Equal

Intellectual Property Regimes and Green Industrialisation: Discussion Paper

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Executive Summary

Developing countries face the twin challenge of industrialising while adopting green technologies, a process heavily influenced by intellectual property regimes (IPRs). Strong IP rights can stimulate innovation, but they also raise barriers to the diffusion of climate-critical technologies. This tension is evident in global climate negotiations: many low- and middle-income countries argue that strict IP protections make green solutions "out of their reach" due to high costs, pushing for measures like patent exemptions or compulsory licenses, whereas developed countries insist that strong IP is needed to spur innovation. International rules such as the WTO's TRIPS Agreement require all members to grant 20-year patents in all fields, limiting policy space to treat green technologies differently. Over time, this system has concentrated technology ownership in a few nations: roughly four-fifths of green technology patents are held in high-income countries (with about 19% in China), while developing countries account for only ~2%. The result is a pronounced *knowledge divide* – today's IP systems have "froze[n] the advantages of already industrialised nations," leaving developing economies dependent on older or openly available technologies and constraining their ability to innovate locally.

This background paper reviews the existing literature on Intellectual Property Regimes and Green Technology to establish an overview of the green technology sector and identify the main barriers and policy options to facilitate access and promote technology diffusion across developing countries. Across the literature, there is a broad consensus that current IP regimes, as they stand, pose significant challenges to a just green transition by creating four key barriers: (i) access costs, (ii) transaction costs, (iii) legal and institutional constraints, and (iv) information/capacity gaps. Table 1, summarises IPRs barriers and existing alternatives as presented in the literature.

Access costs are the direct financial barriers that hinder developing countries from obtaining green technologies. Patent-based monopolies often allow rights-holders to charge high license fees or royalties, keeping cutting-edge renewables and clean-tech unaffordable for many firms in the Global South. Complex patent landscapes exacerbate the problem: patent thickets (dense webs of overlapping patents), technology bundling requirements, and restrictive licensing terms all increase the cost and complexity of accessing green tech, deterring new entrants and reinforcing dependence on foreign suppliers. In short, high access costs not only impose immediate financial burdens but also slow down technology diffusion and deepen technological inequality between countries.

Beyond financial costs, developing countries face high **transaction costs** in acquiring green technology. These are the "hidden" costs – time, effort, uncertainty, and complexity – involved in obtaining technology, and they can impede adoption just as much as outright costs.

The international IP legal framework itself often limits the ability of developing nations to acquire and develop green technology. Most core climate technologies are patented by foreign firms, and overlapping patent thickets mean a newcomer risks infringement even by attempting to enter technology-intensive sectors like solar PV, wind turbines, or batteries. Collectively, these **legal and institutional barriers** skew the playing field in favour of incumbent technology holders and constrain the policy toolbox that developing countries can deploy for green industrialisation.

Significant "soft" barriers – gaps in **information, know-how, and human capacity** – also hinder green industrialisation in the Global South. Limited awareness of technology, lack of IP and negotiation expertise, and insufficient technical absorptive capacity also hinder the effective adoption of advanced green technologies. The consensus in the literature is that closing these gaps must go hand-in-hand with IP reforms.

Table: Key Barriers and Alternatives

Dimension	Barriers	**Alternatives** (Proposed Solutions)
Access Costs	• Licenses and Royalties; • Patent thickets, technology bundling, and restrictive licensing practices; • Absorption costs;	• TRIPS flexibilities; • Patent pools or collective licensing platforms; • Financial mechanisms – e.g. *tiered pricing* for poorer markets or international subsidies (via climate funds) to buy down licensing costs.
Transaction Costs	• Information & search hurdles; • Lengthy negotiations and complex legal processes; • High complexity and bureaucratic complexity.	• Improve information platforms; • Standardise and streamline licensing processes; • Build local capacity in IP management.
Legal & Institutional Barriers	• Strict global IP rules; • Overlapping patents (patent thickets) • External pressures and sanctions; • TRIPS-plus trade deals;	• Maximise use of flexibilities and act collectivelly to avoid trivial patents. • Pursue international reforms such as a climate waiver; • Strengthen South–South collaboration.
Information, Knowledge & Capacity Gaps	• Awareness gap • Skilled human capital gap • Technical capacity gap	• Invest in domestic innovation capacity; Improve IP literacy and institutional capacity • Encourage South–South knowledge sharing • Upgrade information systems using modern tools

The literature also highlights that IP barriers are highly context-specific, varying significantly across countries, sectors, market structures, and local capacities (Glachant and Dechezleprêtre 2017; Rai et al. 2014). Against the backdrop of global IP regimes, it is indispensable to capture the nuanced perspectives of those directly engaged with these challenges, including private companies and policymakers. This project aims to fill this knowledge gap and co-create actionable alternatives including through engagement with local stakeholders in Brazil, Indonesia, Mexico and South Africa. The project seeks to deepen the understanding of how IP barriers are experienced in practice and to explore the range of alternative solutions currently under consideration or in implementation at national and industry levels.

The consideration of the alternatives identified in the literature indicates that collective action among developing countries has become increasingly urgent. Pooling resources, sharing knowledge, and coordinating policy responses can enhance their negotiating power and promote South–South collaboration, allowing the pursuit of shared interests and the development of alternative models that challenge the existing status quo. However, to date, such cooperation has not materialised. Divergent national priorities, differing levels of technical and institutional capacity, and the complex web of bilateral relationships shaped by geopolitical competition are believed to be key barriers to deeper cooperation among developing countries. A deeper dive into developing countries' green industrialisation strategies and diplomacies may help to understand not only the obstacles to further cooperation but also the pathways to overcome these challenges and improve coordination among them. Furthermore, by strengthening this collective stance, developing countries can better navigate a multipolar world and advocate for more equitable access to green technologies.

Foreword

Equal International has prepared this background paper as the foundation for a new programme of work on intellectual property (IP) regimes and green industrialisation, undertaken in collaboration with the Open Society Foundations' Economic and Climate Prosperity programme. It sits at the intersection of two long-standing concerns in Equal's work: how global and national rules shape access to essential goods and services, and how to design practical pathways that reach those who are most marginalised and left behind. Equal International is a specialist think tank focused on inequality and access to public goods, with a track record of working from ideation through to implementation. We convene diverse stakeholders to co-create solutions, design institutional innovations, and support their uptake in real policy and market settings. Our team has decades of experience at the sharp end of access debates — particularly in health, medicines, and essential services in low- and middle-income countries — including work that helped shape or inform initiatives such as the Global Fund to Fight AIDS, TB and Malaria, UNITAID and the Medicines Patent Pool, as well as the development and political road-testing of the Global Public Investment proposal.

We bring that experience and our co-creation methodology to bear on the emerging challenge of ensuring that green transition is not only fast but also fair. The research programme of which this paper forms a part starts from a simple but urgent proposition: developing countries are under pressure to industrialise and decarbonise simultaneously, yet access to green technologies is constrained by IP rules and market power that overwhelmingly favour a small number of countries and corporations. Existing IP regimes have been built around the promise of incentivising innovation, but they also create access, transaction, legal and capacity barriers that can slow the diffusion of climate-critical technologies and entrench technological dependence.

At the same time, there is no coherent, shared Global South agenda on how IP rules should evolve to support green industrial policies, despite a proliferation of proposals — from flexibilities and waivers to patent pools, open models and South–South initiatives. Against this backdrop, OSF has asked Equal to generate actionable, politically informed analysis that can support partners in shaping such an agenda. This literature review is therefore not an abstract academic exercise, but a working tool for an advisory group of policy-makers, practitioners, civil society leaders and experts, and for the key informants we will interview. It synthesises what is currently known about how IP regimes affect access to green technology, organises that evidence into an accessible problem map (covering access costs, transaction costs, legal and institutional constraints, and information and capacity gaps), and surfaces the main alternative models and reform ideas already on the table. It is intended to give readers a common language and evidence base from which to interrogate their own experience, test the relevance of different models in their contexts, and jointly identify where policy, diplomacy and investment could have the greatest leverage. At the same time, the paper is designed to demonstrate the distinctive value that Equal brings to this field: a focus on inequality and marginalisation; deep experience of access-to-medicines and IP debates; and a tested co-creation methodology that moves from analytical mapping to shared political strategy. In doing so, it also serves as a prospectus for potential partners and funders who are looking to back Southern-led, practically oriented work on intellectual property and green industrialisation — work that connects rigorous analysis to coalition-building, policy influence and ultimately to fairer access to green technologies for those countries and communities who currently stand to gain the least, while bearing the most significant risks from climate change.

Introduction

Developing countries face the dual challenge of industrialising their economies while transitioning to sustainable, *green* technologies. Green industrialisation — building domestic industries in renewable energy, clean technologies, and other low-carbon sectors — is critical to achieving climate goals and advancing development. However, affordable access to green technology remains difficult for many developing countries (Rafitoson and Correa 2025). Intellectual property regimes play a pivotal role in this dynamic. On the one hand, patents and other IP rights are designed to incentivise innovation by granting inventors temporary monopolies. On the other hand, these monopolies can raise costs and hinder the diffusion of technology, thereby slowing the widespread adoption of green solutions in the Global South (Raiser et al. 2017; Abdel-Latif 2015). This tension has led to a polarised debate: many low- and middle-income countries argue that strict IP protections act as barriers to technology transfer, while developed countries and industry groups insist that strong IP is an *enabler* of innovation and a necessary facilitator of transfer (Abdel-Latif 2015).

In international climate negotiations, this debate has remained contentious and unresolved. Developing nations have repeatedly raised concerns that critical climate technologies are "out of their reach due to intellectual property rights and prohibitive costs" (Abdel-Latif 2015), proposing measures such as patent exemptions or compulsory licensing for green technologies. These proposals have met firm resistance from developed countries, resulting in a stalemate — references to IP were largely bracketed or dropped in UNFCCC texts due to lack of agreement (Abdel-Latif 2015). Meanwhile, global IP frameworks such as the World Trade Organization's (WTO) TRIPS Agreement require all WTO members to implement minimum IP standards (including 20-year patents across all fields of technology), limiting the policy space for countries to treat green technologies differently (Glachant and Dechezleprêtre 2017). Some flexibilities exist under TRIPS (e.g., compulsory licensing), but they have been underutilised for climate technology so far (Abdel-Latif 2015). The international IP system has even tightened over time through "TRIPS-plus" trade agreements that impose higher standards of protection, further constraining developing countries' options (Menezes 2018).

Against this backdrop, recent literature explores how IP regimes impact the diffusion of green technologies and the prospects for green industrialisation in developing economies. Many studies find that the effect is highly context-specific — depending on the type of technology, the capacity of the recipient country, and the structure of markets (Glachant and Dechezleprêtre 2017; Rai et al. 2014). Nevertheless, beyond specific contexts, there is a broad consensus on the barriers, asymmetries, and dependencies imposed by existing intellectual property rights (IPR) regimes. This review synthesises the evidence across four dimensions of IP-related barriers: access costs, transaction costs, legal and institutional barriers, and information, knowledge and capacity gaps. Throughout, it maintains a professional, evidence-based tone, aiming to inform policy-makers and researchers seeking to align IP policy with climate and development objectives.

Intellectual property rights regimes and green industrialisation

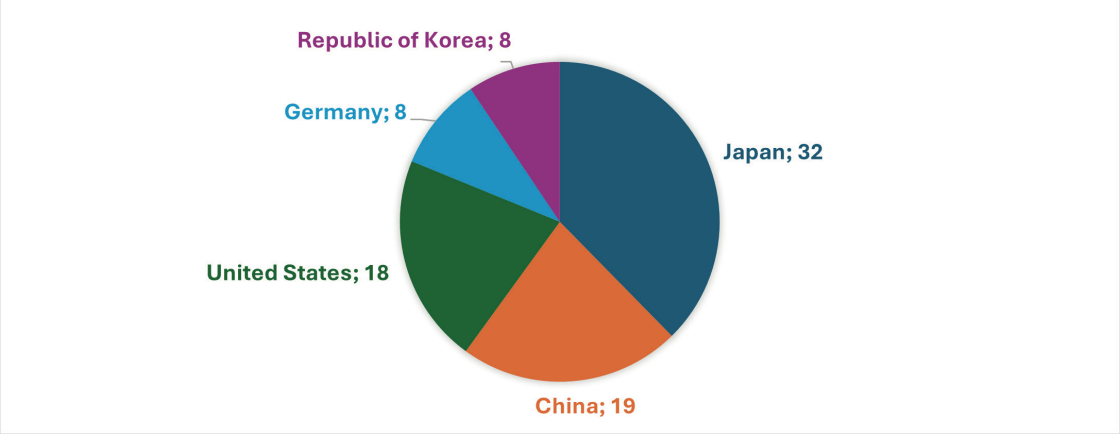
Efforts to foster green industrialisation in the Global South require not only financing and infrastructure, but also access to advanced technologies (solar panels, wind turbines, energy storage, efficient appliances, etc.). International IPR regimes set the playing field for technology access and condition the design and implementation of green industrialisation policies. Proponents of stronger IPR regimes have argued that they stimulate inventive activity by allowing innovators to appropriate returns from sunk research and development (R&D), a rationale grounded in the economics of knowledge spillovers and dynamic incentives (Nordhaus 1969; Scotchmer 2004). A related claim is that credible enforcement promotes international technology diffusion: when destination markets safeguard patents and trade secrets, multinationals are more willing to engage in local production through licensing, disclosing know-how, or investments. (Mansfield 1994; Javorcik 2004). Such a rationale is embedded in the WTO's Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS). The TRIPS established minimum standards of IPR protection worldwide and was negotiated by developed countries as part of a package deal that included access to markets, bilateral concessions and threats (Liebig 2001; Drahos 2002; Correa 2023).[1] Developed countries established TRIPS to enforce a uniform IP framework worldwide, regardless of the context in which the technology is deployed or the type of technology involved. The TRIPS agreement ensures, then, that technology diffusion beyond the borders where it was created mainly benefits large patent-holding companies, maximising their profits (Baker et al. 2017; Correa 2023). Even though Article 66.2 of the TRIPS established an obligation "to provide incentives to enterprises and institutions in their territories to promote and encourage technology transfer to least developed countries (LDCs)" (Watal and Caminero 2019), as developing countries feared, the TRIPS froze the comparative advantage of already industrialised countries (Correa 2023). The current IPR system thus reflects and reproduces this power-knowledge imbalance. Technological knowledge is concentrated under patent or trade-secret protection held by firms in developed countries, while developing countries often have access only to older or openly available technologies (Nathan 2025).

Access to green technology (see Box 1) should be understood against the backdrop of this highly concentrated regime of production and circulation. Renewable energy, electric vehicles, and climate adaptation technologies are evolving rapidly and are being patented by multinational companies and circulated across developed countries. Indeed, the global patent landscape for green technology remains highly concentrated in a few countries and corporations. A UNIDO Policy Brief found that high-income countries hold 79% of green patents, China has 19%, and developing countries account for just 2%. (Lavopa and de las Mercedes Menéndez 2023).[2] The breakdown of these figures by country (Figure 1) is even more concerning: 85% of green patents are concentrated in just five nations — Japan (32%), China (19%), the United States (18%), Germany (8%), and the Republic of Korea (8%) (Lavopa and de las Mercedes Menéndez 2023, 7). These figures reveal that the global green innovation race is led by a handful of developed nations (Gupta et al. 2023).

1 However, as several studies indicate, these promises have remained largely unfulfilled (Correa 2016). For example, a survey of innovation outcomes found no clear correlation between the strength of patent regimes and a country's innovative performance — nations with longer patent terms or more extensive patent coverage were not significantly more innovative than those with weaker protection (Correa 2016). This calls into question the theoretical rationale that strong IP rights are universally beneficial for technological progress. In fact, the conception underpinning TRIPS may have been flawed in assuming that one-size-fits-all patent rules would drive innovation across diverse economies (Correa 2016). Instead, evidence suggests that factors like competition, open knowledge flows, and baseline scientific capacity are crucial drivers of innovation, and overly stringent IP rules can even impede those factors (Correa 2016; Boldrin and Levine as cited in Correa 2016).

2 Adopting a different approach (Borthakur 2023) found that from 2000 and 2017, 3,461,573 Environmentally Sound Technology patents were generated. According to the author, 48% of these patents were invented in China, 14% in the United States, 11% in Japan, and 5% each in Germany and the Republic of Korea. Together, the five countries account for 94% of EST patents filled in the period (Borthakur 2023, 568).

Figure 1: Percentage of patents per country (Top 5 holders)



Moreover, green technologies are overwhelmingly held by private-sector firms, especially large multinational companies in key industrial sectors. Private companies account for over two-thirds of all green technology patents worldwide (for patents filed 2000–2022). In contrast, individuals (independent inventors) hold about 14%, and universities or public research institutions about 9% of green patents, with only a negligible fraction attributable to cross-sector collaborations. Within the private sector, industrial and manufacturing companies play a dominant role. As of 2023, nearly 60% of all green-related patents worldwide are held by manufacturing industries (Lavopa and de las Mercedes Menéndez 2023, 5).

Box 1: Green technology

Green technologies encompass products, processes and services aimed at reducing environmental impact throughout their entire life cycle, from raw material extraction to manufacturing, usage, and disposal. The European Patent Office labels patent documents related to climate change technologies with the code Y02, adding a specific classification beyond the usual categories. This Y02 classification includes technologies that control, reduce, or prevent human-caused greenhouse gas emissions under frameworks such as the Kyoto Protocol and the Paris Agreement, as well as technologies that help adapt to the negative effects of climate change (Lavopa and de las Mercedes Menéndez 2023).

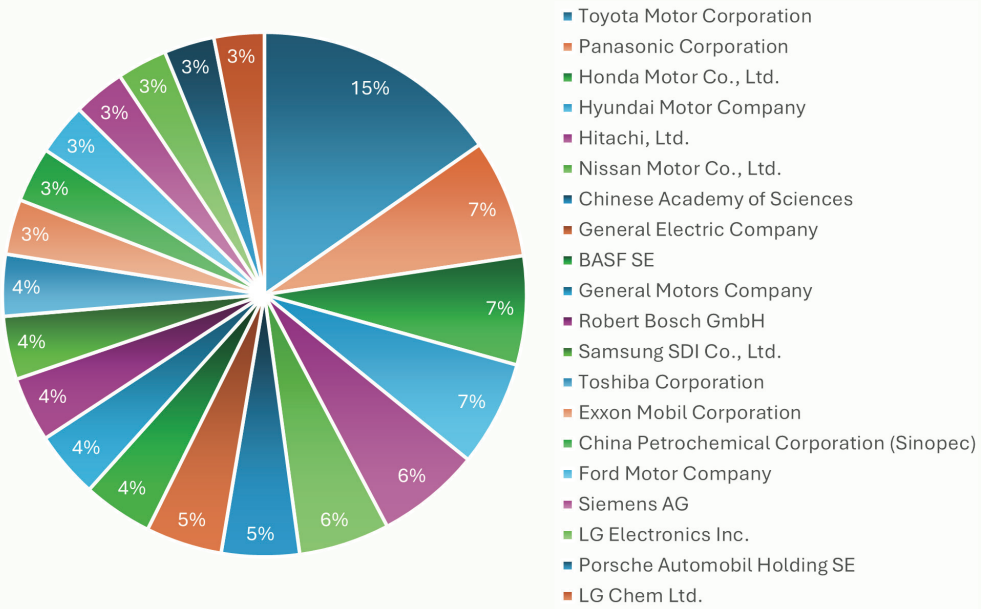
The Cooperative Patent Classification scheme **Y02** covers technologies related to mitigating or adapting to climate change. It includes subclasses such as:

- **Y02A** for climate change adaptation technologies
- **Y02B** for mitigation technologies in buildings
- **Y02C** to address greenhouse gas capture, storage, or disposal
- **Y02D** for mitigation in ICT focused on reducing energy
- **Y02E** relates to reducing greenhouse gas emissions from energy generation, transmission, or distribution
- **Y02P** for technologies in goods production and processing
- **Y02T** for clean transportation
- **Y02W** for wastewater treatment and waste management
- **YO4S** for smart grids.

Green technology innovations often require heavy R&D investment and capital, which favours big corporations. Hence, a few large corporations own a disproportionate share of the IP. For example, in the automotive sector's shift to electrification, companies such as Toyota, Honda, Hyundai, Nissan, General Motors and Ford each hold thousands of patents on electric vehicle and battery technologies. Similarly, in wind energy, just a handful of firms (Vestas, Siemens Gamesa, GE, Goldwind) account for most turbine technology patents and market share. This corporate concentration means these companies can set technology standards and benefit from economies of scale. Figure 2, based on Borthakur's work on Environmentally Sound Technologies (EST), shows the share of patents held by 20 organisations.[3] Different analyses name different companies depending on the metric, but a few names recur as top patent holders in decarbonisation technologies. Toyota is frequently cited as a top holder of "world-class" green patents (thanks to its hybrid and fuel-cell vehicle research) (EconSight 2023). Samsung (the electronics giant) appears right behind, due to its work on batteries and solar panel components. Others in the top tier include General Electric (with broad energy tech patents), Siemens, Mitsubishi, and newer entrants like Tesla (which, despite opening some patents, still has many filed). The concentration is such that the 10 companies with the largest green patent portfolios likely control a significant share of the total patent landscape in certain subfields (e.g., the top 3–5 battery makers hold most battery tech patents).

As discussed below, when a few companies hold critical patents, it can create high barriers to entry for other innovators and for local manufacturers in countries that need the technology. Patents give their holders exclusive rights, so others must negotiate licenses or risk infringement. This can slow down the diffusion of technology. There is broad consensus in the literature that, although patents incentivise innovation, they also *"limit the further commercialisation of mitigation technologies… and thus hinder global access to mitigation solutions."* (Raiser et al. 2017). Furthermore, there is an overlap with competition law. If a few companies not only hold patents but also dominate the market (forming an oligopoly), regulators may be concerned about anti-competitive practices. Some have argued that competition law (antitrust) could be invoked if patent holders unduly prevent the dissemination of climate-critical technologies (Dreyfuss and Pila 2018).

Figure 2: Percentage of patents per organisation

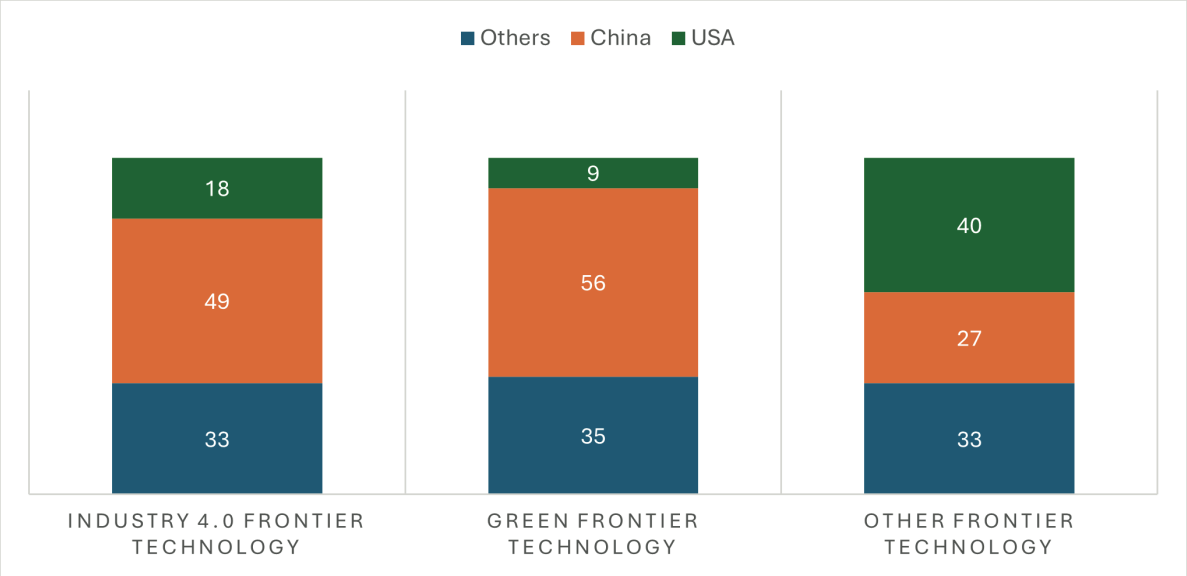


Source: (Borthakur 2023, 519)

3 It is noteworthy that, even when using a different metric than that employed in the studies cited above, these organisations are headquartered in the same five countries: Japan, China, the United States, Germany, and the Republic of Korea.

The technological divide between developed and developing nations highlights the risk of a new industrial revolution that is actually reshaping and deepening existing international inequalities. Indeed, within the developing world, most countries have only marginal ownership of green tech IP, with a few notable exceptions. China stands out as an emerging economy that has rapidly built a large green patent portfolio over the past few decades. China holds a dominant position in the global green technology patent landscape.[4] In the specific domain of green frontier technologies from 2000 to 2021, China led with 56% of all patents, significantly outpacing the United States at 9% (see Figure 2). China demonstrates particular strength in wind energy and solar panels, where it generated 33,066 and 31,365 patents, respectively, compared to 2,963 and 1,586 from the US (UNCTAD 2024b).

Figure 3: Country share of patents by frontier technology (2000–2021)



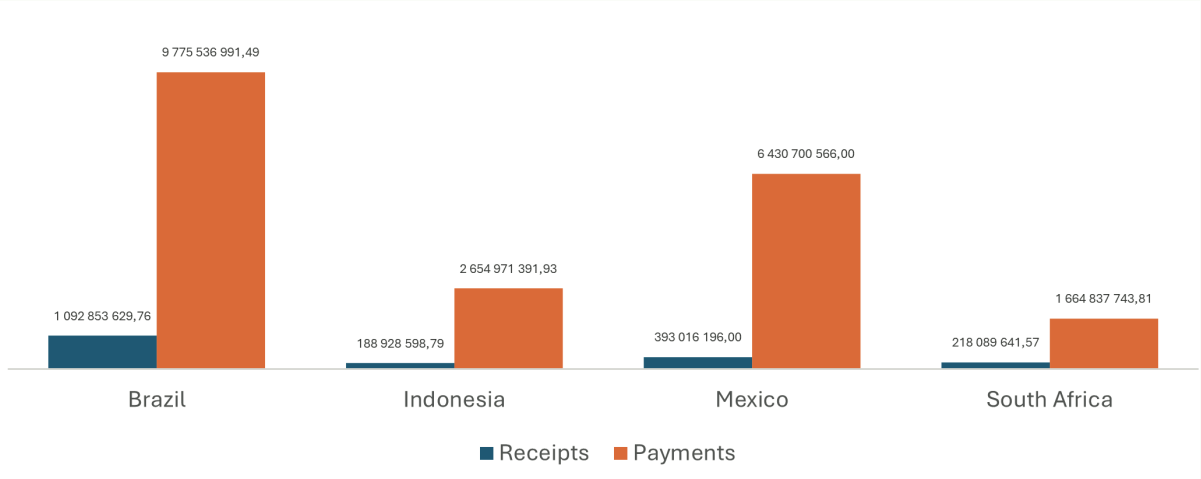
Source: (UNCTAD 2024b)

As disclosed by a recently published report by UNCTAD, no other developing country comes close: "None of the other emerging economies has registered many patents, and the gap with the industrialised world does not seem to be narrowing," (UNCTAD 2024, 112). For example, as of the late 2010s, Brazil accounted for only about 0.6% of global green patents, India 0.2%, Mexico 0.1%, South Africa 0.05%, and Indonesia effectively 0% (id. Ibid.). All five of these major developing economies combined still represent around 1% or less of worldwide green technology patent counts. This concentration of green technological capabilities in a few countries raises concerns about widening developmental gaps.

The costs of accessing technology for developing countries primarily consist of direct monetary payments, such as royalties, fees, and charges, paid to foreign rights holders for using intellectual property, including patents and industrial processes relevant to technologies (South Centre 2022). Figure 3 offers a comprehensive overview of cross-border payments for the export and import of intellectual property.

4 Since 2000, China has experienced a rapid surge in green patenting, and by 2017, it had accumulated 148,032 green patents across all patent offices, accounting for 17.7% of the world's total, second only to Japan. At the United States Patent Office (USPTO), Chinese inventors received over 6,200 green patents during this period, approximately 2% of all such patents there (UNCTAD 2024b, 112).

Figure 4: Charges for the use of Intellectual Property (Balance of Payments — current US$)

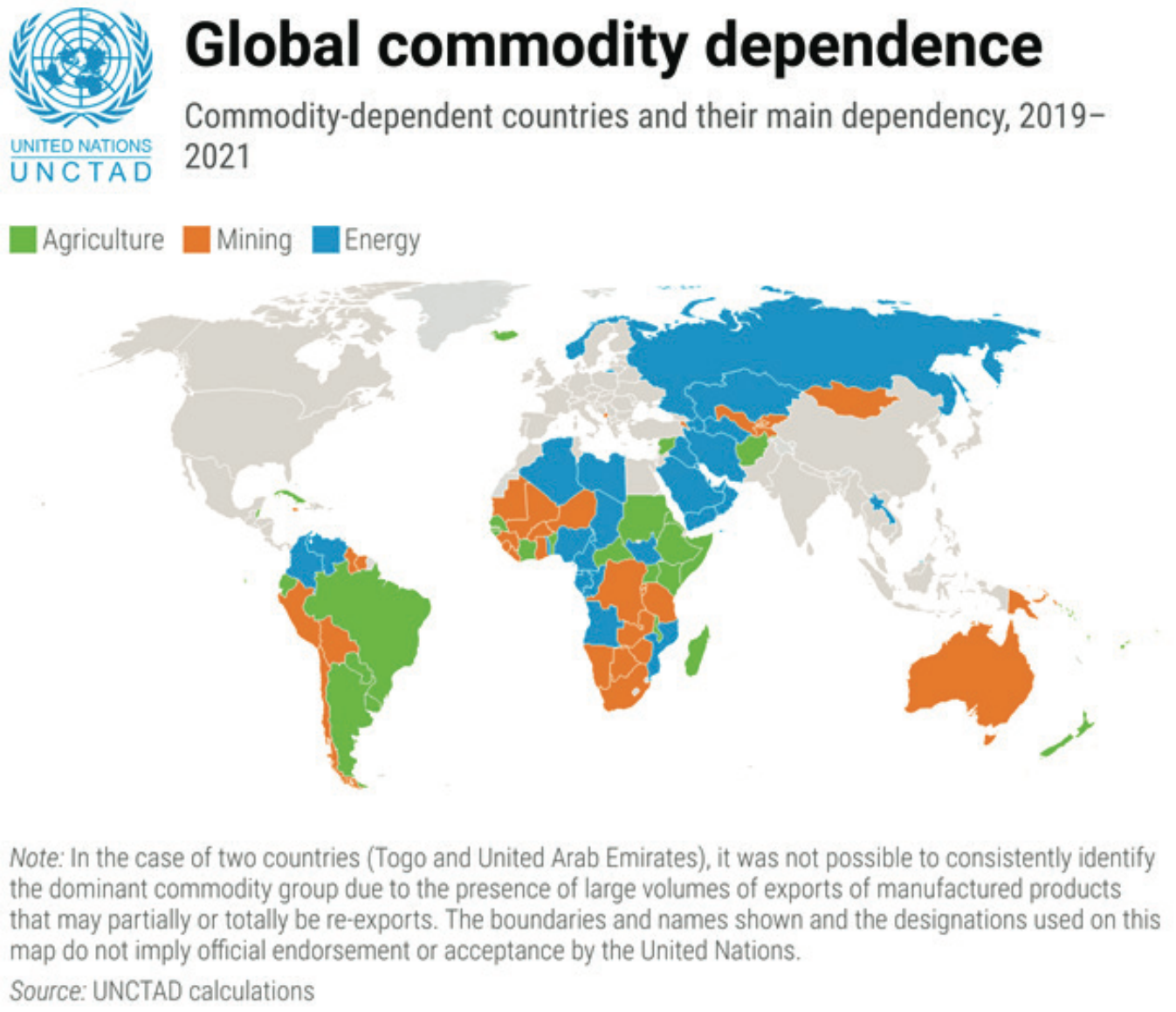


Source: World Bank, "Charges for the use of intellectual property, payments and receipts".

These transactions are documented in each country's Balance of Payments. Nevertheless, they reflect a fraction of the actual IPR expenses. Additional costs may be included in product and service pricing or transferred through related transactions, such as investments and mergers (South Centre 2022). Despite these limitations, the data reveal a noticeable imbalance between inbound and outbound transfers, typical of middle-income countries (MICs) — a pattern evident in Mexico, where payments are 16 times the amount received. While on average, MICs pay $6 for every dollar received, OECD countries have a ratio of 0.71. Although this data does not include specific figures for green technology, considering the IPR concentration described above, it is reasonable to assume that this imbalance is maintained or even worsened.

This concentration shows that developing countries rely on imports to access essential technologies, such as green technologies, with limited local production or innovation. As Rafitoson and Correa observed, the current global IP regime contributes to "concentrated production in a few countries, delaying global progress in the deployment of green and climate-friendly technologies" (Rafitoson and Correa 2025). Such a concentration contributes to keeping "nearly half of UN member countries (as) commodity dependent, relying on raw materials for over 60% of their export revenue (see Figure 4)"(UNCTAD 2025).

Figure 5: Global commodity dependence



Source: (UNCTAD 2024a)

The concentration of green technology patents and capabilities in a handful of industrialised countries has consequences for global development and climate action. This imbalance limits developing countries' ability to innovate and access critical green technologies, leaving them reliant on costly imports and subject to restrictive intellectual property regimes. As a result, these nations face increased technological and economic inequalities, struggle to move up global value chains, and risk missing out on the opportunities of a green transition. The lack of affordable and accessible green innovations hampers their efforts to fight climate change, perpetuating dependence and slowing global progress toward sustainability. Furthermore, current IPR regimes not only reinforce these disparities but also constrain and narrow the policy space available to developing countries for implementing effective green industrial policies. This restriction limits their capacity to design and execute strategies that would foster domestic innovation, build local capabilities, and facilitate equitable participation in the green economy. The following sections will unpack IPR costs and barriers imposed upon developing countries, and some alternatives to address intellectual property challenges and broaden the space for green industrial policies.

Access costs

Access costs are financial barriers that hinder developing countries from obtaining green technologies. High access costs directly slow the diffusion of green technology. Considering the green industrialisation landscape, most developing countries might end up supplying raw materials to support the green products protected by intellectual property that they will need to import. IPR regimes contribute to keeping developing countries in a lower position within green value chains while internalising most of their social and environmental externalities. Every year of delay in adopting a clean technology due to cost means continued reliance on polluting alternatives (Rafitoson and Correa 2025). In other words, when green tech is unaffordable, there is not only an economic cost but an environmental cost in foregone emissions reductions. Furthermore, high prices also limit the scale of implementation: a technology that is only affordable for one region will not achieve the wide deployment needed for significant climate or development gains. These costs include:

A. **Licenses and royalties:** Patent holders often charge monopoly prices in the absence of competition.[5] Upfront license fees or per-unit royalties significantly raise production costs in developing countries and may price out producers and consumers in the Global South (Rafitoson and Correa 2025; Correa 2018; Baker et al. 2017). When license fees are set at levels that only large or rich-market firms can afford, local industries in the Global South either cannot enter the field or must rely on older, non-patented tech. This perpetuates dependence on imported finished equipment, undermining local industrial growth. Indeed, a recurring theme in the literature is that patent-based monopolies tend to keep cutting-edge technology prices high, placing them out of reach for many companies in the developing world (’t Hoen 2009; Zaman 2013; Watal 2014; Baker et al. 2017). Nathan (2025) notes that the “knowledge divide” enforced by IPR regimes means that developing nations often rely on older, commodified technologies while patented knowledge yields significant profits for its holders. Even when licenses are available, they may come with **onerous conditions** that add costs. For instance, some technology licenses require the licensee to buy certain proprietary inputs or services from the licensor (a form of bundling), or to pay for ongoing technical support. There may also be **certification and compliance costs** associated with local production of protected technologies.

B. **Patent thickets, technology bundling, and restrictive licensing practices** are major obstacles that increase the cost and complexity of accessing green technologies for developing countries. A patent thicket is a dense web of overlapping patents covering incremental improvements to a single technology, making it difficult for new entrants to innovate or produce without negotiating with multiple patent holders (May and Sell 2006; Maurer 2015). In the field of green industrialisation, the Toyota Prius case demonstrates how a company can hold thousands of patents to prevent other companies from circumventing these composite technologies without obtaining licensing approval (Maskus 2012). Bundling of technologies occurs when patent owners require licensees to acquire a package of patents or to purchase proprietary inputs and services alongside the main technology, raising the overall cost and often including unnecessary or unwanted elements (Hilty 2016). Restrictive licensing practices involve imposing stringent conditions on the use of technology, such as limiting the scope of production, requiring exclusive purchases, or demanding high royalties and ongoing fees. Together, these practices significantly increase financial, legal, and administrative barriers for developing countries, deterring local innovation, perpetuating dependence on foreign suppliers, and delaying the adoption of critical climate technologies needed for sustainable development.

C. **Absorption costs:** According to the Intergovernmental Panel on Climate Change, technology absorption refers to a country’s ability to understand, use, adapt, and learn from imported technology to build

5 As Correa has noted, the price of a patented product can be many times higher than the competitive price — in the pharmaceutical context, a patented drug that costs $84,000 in the US was supplied for under $300 in countries without that patent (Correa 2018).

domestic capabilities. Technology absorption encompasses investments in specialised hardware, technical training, and infrastructure, which often dwarf the initial license fee. Simply obtaining a patent license is insufficient if local firms lack the capital and expertise to implement the technology effectively (Metz et al. 2000; Olawuyi 2018; Nathan 2025).

D. **Sanctions**: Countries must weigh the risk of trade retaliation when trying to reduce costs; using lawful TRIPS flexibilities (such as compulsory licenses) can provoke unilateral pressure or sanctions from powerful trading partners (e.g., the US Special 301 list), adding indirect barriers to affordable access (Muñoz-Tellez et al. 2019).

The literature highlights several approaches to **facilitate access to green technologies**:

- **IPR flexibilities:** Governments can employ TRIPS flexibilities, such as compulsory licensing, to authorise local production or importation of patented green technologies without the patent-holder's consent (while paying a reasonable royalty) (Maskus and Reichman 2004; May and Sell 2006; Zhou 2019; Gupta et al. 2023). This tool, used effectively in the pharmaceutical sector to lower medicine prices (Correa 2018), is increasingly advocated for climate-critical technologies under the argument that climate change is a global public health emergency (Vawda 2021; Nathan 2025).
- **Collective initiatives and voluntary measures:** Proposed patent pools would allow multiple patent holders to license a bundle of green technologies as a package on standardised, low-cost terms (World Bank 2012; Muñoz-Tellez et al. 2019; Rafitoson and Correa 2025). While no major climate tech pool exists yet, this model (inspired by the Medicines Patent Pool in health) could drastically cut licensing costs and complexity by providing "one-stop" access (World Bank 2012). Similarly, some firms have made patent pledges — for example, Tesla pledged not to enforce certain electric vehicle patents, effectively opening them for free use. Such voluntary measures show that alternative IP models can help disseminate technologies (Correa and Hilty 2022).
- **Financial mechanisms:** There are calls for differential pricing and subsidies to help developing countries afford green tech. For instance, companies could offer tiered pricing (lower prices in poorer markets), and international funds like the Green Climate Fund could subsidise or 'buy down' the cost of licenses for climate-essential technology (Rafitoson and Correa 2025). So far, these ideas remain mostly aspirational, and existing programs (e.g., WIPO GREEN) have not significantly lowered costs at scale. The consensus is that without deliberate interventions — whether through policy tools or financial support — many developing nations will remain unable to afford key green innovations (Muñoz-Tellez et al. 2019; Nathan 2025).

Transaction costs

Beyond pricing, developing countries face high transaction costs in acquiring green technology. In contrast to the upfront price of a technology (the access cost), transaction costs concern the process of obtaining the technology. If that process is too onerous, it can impede adoption just as surely as high prices can. Even once a needed technology is pinpointed, securing a license can be a lengthy, complex process. Negotiations involve navigating terms on scope, royalties, and confidentiality, typically requiring specialised legal expertise that many developing-country institutions lack. These transaction costs include:

A. **Information and search hurdles:** Identifying who holds relevant patents or provides a needed technology is often difficult. Patent information is fragmented across multiple databases and is technically complex. Moreover, there is no common taxonomy for green technology as the International Patent Classification (IPC) and the Cooperative Patent Classification (CPC) do not overlap. Besides, infor-

mation asymmetry is a key issue: developing-country firms and researchers often "don't know what they don't know" regarding available solutions (Ido 2019). Platforms like WIPO's GREEN database and the United Nations Framework Convention on Climate Change (UNFCC) Climate Technology Centre & Network (CTCN) aim to connect technology providers with seekers, but awareness and usage of these platforms on the ground remain limited (Syam 2017; Abdel-Latif 2015). The result is that opportunities are missed or multiple parties duplicate efforts in mapping the same technology landscape. Better centralisation and transparency of technology information — for instance, user-friendly patent landscape resources for developing countries — would significantly reduce search costs.

B. **Hidden costs of technology transfer:** Even when a green technology is available and nominally affordable, developing-country actors often face significant transaction costs in acquiring and implementing it. These are the indirect costs — time, effort, uncertainty, and complexity — involved in searching for relevant technologies and patent information, negotiating licenses or partnerships, navigating legal processes, and managing cross-border logistics. Such costs can delay or derail green projects, acting as a hidden barrier to technology transfer (Muñoz-Tellez et al. 2019).

C. **Complex negotiations and legal procedures:** Once a technology is identified, negotiating a license or joint venture can be lengthy and complex. License agreements must settle detailed terms (scope of use, territories, royalties, confidentiality, liability for infringement, etc.), and developing-country entities often lack experience and specialised lawyers for such negotiations (Correa 2025). They may have to hire costly external counsel, yet still face a power imbalance if the patent owner is a large multinational with a seasoned licensing team (Nathan 2025). Cumbersome legal frameworks can nullify flexibilities in practice. For example, the WTO's Article 31bis mechanism (to import medicines made under compulsory license) was so procedurally complex that it was scarcely used in 15 years (Vawda 2021; Muñoz-Tellez et al. 2019). Similar red tape for climate tech transfer would likewise deter countries from utilising available IP flexibilities.

D. **Uneven effects on seekers and suppliers**: High transaction costs not only burden those trying to acquire technology but can also discourage patent holders from engaging with many small licensees or partners. If negotiating and managing numerous deals becomes too costly, a technology owner might choose to license only to major markets or not at all, preferring to export products rather than share know-how. This dynamic further restricts the diffusion of technology to smaller or poorer countries, even if they are willing to pay, simply because the process is perceived as too troublesome by the supplier.

To lower these hidden barriers, the literature suggests several measures:

A. **Improving information platforms** to make patent and technology data more accessible (Syam 2017). A one-stop portal for green technology offers and needs — possibly integrating WIPO, UNFCCC, and other databases — would help firms quickly find available solutions and licensing opportunities.

B. **Standardising contracts and processes:** Developing model licensing agreements and toolkits can simplify negotiations for inexperienced parties. Streamlining legal procedures (e.g., simplifying the process for invoking a compulsory license or fast-tracking approvals for climate-related tech transfer) would reduce delays (Nathan 2025).

C. **Building local capacity:** Investing in training for local lawyers, patent officers, and tech transfer specialists can empower developing countries to handle negotiations and searches more efficiently (Syam 2025). In essence, strengthening the ability to navigate the IP system domestically can cut both costs and delays.

Legal and institutional barriers

The IPR legal framework itself often limits technology transfer. TRIPS and related agreements mandate strong patent protection worldwide, which has constrained the ability of latecomer countries to acquire green technologies. Correa (2025) notes that imposing uniform 20-year patent terms across all fields essentially "froze" the advantages of already industrialised nations, preventing today's poorer countries from imitating and producing new innovations. Many core climate technologies are patented by foreign firms, and overlapping patent thickets can render it infeasible for a newcomer to enter a sector without risking infringement (Correa 2025; Correa and Hilty 2022). Incumbents can also extend monopolies through minor follow-on patents, further locking out competition. Overlapping and ever-expanding patent rights create further obstacles, such as:

A. **Restrictive licensing practices:** Patent holders often impose conditions that limit wider diffusion — for example, exclusive licenses to a single local firm or restrictions on fields of use (Ido 2019). Such terms can create local monopolies and prevent multiple firms from using a technology.

B. **Litigation and external pressures:** The threat of patent infringement lawsuits (with their high costs) can deter firms in developing countries from trying to produce patented technology. Moreover, political pressure (e.g., US Special 301 trade pressures) discourages governments from using flexibilities such as compulsory licensing or stricter patent criteria (Muñoz-Tellez et al. 2019). This creates a chilling effect on policy measures that would promote access.

C. **TRIPS-plus constraints:** Free Trade Agreements and investment treaties often require stronger IP protections than TRIPS, further shrinking policy space. These "TRIPS-plus" provisions can mandate longer patent terms or limit compulsory licensing, and some treaties enable investors to sue governments over IP-related measures (Syam and Cai 2016; Khor 2017). Such commitments make it harder for countries to implement pro-access policies for green tech.

Experts urge developing countries to fully use permissible flexibilities (e.g., issuing compulsory licenses for crucial green tech and adopting strict patentability criteria to prevent trivial patents) and to do so collectively to withstand pressure (Vawda 2021). Internationally, proposals include a WTO *climate waiver* or declarations affirming the primacy of climate needs, as well as inserting safeguards into trade agreements to protect the right to access green technologies (Blasetti and Correa 2021). Greater South–South collaboration in R&D and patent pooling is also advised to reduce reliance on Northern-held IP (Syam 2017; Menezes 2018; Uddin and Karim 2020).

Information, knowledge and capacity gaps

Significant "soft" barriers also hinder green industrialisation. Many developing countries lack access to vital information, skills and know-how needed to acquire and deploy advanced technologies. These gaps include the following three areas:

A. **Limited awareness of technology options:** Many developing countries face gaps in information and know-how, hindering the adoption of green technology. They often lack awareness of existing or suitable technologies and scattered, hard-to-access data on climate-friendly solutions. While portals like WIPO GREEN and UNIDO aim to share information, many practitioners remain unfamiliar with them (Syam 2017).

B. **Shortage of IP and negotiation expertise:** Accessing foreign technology or protecting local innovation requires IP management expertise, often lacking in developing countries' institutions. These entities frequently lack dedicated IP staff and struggle with patent searches, filings, and licensing negoti-

ations. As a result, they miss opportunities or accept unfavourable terms (South Centre 2022). Tools like compulsory licensing or patent oppositions are underused due to unfamiliarity (Syam 2025). Building "IP literacy" is vital to facilitate technology transfer.

C. **Insufficient technical absorptive capacity:** Countries and companies need the human and institutional capacity to absorb and adapt it. Many advanced green technologies require skilled engineers, technicians and researchers to be implemented effectively. If a country lacks a strong expertise base, even openly available technology may not yield results (Vawda 2021; Nathan 2025).

The consensus in the reviewed literature is that closing these gaps must go hand in hand with IP reforms. Policy-makers aiming for green industrialisation should invest in building robust domestic innovation systems, establishing skills-upgrade programmes, strengthening universities and R&D institutes, setting up technology transfer offices, and fostering networks that enable knowledge to flow (Syam 2025; South Centre 2022). South–South cooperation remains an underused opportunity: emerging economies with specialised expertise, such as China or India in renewables, can exchange knowledge with less developed countries via joint projects and technical support (Muñoz-Tellez et al. 2019). Improving information platforms is also critical: consolidating databases and using tools such as AI to make patent data more accessible would help developing-country stakeholders identify available technologies and partners (Syam 2025). Ultimately, empowering developing countries not just to receive technology but to adapt, improve, and create it is essential for a sustainable and equitable green transformation (Nathan 2025).

Conclusion

The literature reviewed demonstrates a clear consensus that the current global IP regime poses a significant challenge to green industrialisation in developing countries. While strong IP rights can incentivise innovation, they have also created barriers to the diffusion of climate-critical technologies in the Global South. Patents for renewable energy and other green innovations remain heavily concentrated in a few advanced economies — roughly four-fifths of green technology patents are held in high-income countries — leaving developing nations with limited access to cutting-edge solutions. This imbalance reinforces a *"knowledge divide"* (Nathan 2025) and perpetuates technological dependency, undermining both global climate goals and the industrial development of poorer countries. In effect, today's IP systems have *"froze[n] the advantages of already industrialised nations"*, constraining latecomer countries' ability to acquire, imitate, or locally produce the green technologies needed for sustainable development. The result is a tension between innovation and diffusion: IP protections that drive research in the North are, at the same time, impeding technology transfer and equitable access in the South.

Across the studies surveyed, multiple barriers rooted in IP regimes are identified as hindrances to technology transfer and green industrialisation. High access costs — driven by patent-based monopoly pricing, licensing fees, and restrictive terms — make advanced green technologies unaffordable for many developing-country firms and governments. These costs translate directly into delays in adopting clean technology, with real economic and environmental consequences as countries remain reliant on older, polluting alternatives. Equally problematic are the steep transaction costs involved in obtaining technology: fragmented patent information, protracted licensing negotiations, and the need for specialised legal expertise often overwhelm the capacity of developing-country institutions. Even willing technology seekers and providers face disincentives — complex processes and legal uncertainties can deter firms from engaging in licensing deals with multiple small partners, effectively limiting diffusion to larger markets. The legal and institutional framework further skews the playing field. The WTO's TRIPS Agreement mandates uniform IP standards that limit policy space for countries to pursue differentiated approaches for climate technologies. Subsequent *"TRIPS-plus"* trade agreements have tightened these rules even more, curtailing the use of flexibilities such as compulsory licensing and extending patent monopolies. Such

constraints, combined with the threat of litigation or trade pressure if countries challenge IP rights, create a chilling effect on proactive technology transfer policies. Finally, information and capacity gaps remain a softer yet crucial barrier: many developing countries lack adequate data on available green solutions, as well as the technical and legal expertise to negotiate access or to adapt technologies to local needs. In summary, the evidence indicates that without intervention, IP-related barriers — from prohibitive costs and onerous transactions to restrictive laws and knowledge deficits — will continue to slow the diffusion of green innovations to those who need them most, with dire implications for both industrial development and climate action in the developing world.

Taken together, the evidence reviewed in this background paper points to a structural misalignment between the urgency of green industrialisation in developing countries and the way in which current intellectual property regimes allocate control over climate-critical technologies. Strong IP protections have helped to stimulate innovation. Still, they have also concentrated technological capabilities and decision-making power in a small number of countries and firms, driving up access and transaction costs, constraining policy space and reinforcing information and capacity gaps in the Global South. At the same time, a rich but fragmented landscape of alternative models and reform proposals has emerged — from TRIPS flexibilities and waivers to patent pools, open and collaborative licensing, differentiated pricing, South–South knowledge sharing and new forms of public and philanthropic finance — without yet coalescing into a shared, politically viable agenda for change. The task ahead, and the purpose of the wider research process led by Equal International, is therefore not simply to add another set of recommendations to an already crowded field, but to work with key actors to identify where the real policy demand lies, which combinations of tools are most promising in specific contexts, and how a Global South-led strategy on IP and green industrialisation could be built and sustained. This will require integrating legal, economic and technological analysis with an honest reading of power, incentives and diplomacy. This paper aims to be a shared reference point for discussions and key informant interview to follow where there will also be an opportunity to challenge and refine its framing, fill gaps in the evidence, and surface concrete entry points for action at national, regional, and multilateral levels. For multinational agencies, governments and the private sector the conversations that flow from this paper can help identify where targeted support — for example, to country-level coalitions, policy-maker convenings, experimentation with alternative IP arrangements, or long-term capacity-building — could unlock disproportionate benefits for green industrialisation and economic justice.

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