-carbon materials. The absence of green public procurement policies, product labeling based on embodied carbon, and fiscal incentives for adopting green steel prevents the emergence of a strong and predictable domestic market for green steel products (CSIS, 2025b). Without these mechanisms to signal long-term demand, firms face weaker incentives to invest in decarbonization, even when supply-side measures are in place.

Overall, this case study highlights that Indonesia's steel decarbonization challenge is not primarily one of technological availability, but of structural readiness—of which weak and uncertain demand for low-carbon steel and clean energy are central elements. While low-carbon production pathways are technically feasible, their deployment is constrained not only by energy system dependence on coal, capital-intensive investment requirements, and gaps in enabling infrastructure, but also by the lack of clear and durable demand signals for green steel, particularly in the domestic market. As a result, Indonesia's steel sector risks becoming trapped in a high-emissions vicious cycle: ongoing capacity expansion weakens future access to increasingly climate-conscious markets, while fragmented policies and weak demand-creation measures delay the conditions necessary for a green transformation of the steel industry.

5 A more effective green industrialization model for the Global South

In a world where trade rules are no longer effectively enforced, policy space in conducting green industrial policies does seem to be looking particularly abundant. Combine that with an increasingly inward-looking global market and pressing domestic social-economic issues, it is natural to see that the more inward-looking instruments of green industrial policies, such as local content requirements and trade protection, will be increasingly adopted, especially among the Global South, which has more serious fiscal constraints. However, as Juhász and Lane (2024) and Rodrik (2015) shows, the path of green industrial policy chosen by policymakers is never independent of the context that governments are dealing with. In their analysis, political realities heavily shape the type of green industrial policies that are ultimately chosen by politicians. Our analysis, on the other hand, complements that view by showing that global trade and geopolitical realities can also play an essential role in shaping the path of green industrialization trajectory among aspiring nations. In this setting, the kind of green industrial policies that can effectively deliver results both in terms of driving productive capability in the green industry as well as addressing environmental concerns may look different and less straightforward than what the proponents of industrial policy would typically argue.

Subject to the new constraints and opportunities posed by the rapidly evolving global economic landscape and lessons from Indonesia's experience, we argue that a more effective green industrialization model should consider the following principles.

First, in the short term, trade and investment regime should be kept relatively open to attract relocating production facilities in the LCT sectors as multinational companies (MNCs) continuously diversify their supply chain base away from the competing powers. Given that many Global South countries remain distant from the low-carbon technological frontier, the most feasible strategy that governments in those countries can devise is leveraging foreign technologies and integrating into existing global supply chains as an initial strategy for learning and capacity-building in low-carbon industries, rather than attempting to develop complete domestic low-carbon technology supply chains from scratch. This is what China did with its solar panel industry before moving into the more complex stage of production: exploiting the well-established foreign technology to be produced at scale using China's manufacturing might (Liu & Goldstein, 2013). Attempting to do everything domestically at once would be highly time- and resource-intensive, making decarbonization significantly more expensive and ultimately slowing the transition.

This does not mean that the government should be largely absent from intervening. Rather, intervention might be better targeted to areas that can facilitate the development of absorptive capacity while domestic industries learn from foreign technology. This can be in the form of R&D subsidy or tax incentive that can help quicker learning by domestic firms or upgrading into more technology-intensive part of the LCT supply chain. This brings us to the second principle that Global South nations should consider when developing a more effective green industrialization model. While attracting foreign direct investment (FDI) in clean technology, especially in assembly, can be an important first step in connecting local firms to global LCT value chains, in the longer run countries will eventually need more targeted industrial policies to close productivity and capability gaps as they move into more complex, higher-value segments of LCT as well as greener method of production for carbon-intensive products. China's case in the development of wind turbine and upstream stage of solar panel production provides a valuable lesson (Liu & Goldstein, 2013). When China needs to move beyond its pre-existing specialization in the unskilled and large-scale manufacturing toward a more technologically intensive sector, a targeted subsidy in production, combined with demand-based incentives to promote more massive deployment in renewable energy, can be effective in driving new productive capabilities in the LCT sector. In relation to this, for Global South countries confronting an increasingly complex array of climate-related trade measures that demand more substantial decarbonization in traditional industries—such as border carbon adjustment (BCA) mechanisms and deforestation-free regulations—a more targeted form of green industrial policy is warranted. Such policies are necessary to support their adjustment to emerging patterns of global trade governance and to facilitate the adoption of more environmentally sustainable production methods.

Third, as China maintains its dominance in LCT exports, the Global South should pivot toward its own renewable energy demand as a key driver of green industrialization. This does not mean abandoning export markets, which still provide valuable disciplining mechanism for domestic firms that receive industrial policy support. But given China's dominance, a more realistic strategy may entail a larger share of domestic demand than did China itself, whose early green industrialization was powered largely by renewable energy demand from Europe and other advanced economies (Liu & Goldstein, 2013). China's experience with wind power shows that promoting domestic demand for wind energy can help the country learn and catch up technologically, and eventually build the ability to make its own wind turbines and sell them to the global market (Liu & Goldstein, 2013). In this sense, the more appropriate green industrialization trajectory for the Global South in the current global landscape should not follow a straight line and merely replicate China's export-led model. As Indonesia's experience above illustrates, the development of its solar panel and green steel industries is severely constrained by weak domestic demand for solar power and materials with a green premium.

Fourth, a robust regulatory and institutional framework is essential for effective intervention in the green industry. Indonesia's experience offers valuable lessons. In a decarbonizing world, countries seeking to participate in low-carbon supply chains must carefully balance ambitious emission-reduction targets with broader goals of industrial competitiveness. Achieving this balance can provide policy clarity that, in turn, guides the design of suitable institutional arrangements—including coherent governance structures, inter-ministerial coordination mechanisms, and targeted industrial policies—needed to catalyze green industrialization. Importantly, ambitious decarbonization initiatives should not be devised in isolation. Rather, it needs to be complemented by industrial assistance to help firms navigate the short-term competitiveness disadvantage associated with adopting more stringent environmental requirements. So, appropriate and more effective green industrial policies should pursue decarbonization without sacrificing industrial competitiveness, and vice versa. Otherwise, they amount to either narrow climate policy or traditional industrial policy, respectively.

Additionally, what we learn from Indonesia's case is that an overly narrow focus on a single model, especially one that is based on mineral processing, may risk crowding out or closing off other potential pathways to green industrialization, such as becoming a production hub for the more downstream clean technologies, as Vietnam has done with EV in the 2020s and China with its solar panel export in the early 2000s. While Indonesia's green industrial policies have largely focused on the mineral sector and LCT that use processed minerals, other economies in the ASEAN region are more flexible in their positioning. Having a broad-based green industrialization strategy, therefore, not only mitigates the risks of overdependence on a single pathway but also maximizes opportunities to capture diverse and evolving segments of the global clean technology supply chain.

Fifth, policymakers must always strive to devise green industrial policy instruments that can mitigate the source of market failure inherent in any low-carbon supply chain. The more direct the instrument, the higher the chance that it might actually help build capacity in the low-carbon economy. However, it may not necessarily address the trilemma problem discussed above. Due to multi-objective nature in any green industrial policy context, policymakers will find it challenging to fulfill all objectives at once. However, acknowledging these deficiencies in green industrial policies does not mean that nations should abandon the goal altogether, as pursuing green industrialization, coupled with other more climate-focused policies, is better positioned to address the urgent climate problem when implemented properly (Blanchard et al., 2023). The lesson from the discussion above, as well as from other studies such as Harrison et al. (2017) and Rodrik (2015), is that policy instruments must be designed in accordance with what type of market failure they seek to address.

Lastly, considering the increasing prevalence of green industrial policies worldwide, a more effective green industrialization model must also involve a foreign policy strategy in which Global South nations play a far more proactive role in diplomacy and in international negotiations to shape the new international economic order. The focus here is on advocating for a system that provides them with greater policy space, particularly for implementing green industrial policies. This will help the world tackle the problem of climate change with greater political acceptability. The expansion of green industrial policies will require flexible and supportive international rules rather than constraining ones, so that these countries can pursue low-carbon growth and structural transformation depending on their capability (Bandara et al., 2025). In light of this, we echo the argument made by Ahumada and Chang (2025) on the need for the new international economic order, whatever form it may take, to give developing countries more policy space. Yet, at the same time, we also argue that the Global South nations must also find a middle ground on how to ensure that the greater policy space does not worsen trade tensions among nations and does not trigger a wave of tit-for-tat protectionism instinct. The latter point is critical for Global South nations to consider, as uncontrolled protectionist policies will ultimately limit the prospects for green industrialization in the Global South rather than expand them, as export markets become increasingly difficult to penetrate due to excessive support and preferences for domestic producers. The appropriate mix, therefore, would entail combining greater policy space with some kind of restraints or specific conditionality, tailored for the context faced by the Global South economies.

One thing to consider here is that not all types of green industrial policies are created the same. While the more discriminatory tools amongst them, such as tariffs, may restrict the supply of clean technologies, subsidies, on the other hand, tend to make them more abundant, although both can be trade-distorting (Rodrik, 2015). Additionally, subsidies mitigate knowledge and environmental externalities more directly, while tariffs do not. Instead, tariffs can raise the price of low-carbon technologies, and they only indirectly address knowledge spillovers by giving local firms more room to grow through reduced foreign competition. Hence, in a world where the balance on green industrial policies must be attained, subsidies should be the kind of policy space that the Global South is allowed to implement in order to expand the supply of green goods, while tariffs and any kind of trade protection are the type of policy lever that should be discouraged by binding rules, as they do not help with making LCTs more widespread.

6 Concluding remarks

Green industrialization can be an effective climate change mitigation strategy, and countries can leverage a broad array of green industrial policy instruments to promote it. This paper examines which green industrial policy approach remains feasible for the Global South nations in light of current global trade and geopolitical realities. Many countries in the Global South do not belong to the main geopolitically competing blocs, but instead function as connector economies linking rival powers. Thus, they are well placed to leverage the current reorganization of global trade and production, including in the low-carbon sector, sparked by the uncertain geopolitical climate. However, a new set of constraints also emerges as many big markets are increasingly turning inwards, as evidenced by the more prevalent use of green industrial policies in recent times. Within that global environment, we then theorize about the type of green industrial policies that are more viable for the Global South nations to pursue in order to advance their green industrial development agenda.

We argue that a more viable and effective green industrialization approach, given the constraints, should at least have the following six elements: (i) facilitative trade and investment policies in the short term to attract the relocating companies under uncertain geopolitical climate, (ii) a well-targeted industrial policies in the longer term aimed at enhancing productive capabilities in the more complex low-carbon supply chain, (iii) a greater emphasis towards domestic renewable energy market as the engine of green industrialization, (iv) a robust regulatory and institutional framework, which balance decarbonization with industrial competitiveness objectives, (v) a well-design instrument that directly target the source of market failure, and (vi) integrated foreign policy strategy to shape new international economic order that allow for a greater policy space for the Global South nations to do green industrial policies.

Building on these elements, future endevour could explore several promising research avenues. First, comparative case studies across Global South economies could assess how different configurations of trade, investment, and industrial policies shape green industrial outcomes under varying geopolitical and institutional conditions. This will help us better understand which policy climate works best under the current global economic landscape. Second, a more empirically grounded study is needed to test whether a robust domestic renewable energy market and overall environmental policy can help countries build productive capacity in the LCT sector and adopt greener production methods. This could be critical for clarifying whether starting with the domestic market is a promising strategy for catalyzing green industrialization.

Finally, the issue of how to design the new international economic order—especially the rules governing green industrial policies—warrants its own dedicated research agenda. It is becoming increasingly clear that preserving sufficient policy space for green industrial strategies can help the world address climate challenges more effectively by stimulating greater production of low-carbon technologies and greener products. However, designing such an order in a way that avoids escalating trade tensions among participating countries will require careful, in-depth analysis.

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A Appendix

Table A1: Summary of decarbonization and industrial policy strategies in Indonesia

Policy Domain	Policy / Document	Decarbonisation strategy	Industrial policy strategy	Notes
National Development Planning	Long-Term National Development Plan (RPJPN) 2025–2045	Targeted 93.5% reduction in GHG intensity by 2045, embedded in the economic transformation and socio-ecological resilience agenda.	None	Climate ambition is articulated at the macro level, but no instruments are specified to translate targets into industrial transformation.
	National Medium-Term Development Plan (RPJMN) 2025–2029	45.17% emissions reduction by 2029 across five sectors.	Strong emphasis on resource-based downstreaming (National Priority 5).	Green economy is framed mainly around waste management and natural resources; industrial decarbonisation coexists with priorities that may increase emissions.
	Low Carbon Development Strategy and Phases in RPJPN 2025–2045 (LCDI)	Multisector modelling (energy, transport, industry, AFOLU); investment needs (2025–2029): Energy IDR 92T, Transport IDR 133T, Industry IDR 416B.	None	Broad analytical coverage, but no unified green industrial transformation roadmap; industry is treated primarily as an emissions-reduction site rather than as a locus of structural transformation or capability upgrading.
Climate Commitments	Long-Term Strategy for Low Carbon and Climate Resilience (LTS-LCCR) 2050	Net-zero emissions economy-wide by 2060 and industrial sector net zero by 2050.	None	Long-term targets are stated without explicit consideration of industrial competitiveness, trade exposure, or policy-induced adjustment costs.
	Second Nationally Determined Contribution (NDC)	Economy-wide emissions reduction commitment submitted to the UNFCCC.	None	Indonesia's formal climate commitment under the UNFCCC framework, without associated industrial policy instruments.

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Table A1 continued

Policy Domain	Policy / Document	Decarbonisation strategy	Industrial policy strategy	Notes
Industry	National Industry Development Master Plan (RIPIN) 2015–2035	Adoption of LCCP-Low and LCCP-High scenarios, with projected emissions 8–17.5% below BAU (1.26–1.49 $GtCO_2e$ by 2035).	None	Remains the formal industrial reference but reflects a pre-Paris, resource-based paradigm and is weakly aligned with decarbonisation objectives.
	Industrial Decarbonisation Roadmap	93.5% emissions reduction by 2045; sectoral modelling of nine energy-intensive industries.	None	Relies on assumed technology adoption and investment uptake; provides technical modelling and cost estimates but lacks fiscal, trade, or competitiveness-oriented policy instruments.
	Circular Economy Roadmap 2025–2045	Adoption of 9R principles; potential GDP gains IDR 593–638T by 2030; investment needs IDR 308T/year.	Indicative list of fiscal and non-fiscal instruments.	Instruments remain non-operational and weakly integrated; circular economy is framed primarily as an environmental and waste-management agenda rather than an industrial upgrading strategy.
	Nickel Industry Decarbonisation Roadmap	Nickel-specific decarbonisation pathway aligned with RPJPN; estimated investment USD 31.4 bn (2025–2045).	None	Focuses on emissions reduction and financing requirements, with limited integration into a broader industrial or competitiveness strategy.
Energy and Electricity	National Energy Policy (KEN) 2025	Renewable energy targets (19–21% by 2030; 58–61% by 2060), energy efficiency, and conservation.	None	Provides energy transition direction but remains agnostic about industrial structure, capability building, and green industrial development.
	National Electricity General Plan (RUKN) 2024–2060	Target of approximately 73.6% renewable energy in electricity supply.	None	Ambitious electricity transition targets, but no linkage to domestic clean-energy manufacturing or industrial capability development.

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Table A1 continued

Policy Domain	Policy / Document	Decarbonisation strategy	Industrial policy strategy	Notes
	Electricity Supply Business Plan (RUPTL) 2025–2034	76% of new capacity from renewables by 2035; total investment needs IDR 2,133.7T.	None	Large-scale investment planning with limited transparency and no explicit connection to green industrial policy.
Downstreaming Strategy	Strategic Downstreaming Framework (BKPM)	None	Resource-based downstreaming across eight priority sectors and 28 commodities, with large-scale investment targets (e.g. USD 618 bn by 2040).	Downstreaming strategy risks entrenching carbon-intensive industrial pathways, particularly in mineral processing, without parallel decarbonisation safeguards.
	Minerals and Coal (Minerba) Grand Strategy	None	Commodity-centric industrial policy focused on domestic value addition through mineral downstreaming.	Reinforces extractive and energy-intensive industrialisation without alignment to climate or green industry objectives.
Industrial Ecosystem Development	Eco-Industrial Park Roadmap	Not yet available.	Not yet available.	Indicates a recognised policy gap at the ecosystem and spatial planning level.

Table A2: Institutional landscape of Indonesia's green industrial policy governance. This Table is adopted from CSIS (2025b)

Institution	Role in green industrial policy	Key limitations
Ministry of Development Planning (Bappenas)	National planning authority responsible for integrating green industrial policy objectives into RPJMN and RPJPN through macroeconomic, sectoral, and environmental planning.	Restricted to planning functions, dependent on sectoral ministries for implementation, and weak enforcement and monitoring capacity.
Coordinating Ministries (Economic Affairs; Food; Infrastructure)	Cross-ministerial coordination on economic transformation, food systems, and infrastructure relevant to green industrial policy.	Lack executive authority and rely on line ministries' willingness and administrative capacity to implement.

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Table A2 continued

Institution	Role in green industrial policy	Key limitations
Energy Transition & Green Economy Task Force	Ad-hoc inter-ministerial task force coordinating working groups on energy, industry, finance, and socio-economic dimensions of the transition.	Low political authority and weak institutionalization and limited continuity.
Ministry of Foreign Affairs	Climate and green diplomacy, including international negotiations, partnerships, and positioning of Indonesia in global climate governance.	Limited technical depth in environmental and industrial policy.
Ministry of Trade	Trade policy related to sustainability standards, green trade instruments, and responses to CBAM and similar measures.	Environmental considerations weakly embedded in trade policy formulation.
Ministry of Investment / BKPM	Promotion and facilitation of green investment, including incentives and development of eco-industrial parks.	Strong emphasis on attracting investment may override environmental safeguards.
Ministry of Industry	Formulation of industrial policy including green industry roadmap, SIH standards, industrial decarbonization, and selected green technologies.	No clear or comprehensive mandate for green technology development and deployment.
Ministry of Environment	National climate focal point responsible for emissions monitoring, environmental regulation, and management of climate and environmental funds.	Primarily perceived as a regulator; equal bureaucratic rank with technical ministries constrains coordination power.
Ministry of Forestry	Management of forest resources and carbon sequestration through forestry-based mitigation.	Limited integration with industrial decarbonization strategies.
Ministry of Marine Affairs and Fisheries	Role in offshore renewable energy, CCS, and mangrove-based mitigation.	Climate and energy roles remain secondary to core fisheries mandate.
Ministry of Agrarian Affairs and Spatial Planning	Land-use planning and permitting relevant for renewable energy and CCS projects.	Procedural complexity and weak alignment with decarbonisation objectives.
Ministry of Transportation (Kemenhub)	Decarbonisation of the transport sector, including electrification and modal shift.	Sector-specific focus with limited linkage to industrial value chains.
Ministry of Energy and Mineral Resources	Energy efficiency and clean energy supply for industry.	Focused on energy supply, pricing, and resource governance rather than industrial transformation.
Ministry of Finance	Fiscal incentives, carbon pricing instruments, and green finance frameworks.	Climate-related financing initiatives remain limited in scale and depth.

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Table A2 continued

Institution	Role in green industrial policy	Key limitations
House of Representatives (DPR RI – Commissions VI, VII, XII)	Legislative drafting and oversight on trade, industry, energy, and environmental policy.	Fragmented oversight across commissions and competing sectoral and political agendas.
Financial Services Authority	Regulation of green taxonomy and sustainable finance in the financial sector.	Indirect influence and depends on voluntary adoption by financial institutions.
National Standardisation Agency	Development of national standards (SNI) for efficiency, emissions, and green products.	Voluntary adoption and partial misalignment with international standards.
National Research and Innovation Agency	Public R&D, innovation policy, and technology roadmapping relevant to the green transition.	Limited funding, weak linkage between research, industry, and policy needs.
Green Industry Certification Body	Certification and auditing for SIH compliance.	Low uptake among industrial firms.
Product Certification Bodies	Certification for ISO standards (e.g. ISO 14001, ISO 50001) and eco-labelling.	Voluntary compliance and uneven enforcement.
Danantara	State-owned financing vehicle for green and transition projects.	Newly established and limited institutional capacity and scale.

csis.or.id
csis@csis.or.id
@csisindonesia
CSIS Indonesia

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Indonesia