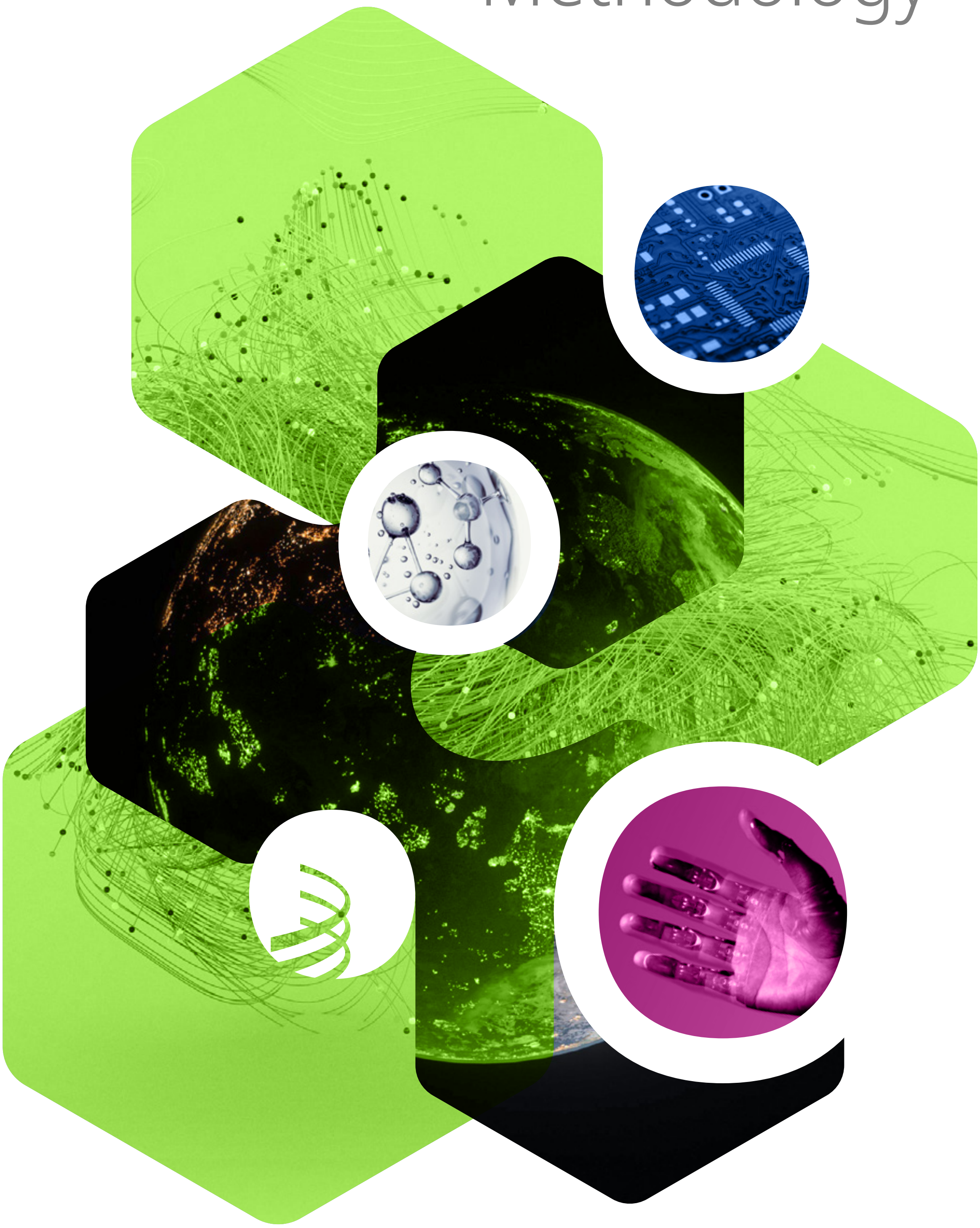
WIPO IPC-Green Technology Concordance

A Harmonized Classification Methodology



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A Harmonized Classification Methodology

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Abstract

The transition to a sustainable global economy depends critically on the development and diffusion of green technologies. Yet measuring innovation in this domain remains challenging, as differing institutional definitions of “green” technology generate inconsistent patent-based indicators, complicating comparative analysis.

This paper introduces the World Intellectual Property Organization’s Green Technology Inventory for Statistical Use (WIPO–GTIS), a new methodological framework based exclusively on consensus-driven International Patent Classification (IPC) codes. The resulting green technology concordance is designed to be accessible, requiring only IPC classification data and no keyword searches; transparent, with a fully documented and reproducible methodology; and robust, having undergone extensive validation, including artificial intelligence (AI)-assisted quality control. [1]

By providing a standardized and reliable framework for identifying green inventions in patent data, WIPO–GTIS aims to support researchers, policymakers and patent offices in measuring and analyzing green technology innovation with greater consistency. In doing so, it seeks to strengthen the evidence base for innovation, sustainability and climate-related policymaking.

[1] A shortened version of this paper, titled "Mapping Green Innovation: An Overview of the New WIPO IPC–Green Technology Concordance," is available at: https://www.wipo.int/web-publications/mapping-green-innovation-an-overview-of-the-new-wipo-ipc-green-technology-concordance/en/index.html

1. Introduction

Climate change represents the defining global environmental and economic challenge of the 21st century. Driven primarily by the accumulation of greenhouse gases from anthropogenic activities – including fossil fuel combustion, industrial production and land-use changes – rising global temperatures are triggering more frequent and intense extreme weather events, biodiversity loss and severe disruption to essential food and water systems. The Intergovernmental Panel on Climate Change (IPCC) notes that these impacts are already widespread, posing fundamental threats to human well-being and sustainable development across all regions of the globe (IPCC, 2023).

The economic consequences of these climate impacts are profound, systemic and intensifying. Major financial institutions, including the International Monetary Fund (IMF) and the World Bank, have repeatedly warned that climate change poses severe dual risks to global financial stability: *physical risks* (destruction of infrastructure, supply chain bottlenecks and declining agricultural and labor productivity) and *transition risks* (the financial shocks associated with stranded fossil fuel assets as economies decarbonize). The Organisation for Economic Co-operation and Development (OECD) has estimated that, in the absence of additional climate action, the economic impacts of climate change could reduce global annual gross domestic product (GDP) by between approximately 1.0% and 3.3% by 2060, with substantially larger losses projected for some developing regions (OECD, 2015).

Green technologies encompass a broad range of innovations that reduce environmental impacts, improve resource efficiency, lower greenhouse gas emissions or increase resilience to environmental risks. Fostering green technologies has emerged as a central component of global efforts to address climate change while simultaneously supporting economic development and industrial transformation. Notable examples include the UK Government Green Financing Framework (HM Treasury, 2025) and the EU taxonomy for sustainable activities (European Parliament and Council of the European Union, 2020), both of which define green investment categories – such as renewable energy, clean transportation and energy efficiency – that closely correspond to the IPC-based classification of green technologies employed in this study.

The transition to green technologies is generating significant economic opportunities worldwide. The clean energy sector has become a major source of investment, innovation and employment. The International Energy Agency estimates that approximately 36 million people were employed across clean energy supply chains globally in 2023, with clean energy sectors serving as the primary driver of growth in energy-related employment (IEA, 2024a). Global investment in clean energy technologies – including renewable energy generation, electric vehicles, batteries, energy efficiency improvements and related infrastructure – reached approximately USD 2 trillion in 2024, substantially exceeding investment in fossil fuels for the first time in history (IEA, 2024b).

Achieving a green and sustainable global economy has emerged as a central focus of international policy, industrial strategy and economic analysis (OECD, 2011), with green technology playing a pivotal role in driving this structural transformation. Consequently, understanding patterns of green technological innovation has become increasingly important for policymakers, researchers and international organizations. However, meaningful international comparisons that monitor technological change, support evidence-based policymaking and evaluate countries' technological capabilities require a coherent and transparent framework that enables technological activities to be categorized in a way that is both analytically relevant and internationally comparable.

2. Aims of this paper

This paper addresses this critical gap by introducing the World Intellectual Property Organization's Green Technology Inventory for Statistical Use (WIPO–GTIS). Developed through a systematic, consensus-based process, this new harmonized methodology relies strictly on an IPC–Green Technology Concordance Table, validated through AI-assisted quality control. The specific objectives of this paper are fourfold.

First, this paper provides a comprehensive review and comparison of existing green technology classification systems. By systematically analyzing the approaches adopted by the China National Intellectual Property Administration (CNIPA), the European Patent Office (EPO), the Japan Patent Office (JPO), the OECD and WIPO's existing IPC Green Inventory, it highlights the similarities and differences across these systems, identifies areas of consensus and divergence and explains how the new WIPO–GTIS classification builds upon and harmonizes these existing efforts.

Second, this paper presents the new WIPO green technology classification methodology, including its underlying principles, development process and resulting taxonomy. The classification comprises five overarching sectors and 36 distinct technology fields, each mapped to specific codes within the IPC system. The methodology is designed to be accessible, requiring only IPC codes without keyword searches; transparent, as it is fully documented and reproducible; and robust, having been validated through AI-assisted quality control. [2]

Third, this paper demonstrates the application of the new classification through global patenting evidence. Using patent family data from WIPO's statistical databases, it presents comprehensive statistics on global green technology innovation trends across countries, patterns of technological specialization and sector-specific dynamics. This empirical analysis highlights the analytical potential of the new classification while also providing substantive insights into the state of global green technology innovation.

Fourth, this paper transparently discusses the limitations of the new classification and identifies areas for future refinement. Any classification system involves trade-offs and limitations arising from the underlying structure of patent classification systems, the evolving nature of technology and methodological choices. By clearly articulating what the new classification can

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[2] Although we do not use keyword searches to identify green technology patents, some patent offices employ keyword searches to classify patents by IPC codes. This implies that, even though we do not directly use keyword searches, we nonetheless benefit from the work carried out by offices that rely on keyword searches for IPC classification. We are grateful to Bettina Reichl for pointing this out.

and cannot capture, the paper aims to support its appropriate use and interpretation while also identifying opportunities for further enhancement.

The remainder of this paper is structured as follows. Section 3 documents the use of patents as indicators of green innovation. Section 4 provides an overview of existing green technology classification systems. Section 5 outlines the new WIPO–GTIS. Section 6 applies this new classification to present trends in global innovation activity in green technologies. Section 7 concludes with a discussion of the main findings. Annex A provides the full methodological documentation, along with the complete concordance table linking the 36 green technology fields to their corresponding IPC codes.

3. Patents as indicators of green innovation

The use of patent data to measure innovation has a long tradition in innovation studies and economic research. Since the pioneering work of Schmookler (1966) and Griliches (1990), patents have been widely employed as indicators of inventive output, with extensive research demonstrating their usefulness for tracking technological change, measuring innovation performance, analyzing knowledge diffusion and assessing the effects of policy interventions. Consequently, patent indicators have become a valuable tool in research on environmental innovation, climate policy and technological change (Acemoglu et al., 2012; Haščič and Migotto, 2015; Johnstone et al., 2010; Popp, 2002). Patent-based measures have been used to examine the international diffusion of clean technologies (Dechezleprêtre et al., 2011; EPO, UNEP and ICTSD, 2010), patterns of technological specialization in renewable energy (Popp et al., 2011), and the development of emerging green technologies, including hydrogen and advanced battery technologies (EPO and IEA, 2020; EPO and IEA, 2023).

While patents have limitations – since not all innovations are patented and patents vary in their technical and economic significance – they remain among the most reliable and widely used indicators of technological innovation. Furthermore, the use of patent indicators to monitor green technology has become common practice among intellectual property offices such as CNIPA, the EPO, the JPO and WIPO, as well as within the OECD. Each of these institutions applies different approaches to mapping patent data to so-called “green technologies”. However, the methodological approaches and the scope and boundaries of what constitutes green technology differ considerably (see Section 4).

Identifying green technologies within the universe of patented inventions presents distinctive challenges. Green technologies constitute a complex and diverse set of fields spanning energy, transport, manufacturing, agriculture, construction, waste management and numerous other domains. Unlike many technology areas that correspond relatively cleanly to established patent classification categories – for example, pharmaceuticals or semiconductors – green technologies represent a cross-cutting theme defined by environmental function rather than technical domain. A wind turbine and an electric vehicle battery serve similar environmental purposes (reducing greenhouse gas emissions) but employ entirely different technical principles and fall under different areas of the patent classification system.

This cross-cutting nature creates a “classification challenge”. [3] Patent classification systems – including the IPC maintained by WIPO and the Cooperative Patent Classification (CPC) jointly

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[3] Patent classification systems are built to classify technical solutions to technical problems, making them ill-suited to fully describe the nature of a technology’s application. Exceptions exist, for example, technologies related to wind

maintained by the EPO and United States Patent and Trademark Office (USPTO) – are organized primarily around technical function, application domain and scientific principle rather than environmental purpose. Consequently, green technologies are dispersed across hundreds of classification categories throughout the patent system. There is no single IPC class or section labeled "green technology"; rather, environmentally beneficial innovations must be identified by recognizing which specific technical categories contain technologies with environmental relevance.

Compounding this challenge is the question of boundaries: what qualifies as a "green" technology? While certain innovations – such as solar photovoltaic cells or wind turbines – are universally recognized as green technologies, many cases involve greater ambiguity. Should a nuclear power plant be included? Some users consider nuclear power to be "green" while others do not. The definition of green technology depends on users' policy priorities, environmental criteria and analytical objectives. The term "green technology" encompasses a broad range of concepts and is referred to differently across disciplines, policy frameworks and industries. Related terms include clean technology, climate mitigation technology, environmentally sound technology, sustainable technology, low-carbon technology, climate technology, resource-efficient technology and circular economy technology (see Figure 1). While these terms may emphasize different environmental objectives, they generally describe technologies designed to reduce environmental impacts and support sustainable development.

These challenges have led various institutions to develop their own approaches to identifying and classifying green technologies within patent data, often employing different definitions of what constitutes a "green" technology and applying different methodological strategies. Notable classification systems have been developed by CNIPA (the IPC Green and Low-carbon Technology Inventory), the EPO (the Y02/Y04S tagging scheme for climate change mitigation technologies), the JPO (the Green Transformation Technologies Inventory), the OECD (the ENV-TECH classification), and WIPO (the IPC Green Inventory). While these initiatives have significantly improved the availability of data on environmental innovation and enabled valuable research, the classifications differ substantially in scope, structure, level of detail and underlying assumptions about which technologies should be considered "green".

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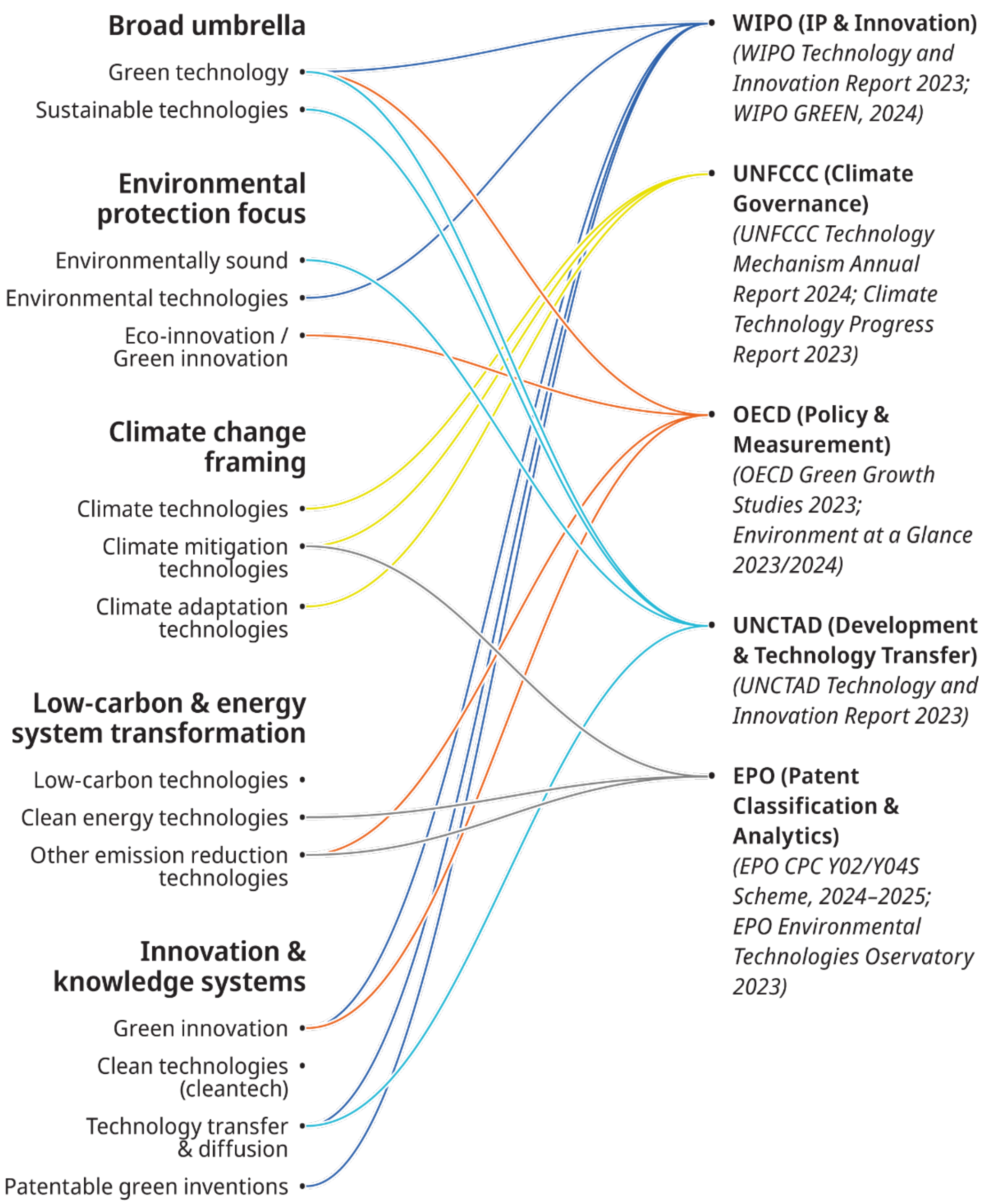
energy or solar energy are considered inherently green by definition. However, the vast majority of technologies are only green when used for green applications; they may have green potential but are not green by general understanding or by IPC classification. This paper therefore adopts a taxonomy that covers three categories: (1) technologies that are green by nature (fully green); (2) those with green potential; and (3) those with green transformation ability. Such technologies may currently be deployed in carbon-intensive applications and may have a prolonged transition period, but there are grounds to believe the underlying technology can meaningfully contribute to a green transformation.

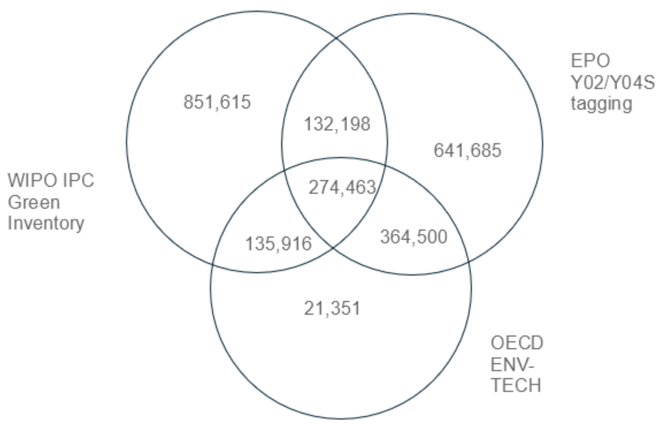
Figure 1. Terminology ecosystem of green technology



Notes: Terminology varies across institutions depending on mandate and purpose. Overlaps exist but emphasis differs.

A recent study shows that applying different classification systems to the same patent universe yields substantially different patent volumes and growth rates, significantly altering the perceived landscape of green innovation (Favot *et al.*, 2023). A comparison of three green technology classifications – OECD ENV-TECH, the WIPO IPC Green Inventory and the EPO Y02/Y04S tagging scheme – showed that only 22.4% of patents were shared across all three systems. [4] Similarly to Favot *et al.*, we compared patent family data based on the following three green technology classifications: EPO, OECD and WIPO. In total, the three classifications identified 2.4 million unique patent families with at least one green technology attribute for the period 2021 to 2023. Only 11.3% of green patent families were shared across all three classifications, while 35.2% were identified only by the WIPO classification and 26.5% only by the EPO classification (see Figure 2). For policymakers seeking to benchmark national performance or evaluate policy effectiveness, such inconsistencies are highly problematic. Similarly, for international organizations tracking global progress toward climate goals, the lack of a harmonized measurement framework limits coordination and weakens evidence-based synthesis.

Figure 2. Comparison of patent families based on the EPO, OECD and WIPO classifications



Source: Author's calculations based on the WIPO Statistics Database, June 2026.

Furthermore, existing classification systems vary in their accessibility and applicability for statistical analysis. Some systems provide comprehensive lists of patent classification codes that can be directly applied by any user with access to patent data. Others, however, require additional information beyond patent classifications – such as keyword searches of patent text – to achieve adequate precision. While keyword-based approaches can improve accuracy for users with access to sophisticated patent databases and search tools, they create barriers for researchers with limited database access, and other users who cannot easily replicate keyword-intensive methodologies.

[4] The result is based on patent applications filed by Italian applicants at the EPO during the period 2011–2020 (Favot *et al.*, 2023).

These considerations underscore the need for a harmonized, internationally recognized statistical standard for identifying patents pertaining to green technologies. Such a standard would enable researchers across countries and institutions to conduct studies using consistent methodologies; facilitate accurate international comparisons of green innovation performance; support policymakers with reliable statistical data to inform policy formulation and evaluation; and lower barriers to green technology analysis for users without access to expensive patent databases and search tools.

4. Existing green technology classifications

The challenge of identifying and measuring green technologies within patent data has prompted several major intellectual property offices and international organizations to develop specialized classification systems (see Box 1). This section provides a comprehensive review and comparison of five major systems: [5]

- CNIPA: IPC Green and Low-carbon Technology Inventory
- EPO: Y02/Y04S tagging scheme for climate change mitigation technologies
- JPO: Green Transformation Technologies Inventory (GXTI)
- OECD: ENV-TECH classification
- WIPO: IPC Green Inventory.

Box 1: Details of each classification can be found at:

- https://english.cnipa.gov.cn/module/download/down.jsp?i_ID=182612&colID=3192
- https://www.epo.org/en/searching-for-patents/technology-platforms/clean-energy
- https://link.epo.org/web/climate_change_mitigation_technologies_europe_en.pdf
- https://worldwide.espacenet.com/patent/cpc-browser#!/CPC=Y02;
- https://doi.org/10.1016/j.wpi.2011.12.004
- https://www.jpo.go.jp/e/resources/statistics/gxti.html
- www.oecd.org/content/dam/oecd/en/publications/reports/2015/06/measuring-environmental-innovation-using-patent-data_g17a2686/5js009kf48xw-en.pdf
- https://www.wipo.int/classifications/ipc/green-inventory/home

CNIPA released its IPC Green and Low-carbon Technology Inventory in 2023. The classification aims to support statistical monitoring of technological progress in China's green technology innovation. The CNIPA inventory shares important characteristics with other green technology

[5] While the patent classification systems listed here focus on identifying technologies within intellectual property data, a complementary set of frameworks has been developed for measuring the economic contribution of environmental and clean technology sectors. These economic statistics frameworks, while not patent classifications per se, provide important context for understanding how green technology innovation measured through patents relates to broader economic indicators such as GDP contribution, employment, trade and investment. The United Nations Statistics Division (UNSD) maintains the Classification of Environmental Purposes (CEP), which provides an international standard for classifying environmental protection and resource management activities across economic accounts (UNSD, 2023). Statistics Canada has developed the Environmental and Clean Technology Products Economic Account (ECTPEA), which measures the economic contribution of environmental and clean technology products in terms of GDP, employment and other economic variables (Government of Canada, 2024; Statistics Canada, 2025a; Statistics Canada, 2025b). Canada's Clean Technology Data Strategy and associated taxonomy define clean technology goods and services for statistical purposes. This area is beyond the scope of this paper.

classifications (as outlined in Table 1) in its reliance on IPC codes and its design for statistical applicability. A notable feature of CNIPA's inventory is its explicit integration of "low-carbon technology" alongside traditional "green technology" categories, reflecting the centrality of decarbonization in China's environmental strategy.

The EPO's approach to green technology classification differs fundamentally from the IPC-based systems. Rather than identifying existing IPC codes associated with environmental technologies, the EPO has developed a dedicated classification scheme specifically for climate change mitigation technologies. Such technologies are designated with Y-codes within the CPC system (Veefkind *et al.*, 2012; Angelucci *et al.*, 2018). The Y-scheme provides exceptional detail in certain technology domains. The methodology underlying the Y-scheme differs significantly from IPC-based approaches. Rather than being applied automatically based on technical characteristics captured in primary IPC/CPC classifications, Y-codes are assigned by patent examiners based on their judgment as to whether an invention contributes to climate change mitigation. However, since August 2022, the tagging of Y02/Y04S codes has been performed using AI, replacing the previous process of manual assignment by patent examiners. [6] The Y-scheme represents a sophisticated and valuable approach to green technology classification. However, this approach also has important limitations. First, Y02 tags are only applied to patents within the CPC system, meaning patents filed only at non-CPC patent offices may not be captured. Second, it creates potential reproducibility challenges: other institutions seeking to develop analogous statistics must either access the EPO's Y-tagged data or develop alternative identification methods.

The JPO's Green Transformation Technologies Inventory (GXTI) (JPO, 2022) is Japan's systematic framework for measuring innovation in technologies supporting the country's Green Transformation (GX) strategy. The GXTI employs Japan's multilayered patent classification system, utilizing not only IPC codes but also File Index (FI) codes and F-terms. F-terms provide another layer of faceted classification, describing technical features, applications and effects across multiple dimensions. This multilayered approach enables the JPO to achieve exceptional precision in identifying relevant technologies, potentially capturing green innovations that might be difficult to isolate using IPC alone. However, this precision comes with an important limitation for international applications: FI codes and F-terms are specific to the Japanese patent system. While all patents filed in Japan receive these classifications, patents filed only in other countries do not. Consequently, researchers seeking to apply the GXTI methodology to analyze green technology innovation in China, Europe, the US or other jurisdictions cannot directly replicate the JPO's classifications unless they map FI and F-terms back to equivalent IPC codes or develop analogous classifications using the CPC or other systems.

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[6] Held, P. (2024). *AI-Supported Classification*, CPC Annual Meeting, March 2024. https://link.epo.org/cpc/11th-CPC_Annual_meeting/EPO_AI-supported_classification.

The methodology underpinning the OECD's ENV-TECH involved systematic expert review of the IPC system combined with validation against technology descriptions and patent examples. For each technology field, environmental and technology experts identified IPC codes corresponding to inventions with clear environmental benefits. The OECD classification is designed to work primarily through IPC codes alone, although the accompanying methodological documentation notes that for certain technology fields, keyword searches may enhance precision. A limitation of the ENV-TECH classification for some users is its structural complexity. With nine domains and over 80 technology fields, the classification provides granular detail valuable for specialized research but is potentially overwhelming for users seeking higher-level overview statistics or policy indicators.

The WIPO IPC Green Inventory, first launched in 2010 and regularly updated since then, represents one of the pioneering efforts to systematically organize patent classification information for environmentally sound technologies (ESTs). The inventory provides a comprehensive listing of IPC classification "places" where green technologies can be found, organized into seven major thematic categories: alternative energy production; transportation; energy conservation; waste management; agriculture/forestry; administrative, regulatory or design aspects; and nuclear power generation (WIPO, 2023). The primary purpose of the IPC Green Inventory is to collect all IPC technical fields relating to ESTs in one place, thereby facilitating searches for patent information in this area. The methodology for developing the inventory involved expert review of the IPC system to identify classification places associated with environmentally beneficial technologies. WIPO has also established a platform to promote the diffusion of green technology: WIPO GREEN (WIPO, 2021) (see Box 2 below) – a global matchmaking service that connects technology providers with technology seekers.

Box 2. WIPO GREEN: connecting the technology marketplace

WIPO GREEN is a global platform connecting providers and seekers of ESTs to facilitate technology transfer and accelerate the deployment of green innovation worldwide. Launched in 2013, the platform operates a public database where technology holders (universities, research institutions, companies) can showcase available technologies, while users (companies, entrepreneurs, governments) can identify solutions relevant to their environmental challenges. It is a solutions database rather than a patent database and there is no requirement for an uploaded technology to have associated patents.

The platform has grown to include over 4,500 registered users from more than 100 countries. Although it has global reach, WIPO GREEN runs on-the-ground green technology matchmaking projects supporting developing and least-developed countries in accessing technologies for climate change mitigation and adaptation, clean energy, sustainable agriculture and environmental protection. Besides uploaded and available technologies, the database also contains a large number of green technology patents identified through the

EPO Y-classification and imported through IPC codes from WIPO's PATENTSCOPE database. This integration of classification infrastructure with technology transfer mechanisms exemplifies how patent information systems can support broader sustainable development objectives.

Since its inception, WIPO GREEN has facilitated technology partnerships contributing to renewable energy installations, waste management systems, water purification projects and agricultural innovations across multiple continents. The platform demonstrates that effective technology transfer requires not only identifying relevant innovations but also creating trusted mechanisms for connection, negotiation and knowledge exchange between providers and users.

Some green technology classifications rely exclusively on the IPC, identifying specific IPC codes associated with green technologies. Others supplement the IPC with additional classification tools; the JPO's GXTI employs FI codes and F-terms, which provide additional granularity beyond IPC but are specific to the Japanese patent system (see Table 1). The EPO's approach creates new classification tags (the Y-codes) within the Cooperative Patent Classification system, which patent examiners apply to relevant documents alongside standard technical classifications. Some systems are designed to work purely through classification codes without requiring keyword searches, while others achieve greater precision by combining classification codes with text-based searches of patent titles, abstracts or claims. These methodological differences have important implications for the accessibility, applicability and international comparability of the resulting statistics. Classifications relying solely on the IPC can be applied by any user with access to patent data, as the IPC is universally assigned to patent documents across all major patent offices. Systems requiring CPC access, JPO-specific classification tools or sophisticated keyword-searching capabilities create higher barriers to entry for users, particularly in developing countries or statistical offices with limited resources for patent analytics.

These methodological differences have practical implications. Researchers prioritizing international comparability and accessibility will prefer IPC-only systems. Those seeking maximum precision for specific jurisdictions may prefer enhanced systems (the JPO's FI/F-terms for Japan; the EPO's Y-codes for European/international applications). There is no single "best" methodology; rather, different approaches serve different purposes within the broader ecosystem of green technology measurement.

Table 1. Overview of major green technology patent classification systems

Organization	Classification framework	Core methodology	Main purpose	Scope	Limitations	Number of categories (see Annex B)
CNIPA	IPC Green and Low-carbon Technology Inventory	IPC	National statistics and policy monitoring	Green and low-carbon technology	Highly comprehensive, but includes very broad IPC codes (e.g., general rail technologies), leading to statistical “noise” and overcounting.	5 major categories
EPO	Y02/Y04S Tagging Scheme	CPC	Classification; search and statistics	Climate mitigation	Relies on the CPC system (not universally used) and human/algorithmic tagging, requiring access to advanced CPC-enabled databases.	Around 12 major categories
JPO	Green Transformation Technologies Inventory (GXTI)	IPC/FI/F-terms/keywords	GX policy monitoring and national statistics	Green transformation	Requires combining IPC codes with highly specific keyword searches, which introduces language biases across different jurisdictions.	6 major categories
OECD	ENV-TECH Indicator	IPC/CPC/keyword combinations	Statistical analysis and international comparison	Environmental innovations	Frequent updates and reliance on complex search strings (including keywords) make it difficult to replicate without specialized database access.	9 major categories
WIPO	IPC Green Inventory	IPC linked to United Nations Framework Convention on Climate Change (UNFCCC) terms	Technology search	Broad	Established to facilitate searches for patent information relating to ESTs, this tool includes relatively broad IPC classifications, which may introduce noise and overcounting in search results. As a result, caution should be exercised when using it for statistical purposes, as it may affect the accuracy of the findings.	7 major categories

Although the methodological approaches and scope of green technologies differ across the five classification systems presented in Table 1, a significant degree of convergence can be observed. A number of technologies are consistently included across most or all systems. These can be identified as core green technologies. In addition, a second group of technologies can be identified for which inclusion is less consistent across classification systems. These are referred to as moderate-consensus green technologies, reflecting variation in definitional criteria and policy frameworks (see Table 2).

The core green technology category comprises technologies that are consistently recognized across classification systems and are associated with clear and direct environmental benefits, particularly in terms of greenhouse gas emission reduction, pollution abatement and resource efficiency. Their widespread inclusion reflects both technical convergence regarding environmental performance and broad policy alignment across jurisdictions and institutional frameworks.

The moderate-consensus category comprises technologies for which classification outcomes differ across systems due to variations in methodological scope, sustainability criteria or policy considerations. These differences are particularly evident in technologies where environmental performance depends on system boundaries, production pathways or lifecycle characteristics. For example, bioenergy and biofuels are generally associated with the energy transition; however, classification varies depending on whether systems include all forms of biofuels or restrict inclusion to advanced, non-food-based feedstocks. Similarly, nuclear energy is included in certain classification systems based on its low operational greenhouse gas emissions, while other systems exclude it due to considerations related to radioactive waste management, safety and broader policy sensitivities.

Table 2. Coverage and overlap in green technology classification systems

Core green technologies (high-consensus: included in all or most classification systems)	**Moderate-consensus green technologies (variable inclusion across classification systems)**
Solar photovoltaic energy generation	Biofuels and bioenergy (included broadly in some systems; selectively in others based on sustainability criteria)
Wind energy generation	Nuclear energy (included in WIPO Inventory and some national systems; excluded from or separated in climate-focused systems due to policy sensitivities)
Electric battery storage	Carbon capture and storage (included in all climate-focused systems but sometimes narrowly defined)

Hydrogen production and fuel cells (emerging technology with varying levels of granular treatment)	
Battery electric vehicles	
Wastewater treatment technologies	Energy-efficient industrial processes (included conceptually but with different scope definitions)
Waste recycling and recovery technologies	Smart energy and grid management systems (varying boundaries between hardware, software and system integration)
Energy-efficient lighting (LED)	Sustainable agriculture technologies (included broadly in comprehensive systems; more selectively in climate-focused systems)
Building insulation and thermal efficiency	

The coverage analysis presented in Table 3 reveals that while substantial consensus exists on core green technologies – particularly renewable energy generation, electric mobility, energy storage and major pollution control/waste management technologies – meaningful divergence exists at the margins. These divergences reflect legitimate differences in policy priorities (what users want to measure), methodological philosophies (comprehensiveness versus selectivity) and technical assessments (which technologies provide sufficient environmental benefits to merit inclusion).

For users, these patterns have several implications. First, statistics on “core” green technologies should be relatively comparable across systems, enabling robust international comparisons. Second, statistics on moderate-consensus or low-consensus technologies should be interpreted with attention to definitional boundaries, and comparisons across studies using different classifications should be made cautiously. Third, the existence of divergence is not necessarily problematic – different institutional contexts may legitimately require different classification boundaries. However, it underscores the value of a harmonized reference classification that could serve as a common baseline for international comparison while allowing specialized extensions for specific policy contexts.

Table 3. Technology coverage comparison across classification systems – selected technologies

Technology	WIPO IPC Green Inventory	OECD ENV-TECH	CNIPA	JPO GXTI	EPO Y02/Y04S	Consensus level
Solar photovoltaic	✓	✓	✓	✓	✓ (Y02E 10/50)	High
Wind energy	✓	✓	✓	✓	✓ (Y02E 10/70)	High
Hydropower	✓	✓	✓	✓	✓ (Y02E 10/20)	High
Nuclear energy	✓ (separate category)	✓ (separate domain)	✓	✓	✓ (Y02E 30/00)	Moderate
Battery electric vehicle (EVs)	✓	✓	✓	✓	✓ (Y02T 10/70)	High
Hydrogen fuel cells	✓	✓	✓	✓ (detailed)	✓ (Y02E 60/50)	High
Biofuels (all types)	✓ (broad)	✓ (selective)	✓	✓	✓ (Y02E 50/10)	Moderate (scope varies)
LED lighting	✓	✓	✓	✓	✓ (Y02B 20/00)	High
Smart grids	✓	✓	✓	✓	✓ (Y04S)	High
Recycling technologies	✓	✓	✓	✓	✓ (Y02W 30/00)	High
Wastewater treatment	✓	✓	✓	✓	✓ (Y02W 10/00)	High
Energy-efficient appliances	✓ (various categories)	Limited	✓	✓	✓ (Y02B 40/00)	Moderate
Sustainable aviation	Limited	Limited	Limited	✓	✓ (Y02T 50/00)	Moderate
Rail transport	✓ (broad)	✓	✓ (broad)	✓	✓ (Y02T 30/00)	Moderate (scope varies)

Key: ✓ = included; Limited = partially covered or limited IPC precision

5. The new WIPO green technology inventory for statistical use (WIPO–GTIS)

The comprehensive review above demonstrates that substantial progress has been made in green technology classification for patent analysis, with multiple sophisticated systems now available. Yet it also reveals important limitations: divergent definitions and methodologies limiting international comparability; varying structural frameworks impeding aggregation and analysis; and accessibility barriers for users without specialized resources (i.e., access to databases for keyword searches). To address these drawbacks, WIPO has developed a new green technology taxonomy specifically designed for statistical use. It is intended to complement existing green technology classifications.

Development of the new WIPO green technology classification (fully detailed in Annex A) was guided by a methodological framework designed to balance international harmonization, precision, global accessibility and transparency. To capture core technologies with broad international recognition, the process employed a consensus-based strategy, prioritizing technologies present in at least two existing classifications (CNIPA, EPO, JPO, OECD and WIPO). This baseline was then refined through rigorous IPC filtering and AI-assisted quality control. The resulting framework is defined by four core design principles:

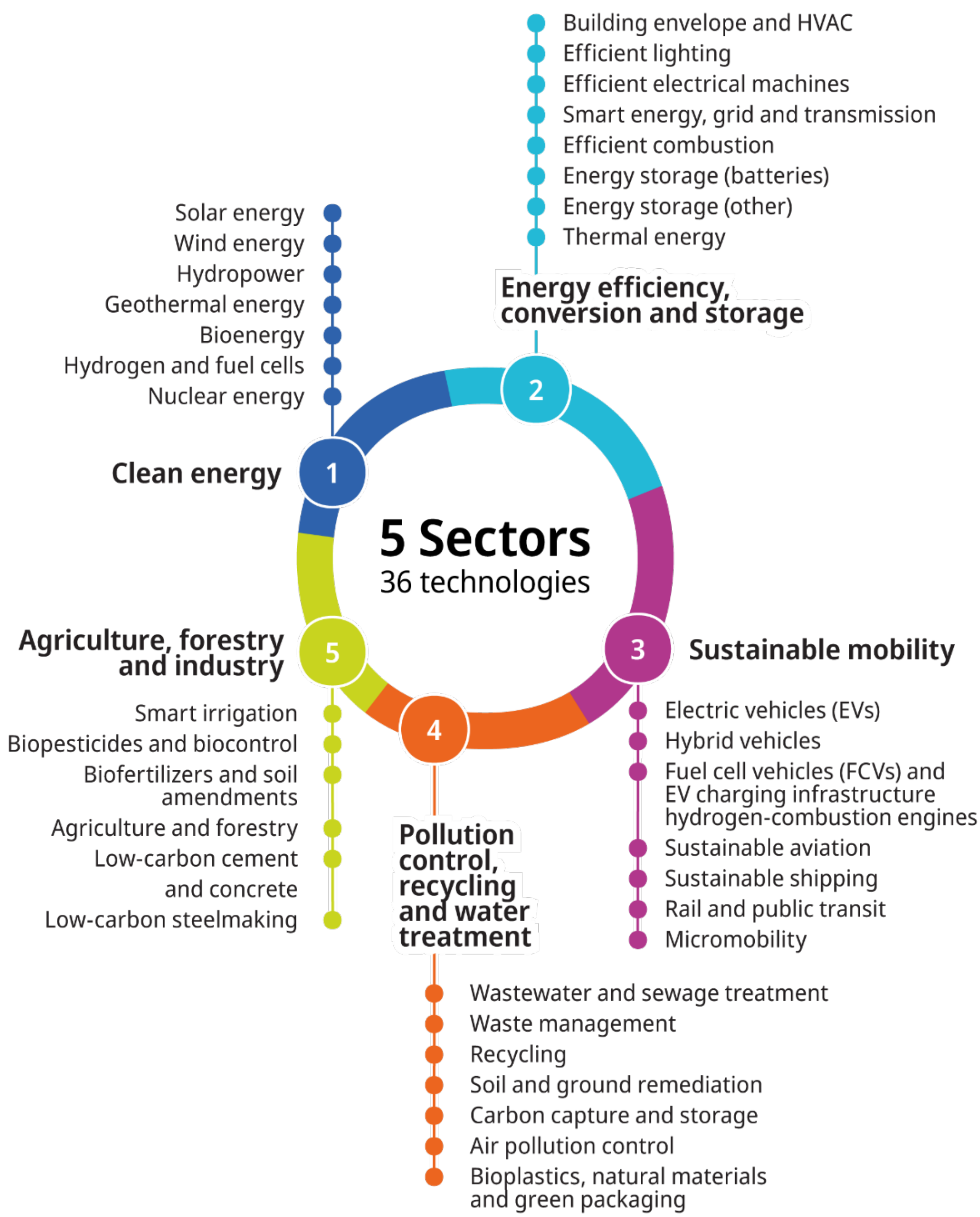
1. **Focus on “core” green technologies**: Instead of attempting to comprehensively capture every tangential application, this taxonomy selectively focuses on essential technologies commonly recognized as green. By systematically analyzing existing classifications (CNIPA, EPO, JPO, OECD and WIPO Inventory), the new approach prioritizes technologies recognized across multiple systems. This consensus-driven method reflects collective international expertise and actively eliminates the “noise” that has historically distorted statistical comparisons. By prioritizing precision and usability over exhaustive coverage, the classification deliberately excludes areas where there is no common agreement as to whether they qualify as green, as well as technologies with significant dual-use characteristics or inherent patent classification difficulties. All limitations are transparently documented.
2. **Exclusive reliance on IPC codes:** The new methodology uses only IPC codes, deliberately avoiding semantic keyword searches, the CPC or jurisdiction-specific systems. This design choice eliminates considerable language biases and removes the need for expensive database subscriptions or specialized search expertise. By relying solely on an

IPC concordance table, the approach democratizes data access. Users worldwide – particularly statistical offices and resource-constrained institutions in developing nations – can easily apply the classification to any standard patent database to generate accurate statistics.

3. **Explicit design for statistical analysis, not patent searches**: Unlike granular systems built for patent office examiners, this taxonomy is optimized explicitly for macro-statistical analysis and international comparison. It features a lean structure of five major sectors (clean energy; energy efficiency, conversion and storage; sustainable mobility; pollution control, recycling and water treatment; and agriculture, forestry and industry) and 36 distinct technology fields. This “middle-ground” design avoids the overwhelming complexity of search-oriented databases while providing meaningful detail for analysis. By minimizing thematic overlap and ensuring sufficient patenting volume across fields, it serves as a highly reliable, user-friendly tool for generating cross-country statistics and tracking global green innovation trends.
4. **Transparency and AI-assisted quality control**: To ensure high accuracy and user trust, the entire development process – including consensus analysis, expert decisions and IPC refinement – is fully documented. This transparency allows users to understand exact inclusion criteria, accurately interpret statistics and easily adapt the framework as policies evolve. A distinctive innovation of this methodology is the use of state-of-the-art AI reasoning models to validate the real-world accuracy of the selected IPC codes. AI was used to analyze random samples of 100 patents per technology field and flag codes that were too broad or imprecise. This rigorous validation, followed by the refinement of low-scoring fields, helps ensure that the classification performs reliably when applied to actual patent data.

The complete classification comprises of five sectors and 36 technology fields (see Figure 3), capturing the breadth of green technology innovation relevant to climate change mitigation and broader environmental sustainability.

Figure 3. Overview of the new WIPO Green Technology Inventory for Statistical Use (WIPO–GTIS)



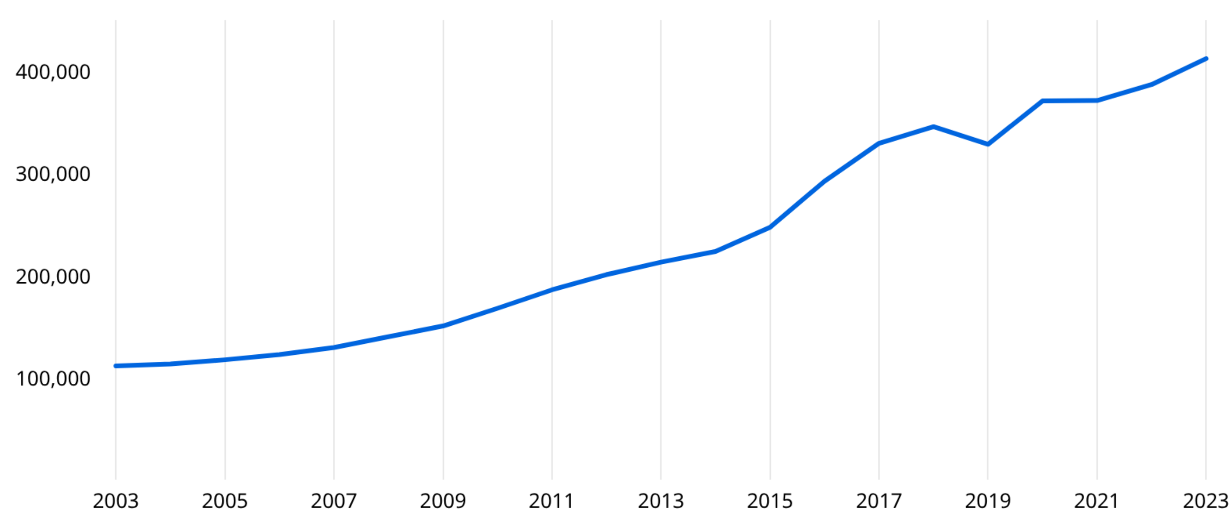
6. Global innovation activity in green technologies: a patent perspective

This section provides an overview of global patenting activity related to green technologies, covering the 2003 to 2023 period. The analysis is based on patent family data drawn from WIPO's statistics database.

Strong and sustained expansion of green innovation

Global green technology patenting has exhibited a clear upward trend over the past two decades. Between 2003 and 2023, green technology patent families grew from approximately 111,400 to around 412,300 – an approximately 3.7-fold increase, equivalent to a compound annual growth rate of 6.8% (see Figure 4). Growth in the early period was modest, with annual rates ranging from 1.6% to 8.2% between 2004 and 2009, before accelerating from 2010 onward and peaking at 18.3% in 2016. A brief but sharp contraction followed in 2019 (-5.0%), after which filings rebounded strongly in 2020 (12.9%), though growth stalled to near zero in 2021 (0.1%) before recovering more modestly through 2022 to 2023. The expansion was also highly concentrated: three technology categories – smart energy, grid and transmission; energy storage (batteries); and air pollution control – alone accounted for half of total growth over the period.

Figure 4. Number of patent families classed as green technologies, 2003–2023

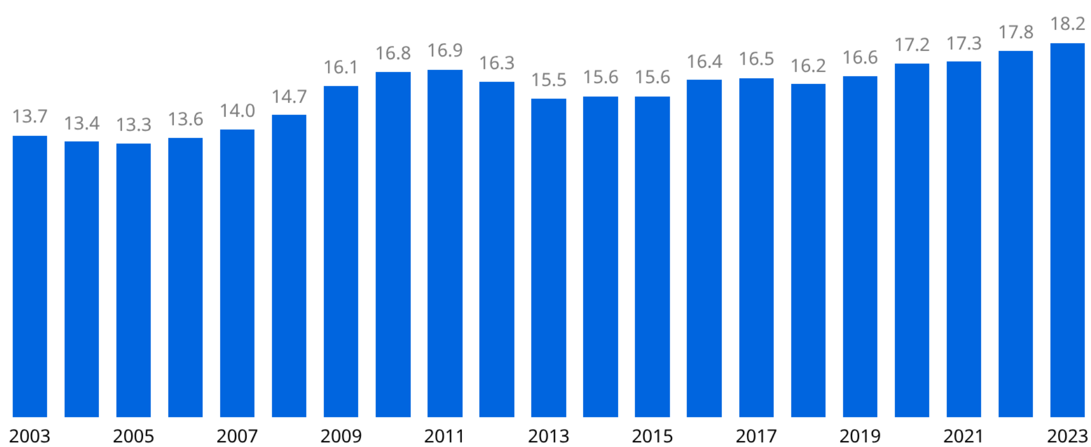


Source: WIPO Statistics Database, June 2026.

In addition, the share of green technology patent families in total patenting activity shows a gradual but clear increase over time, rising from 13.7% in 2003 to 18.2% in 2023 – a gain of 4.5 percentage points (see Figure 5). Following a modest decline in the early 2000s (reaching a low of 13.3% in 2005), the share rose steadily through 2011, reaching 16.9%. However, this upward trend was temporarily interrupted between 2013 and 2015 when the share dipped back below 16% – falling to a low of 15.5% in 2013 – as a rapid surge in total global patent filings, largely driven by China, temporarily outpaced growth in green technology patenting. Notably, the share jumped sharply from 14.7% in 2008 to 16.1% in 2009, as the global financial crisis briefly suppressed overall patent filings while green technology patenting continued to grow. From 2016 onwards, the share recovered and climbed steadily, reaching 18.2% by 2023.

Taken together, these trends indicate that green technologies have not only grown in absolute terms but have also expanded their relative importance within overall innovation activity – a particularly notable finding given that total world patent families more than tripled over the same period.

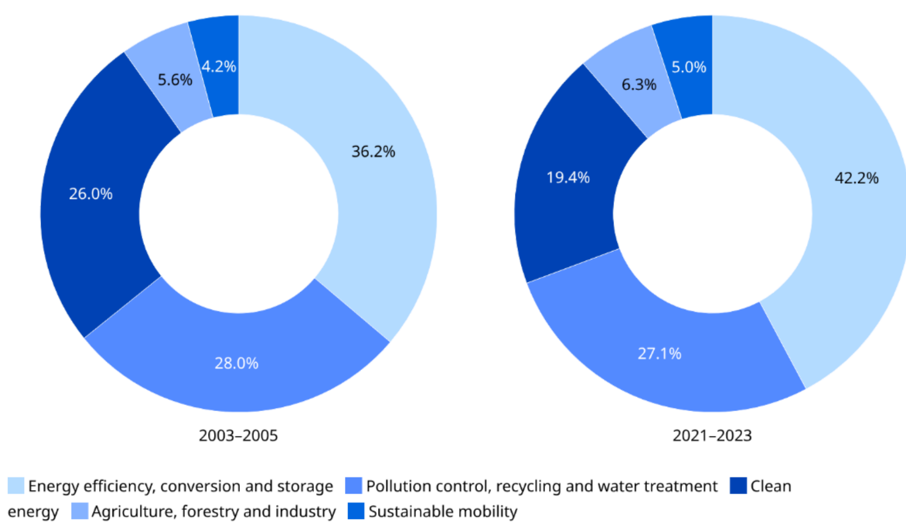
Figure 5. Green technology patent families as a % share of all patent families, 2003–2023



Source: WIPO Statistics Database, June 2026.

The distribution of green patent families across sectors reveals a clear and evolving pattern, with energy efficiency, conversion and storage reinforcing its position as the dominant sector – increasing its share from 36.2% in 2003–2005 to 42.2% in 2021–2023, the largest shift of any sector over the period (see Figure 6). Strikingly, this gain of 6 percentage points is almost mirrored by the decline in clean energy, which fell from 26.0% to 19.4% over the same period, suggesting a structural shift within green patenting from energy generation toward energy efficiency, conversion and storage technologies. Pollution control, recycling and water treatment remained stable, with its share declining only marginally from 28.0% to 27.1%, retaining its position as the second-largest sector. The smaller sectors – agriculture, forestry and industry, and sustainable mobility – together accounted for around 11.3% of total patent families in 2021–2023. Sustainable mobility recorded a modest increase from 4.2% to 5.0%, suggesting an emerging but growing contribution.

Figure 6. Sectoral distribution of green technology patent families (%), 2003–2005 and 2021–2023

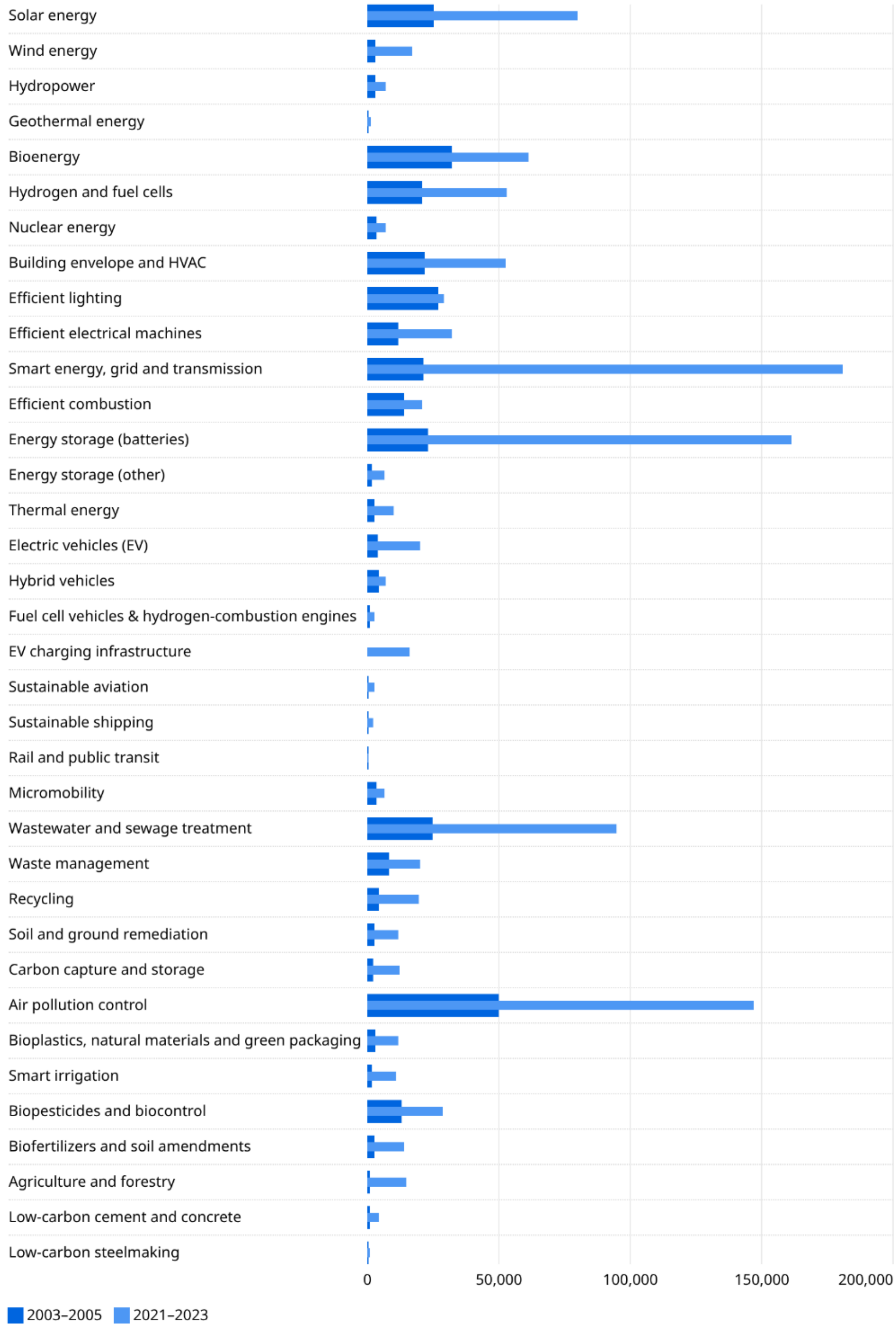


Source: WIPO Statistics Database, June 2026.

Over the period 2021–2023, green technology patenting remained highly concentrated, with the top three fields – smart energy, energy storage and air pollution control – together accounting for 41.8% of all global patent families (see Figure 7). Smart energy, grid and transmission (15.5%) and energy storage (batteries) (13.8%) together accounted for nearly three in 10 global green technology patent families, with both fields having more than doubled their shares compared to 2003–2005. Air pollution control, previously the top-ranked field at 14.7% in 2003–2005, slipped to third place with a share of 12.5%. Beyond the top three fields, wastewater and sewage treatment made modest gains, rising from 7.3% to 8.1%, while solar energy (6.8%) and bioenergy (5.2%) remained significant contributors, yet saw their combined share contract from 16.8% to 12.1%.

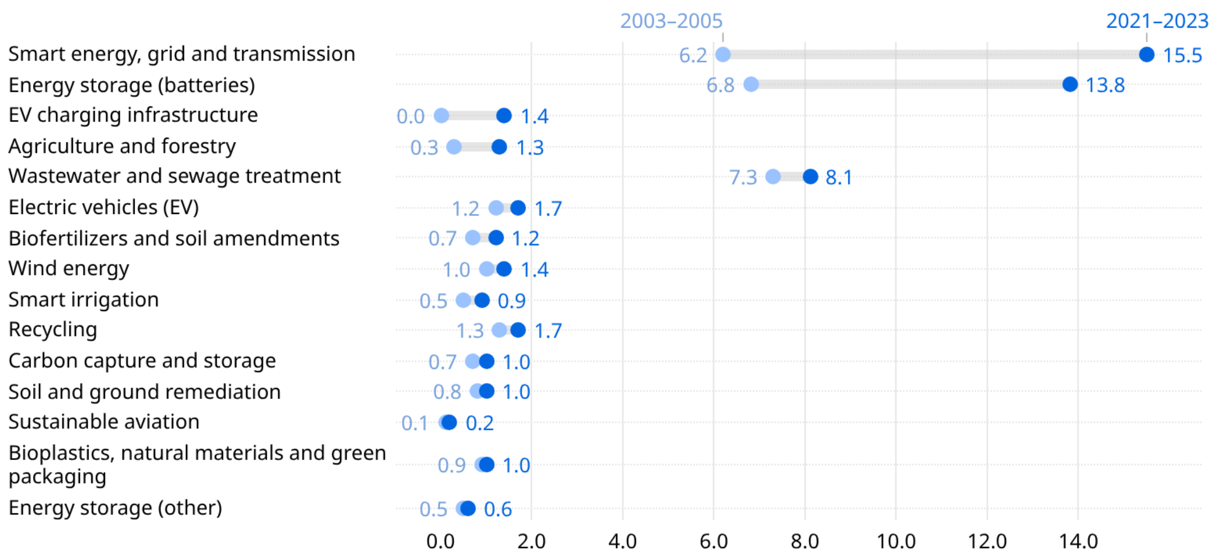
In terms of fastest growing fields, smart energy, grid and transmission recorded the largest increase in share between 2003–2005 and 2021–2023, rising sharply from 6.2% to 15.5% (see Figure 8). This was followed by energy storage (batteries), which gained 7 percentage points. Perhaps most strikingly, EV charging infrastructure – effectively a new field with just two patent families in 2003–2005 – emerged rapidly to record 16,362 families and a 1.4 percentage point gain, while wastewater and sewage treatment added 0.8 percentage points.

Figure 7. Distribution of green technology patent families by technology fields, 2003–2005, 2021–2023



Source: WIPO Statistics Database, June 2026.

Figure 8. Share of green technology patent families by technology (%), 2003–2005 and 2021–2023



Source: WIPO Statistics Database, June 2026.

Source of green technology innovation

In 2023, China dominated green technology patenting with an overwhelming 71.9% share of global green patent families, followed by the Republic of Korea (8.3%), Japan (6.9%) and the US (4.3%). European nations each accounted for less than 3% (see Table 4). This distribution reflects a profound structural transformation: in 2003, Japan held 45.0% of all global green patent families and China a mere 7.8%. The near-complete reversal of this order over two decades is largely attributable to China's exceptional average annual growth rate of 19.3%, far outpacing all other origins. Indeed, China accounted for approximately 95.7% of all net growth in global green patent families between 2003 and 2023 – meaning the global expansion in green technology patenting over this period was, in effect, driven almost entirely by a single origin. [7]

In contrast, Japan and Canada recorded negative growth rates of -2.8% and -0.8% respectively. The "others" category – comprising all origins outside the top 15 – also declined in absolute terms, underscoring a dramatic increase in geographic concentration.

[7] This trend mirrors what is observed for total patent applications, where China's share rose from 4.0% in 2003 to 46.2% in 2023, while Japan's share declined from 32.7% to 11.7% over the same period.

The Republic of Korea stood out as the second-fastest-growing major economy at 8.3% annually, while European countries such as Poland (5.3%), Austria (3.5%) and Denmark (3.1%) demonstrated moderate but consistent growth.

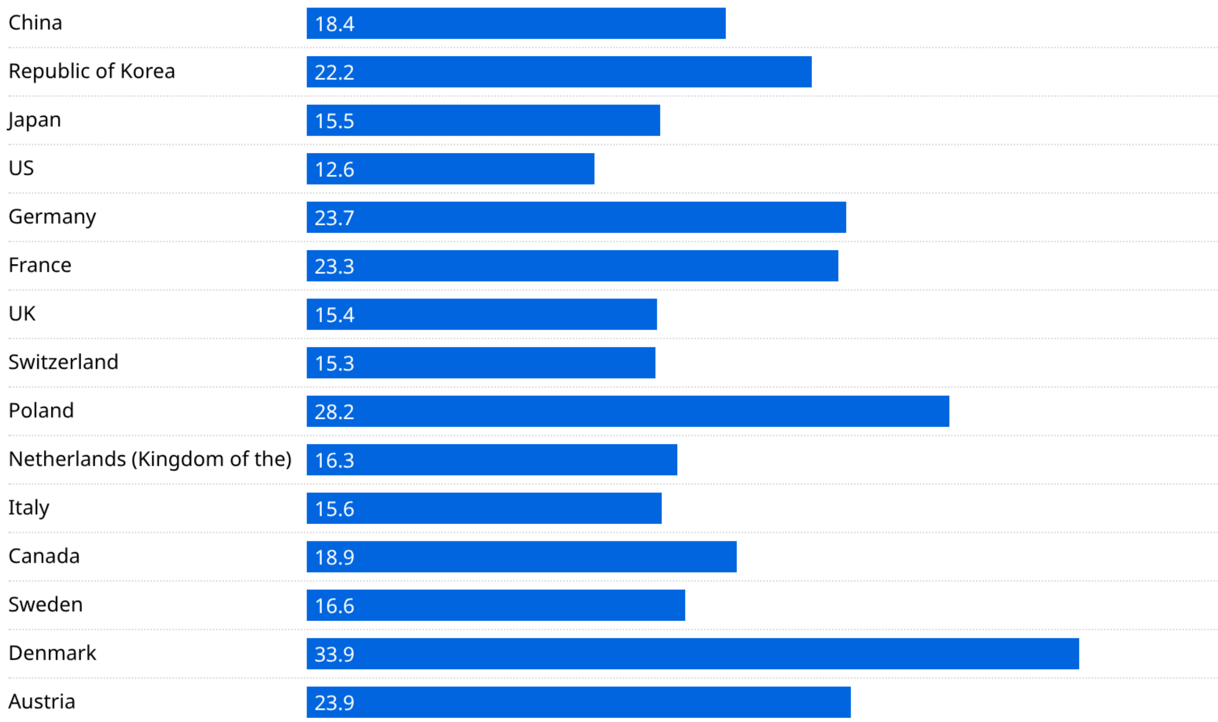
While China dominated in absolute terms, Denmark led among the top 15 origins in green technology intensity, with 33.9% of its total patent families classified as green technologies (see Figure 9). Poland (28.2%), Austria (23.9%), Germany (23.7%), France (23.3%) and the Republic of Korea (22.2%) also demonstrated a strong strategic focus on green innovation relative to their overall patenting activity – all above the global average of 18.2%. In contrast, the US recorded the lowest green intensity among the top 15 origins at 12.6% – notably below the global average – alongside comparably low figures for Switzerland (15.3%), the UK (15.4%) and Japan (15.5%).

Table 4. Green technology patent families for the top 15 origin, 2003 and 2023

Origin	2003	2023	Growth rate (%): 2003–2023	2023 share of total (%)
China	8,685	296,584	19.3	71.9
Republic of Korea	6,926	34,318	8.3	8.3
Japan	50,201	28,346	−2.8	6.9
US	17,737	17,891	0.0	4.3
Germany	6,965	11,015	2.3	2.7
France	2,021	3,634	3.0	0.9
UK	1,618	1,901	0.8	0.5
Switzerland	798	1,357	2.7	0.3
Poland	381	1,062	5.3	0.3
Netherlands (Kingdom of the)	828	1,058	1.2	0.3
Italy	782	1,043	1.5	0.3
Canada	1,164	994	−0.8	0.2
Sweden	508	906	2.9	0.2
Denmark	399	735	3.1	0.2
Austria	317	625	3.5	0.2
Others/Unknown	12,107	10,820	−0.6	2.6
Total	**111,437**	**412,289**	**6.8**	**100.0**

Note: Top 15 origins were selected based on the total number of green technology patent families in 2023.
Source: WIPO Statistics Database, June 2026.

Figure 9. Green technology patent families as a % share of all patent families, by country of origin, 2023

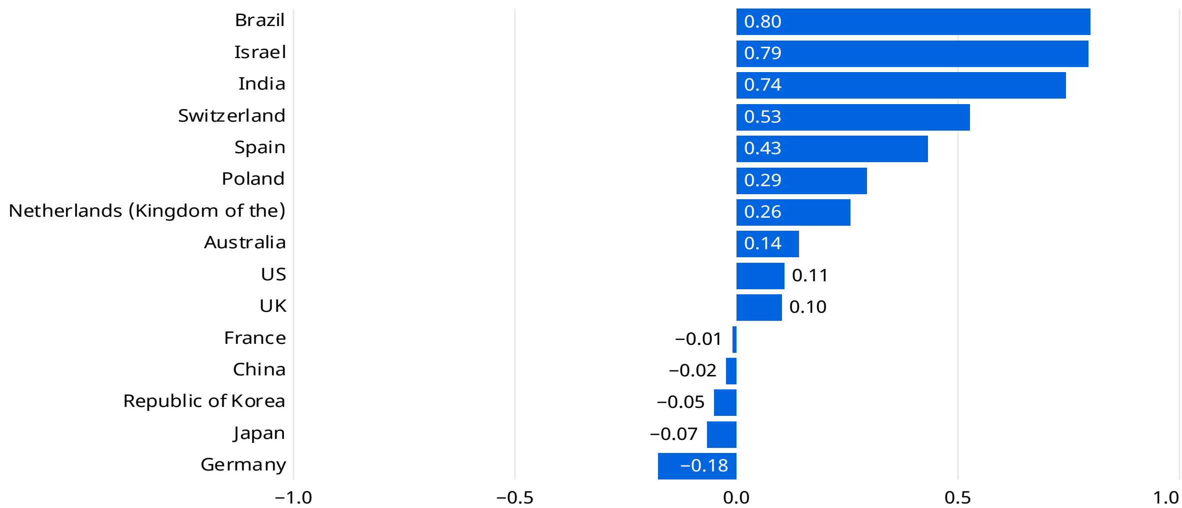


Source: WIPO Statistics Database, June 2026.

The Relative Specialization Index (RSI) captures the degree to which a country's patenting activity in a specific green technology is proportionally greater or smaller than its overall patenting activity. A positive RSI signals above average specialization in a given technology relative to the country's total innovative output, while a negative RSI indicates a comparative disadvantage.

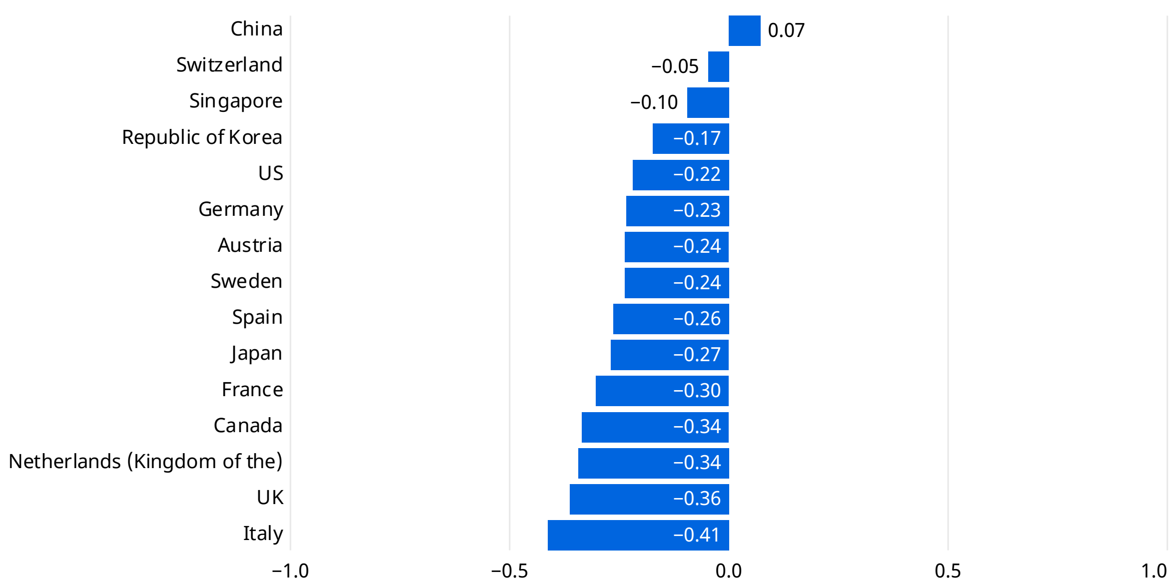
Figures 10 to 14 show the RSI of the leading technology within five green sectors: solar energy (Figure 10); smart energy, grid and transmission (Figure 11); electric vehicles (EV) (Figure 12); air pollution control (Figure 13); and biopesticides and biocontrol (Figure 14).

Figure 10. RSI in solar energy for the top 15 origins, 2021–2023



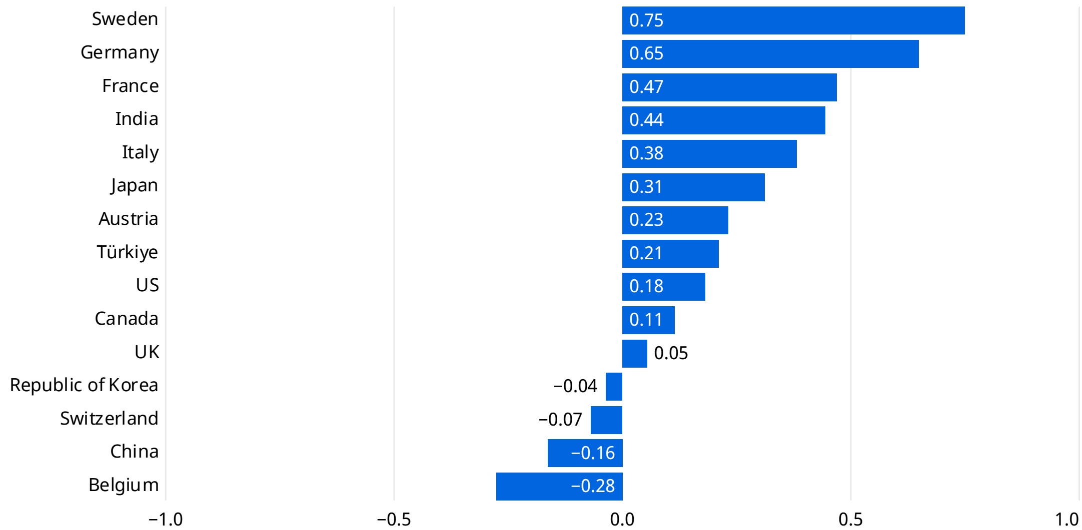
Source: WIPO Statistics Database, June 2026.

Figure 11. RSI in smart energy, grid and transmission for the top 15 origins, 2021–2023



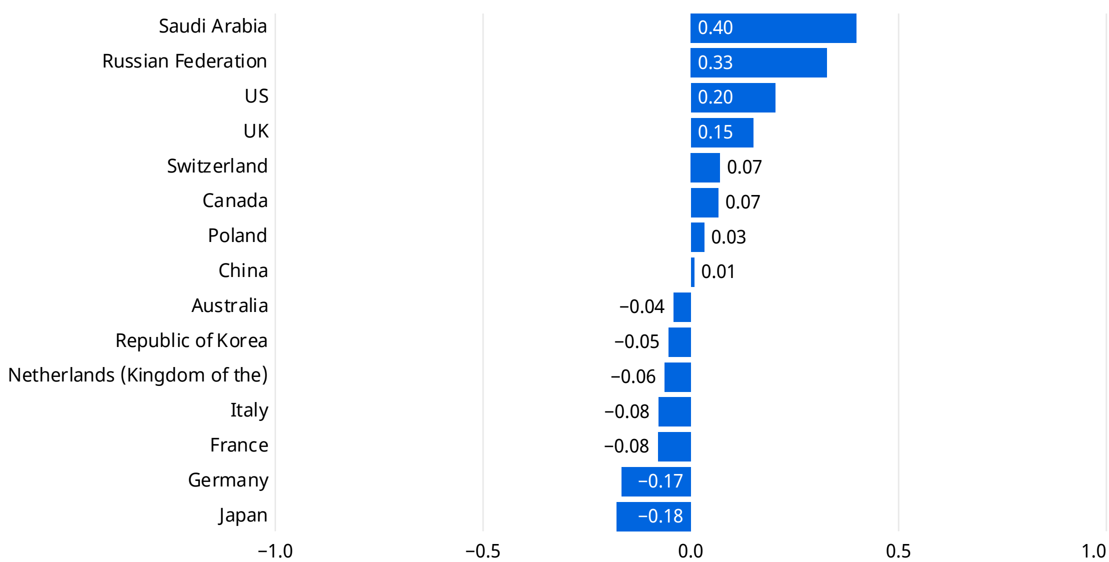
Source: WIPO Statistics Database, June 2026.

Figure 12. RSI in electric vehicles (EV) for the top 15 origins, 2021–2023



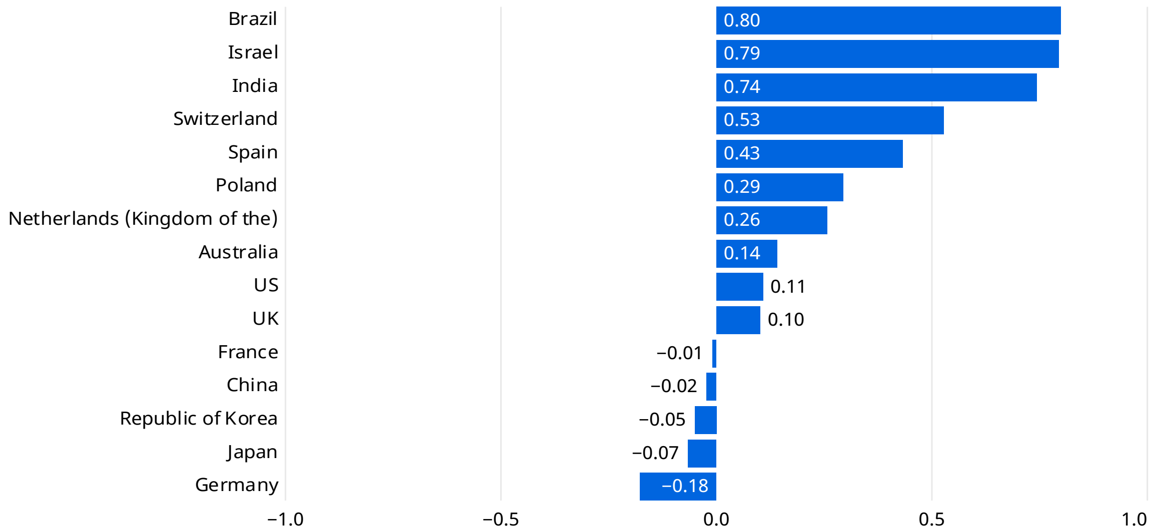
Source: WIPO Statistics Database, June 2026.

Figure 13. RSI in air pollution control for the top 15 origins, 2021–2023



Source: WIPO Statistics Database, June 2026.

Figure 14. RSI in biopesticides and biocontrol for the top 15 origins, 2021–2023



Source: WIPO Statistics Database, June 2026.

Solar energy along with air pollution control exhibit the most evenly distributed patenting activity among the five technologies, with RSI values spread broadly and relatively equally across the top 15 origins (see Figure 10). Singapore stands out with the highest RSI (0.54), reflecting a concentrated and disproportionately strong green technology patenting footprint relative to its overall innovation portfolio. Among the other top 15 origins, Israel (0.19), the Kingdom of the Netherlands (0.17), the Republic of Korea (0.13) and Austria (0.12) record meaningful positive RSI values, suggesting a strong focus on solar innovation.

Smart energy, grid and transmission technology presents a strikingly uniform picture: all countries in the sample, except China, record negative RSI values (see Figure 11). This technological field is dominated by China, which accounted for 82 % of all patent families in this field during the period 2021–2023.

Electric vehicles show the widest dispersion of RSI values and reveal a clear geographical divide (see Figure 12). Sweden (0.75) and Germany (0.65) top the rankings by a substantial margin, reflecting the deep integration of EV-related innovation. France (0.47), India (0.44) and Italy (0.38) also record high positive RSI values.

In air pollution control technology, Saudi Arabia (0.40) and the Russian Federation (0.33) record the two highest RSI values (see Figure 13). The US (0.20) and the UK (0.15) also show positive specialization.

Biopesticides and biocontrol display the strongest concentration of high RSI values, led by Brazil (0.80), Israel (0.79) and India (0.74) (see Figure 14).

No country dominates across all five technologies. Specialization patterns are highly sector-specific, suggesting that green technology innovation systems are fragmented rather than cumulative. Large absolute patent volumes do not necessarily imply positive RSI, while niche and emerging economies show strong relative specialization. Singapore in solar energy, Sweden in EVs, and Brazil and Israel in biopesticides illustrate how targeted industrial strategies or structural economic conditions can generate strong specialization in specific green technologies.

7. Conclusions

The accurate and consistent measurement of green technology innovation has become a prerequisite for effective climate and innovation policymaking. As this paper has demonstrated, the existing landscape of green technology patent classifications – while representing significant intellectual and institutional achievements – is characterized by substantial fragmentation. The five major systems reviewed here differ in scope, underlying methodology, structural granularity and accessibility, producing inconsistent patent-based indicators that complicate cross-country comparisons and international benchmarking.

Applying different classification systems to the same universe of patent data yields substantially divergent counts and growth trajectories, distorting the perceived landscape of green innovation. This inconsistency represents a material obstacle for researchers, statistical offices and international organizations seeking to monitor progress toward sustainability goals, assess national technological capabilities or evaluate the effectiveness of green innovation policies. WIPO–GTIS has been developed precisely to address this gap, offering a standardized, internationally harmonized reference framework grounded in the broadest possible consensus across existing systems.

WIPO–GTIS was constructed through a rigorous, transparent and fully reproducible process guided by four core design principles:

1. Rather than seeking exhaustive coverage, the taxonomy concentrates on universally recognized “core” green technologies by reconciling five major existing classification systems and prioritizing technologies with consensus support across multiple frameworks.
2. The methodology relies exclusively on IPC codes – eliminating dependency on keyword searches, CPC access or jurisdiction-specific classification tools – thereby dramatically lowering barriers to adoption, particularly for statistical offices and researchers in developing countries.
3. The taxonomy is designed explicitly for macro-statistical analysis rather than patent examination, featuring a lean architecture of five sectors and 36 technology fields that balances analytical granularity with operational simplicity.
4. The classification was subjected to AI-assisted quality control, in which advanced reasoning models analyzed random samples of 100 patents per technology field to flag overly broad or imprecise IPC codes, with underperforming fields subsequently refined.

This combination of consensus-driven design, methodological transparency and distinctive AI-assisted validation marks a significant methodological advance over existing approaches. It ensures that the classification performs reliably when applied to real-world patent data.

Application of WIPO–GTIS to global patent data spanning the period 2003–2023 reveals a substantial and sustained expansion of green technology innovation, with patent families growing more than 3.7-fold – from approximately 111,400 to around 412,300 – and increasing their share of total global patenting from 13.7% to 18.2%. This underscores the growing centrality of green technologies within the global innovation landscape. Smart energy, grid and transmission; energy storage; and air pollution control have emerged as the dominant technology fields.

China has become the overwhelmingly dominant source of green patent filings in absolute volume. However, no country dominates across all five technologies. Specialization patterns are highly sector-specific, such as Singapore in solar energy, Sweden in EVs and Brazil and Israel in biopesticides. This illustrates how targeted industrial strategies or structural economic conditions can generate strong revealed specialization in specific green technologies.

These empirical findings illustrate both the analytical potential of the new classification and the depth of insight it can generate for policymakers and researchers. Looking ahead, WIPO–GTIS is designed to evolve in response to technological change and emerging policy priorities: its fully documented methodology enables systematic updates and thematic extensions, while its IPC-based architecture ensures universal compatibility with patent data across all jurisdictions.

Looking beyond the period covered by this analysis, new structural drivers are likely to shape the next phase of green technology innovation. Chief among them is the rapid expansion of AI and the associated growth in data center electricity demand, which the International Energy Agency (IEA) projects will more than double globally, from 460 TWh in 2024 to over 1,000 TWh by 2030 (IEA, 2025). Renewables are expected to meet nearly half of this additional demand, while small modular reactors (SMRs) – attracting growing investment from major technology companies and governments in China, Europe and the US – are positioned to provide low-emissions baseload power from 2030 onward. This convergence of AI-driven energy demand and clean energy deployment is likely to accelerate innovation across several WIPO–GTIS fields, including solar energy; smart grids and energy management; energy storage; nuclear energy; and thermal management.

Future work in this area, drawing on post-2023 patent data, will be well-positioned to assess whether these emerging dynamics translate into measurable shifts in the global green innovation landscape.

Abbreviations

AI	artificial intelligence
CIPO	Canadian Intellectual Property Office
CNIPA	China National Intellectual Property Administration
CPC	Cooperative Patent Classification
EPO	European Patent Office
ENV-TECH	environment-related technologies
GDP	gross domestic product
GXTI	Green Transformation Technologies Inventory
HVAC	heating, air conditioning and ventilation
IEA	International Energy Agency
IMF	International Monetary Fund
IPC	International Patent Classification
IPCC	Intergovernmental Panel on Climate Change
JPO	Japan Patent Office
UKIPO	UK Intellectual Property Office
OECD	Organisation for Economic Co-operation and Development
PV	Photovoltaic
RSI	Relative Specialization Index
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WIPO–GTIS	WIPO Green Technology Inventory for Statistical Use

Annex A. The new WIPO Green Technology Inventory for Statistical Use (WIPO–GTIS)

The proposed Green Technology Taxonomy covers technologies that deliver clear environmental benefits, particularly in climate change mitigation; resource efficiency; pollution reduction; and sustainable production and consumption. Its development followed a systematic four-stage methodology:

1. Comparative analysis of existing classifications to identify areas of consensus and divergence.
2. Expert-led selection and structuring of technology fields.
3. Development and refinement of IPC concordances.
4. AI-assisted quality control.

This subsection outlines each stage, providing transparency on how methodological principles were translated into operational decisions.

Methodology

Comparative analysis of existing classifications to identify areas of consensus and divergence

The first stage involved a comprehensive review of existing green technology classifications used by the CNIPA, the EPO, the JPO, the OECD and WIPO. This analysis built on WIPO's preliminary work mapping IPC codes to the corresponding technologies across these taxonomies. A consensus-based approach was then applied to harmonize the different classification systems. Technologies appearing in two or more sources were designated as high-priority candidates, ensuring that widely recognized "green" technologies were systematically captured. Technologies found in only one classification underwent case-by-case assessment based on two criteria:

1. Sufficient patenting activity to ensure statistical robustness for international comparison.
2. Clear environmental relevance, prioritizing technologies that contribute to substantive sustainability transitions while generally excluding those limited to incremental efficiency improvements in high-emission systems.

Selection of technology fields and overarching sectors

In the second stage, the preliminary list of green technologies was structured into a coherent taxonomy to ensure analytical clarity while avoiding unnecessary fragmentation. The objective was to develop a lean, policy-relevant classification with sufficient granularity for analysis. This process resulted in a consolidated set of 36 green technologies, organized into five overarching sectors reflecting key domains of green innovation:

1. Clean energy.
2. Energy efficiency, conversion and storage.
3. Sustainable mobility.
4. Pollution control, recycling and water treatment.
5. Agriculture, forestry and industry.

The sectoral structure is designed to align with major areas of climate and environmental policy and economic activity, while remaining intuitive for non-specialist users. It also enables both high-level aggregation (e.g., clean energy or sustainable mobility innovation) and more detailed technology-specific analysis within sectors.

IPC concordance and filtering

Following the definition of the 36 technologies, IPC concordances were developed to ensure that all technology mappings rely exclusively on IPC codes, ensuring transparency, reproducibility and compatibility with patent databases. This stage was both the most labor-intensive and most critical for the classification’s practical utility, as the quality of IPC concordance directly determines the accuracy and reliability of patent statistics generated using the classification.

For each technology, IPC codes from existing classifications (WIPO, OECD, CNIPA and JPO) were compiled into an initial pool and assessed for technological relevance and specificity. The analysis was conducted across multiple IPC levels, including classes, subclasses, main groups and subgroups. Where necessary, broader IPC categories were refined to more specific levels to improve precision, while codes that were overly broad or primarily associated with other technologies were excluded to reduce noise and overlap. Although some overlap is inherent in the IPC structure, it was minimized where it indicated insufficient differentiation between technologies. Overall, the objective was to balance comprehensive coverage with analytical precision and robustness.

AI-assisted quality check and refinement

To validate the accuracy of the IPC mappings, an AI-assisted quality control procedure was applied using a state-of-the-art reasoning model. For each technology, random samples of 100 patents were assessed based on abstracts, claims and full-text descriptions to determine their relevance to the intended technology field. The analysis identified inconsistencies and overly broad IPC selections by testing how effectively the mappings translated into relevant real-world patent data. Results were generally robust, with relevance rates ranging from approximately 70% to nearly 100%. However, eight technologies fell below the 70% threshold. For these cases, the IPC mappings were further reviewed and refined to improve precision.

Finalization of the taxonomy

The integration of comparative analysis of existing classifications, expert-driven structuring, IPC-based concordance and AI-assisted validation resulted in a robust and analytically coherent green technology taxonomy. The framework is designed to support international comparisons of green innovation and provides a transparent, reproducible basis for future patent-based economic analysis.

Green taxonomy

Sector 1: clean energy (7 technology fields)

This sector covers technologies that enable the generation of energy with low or zero greenhouse gas emissions. It includes renewable and low-carbon energy sources as well as enabling technologies for energy conversion, storage and distribution. The focus is on primary energy supply technologies that support the decarbonization of electricity, heat and fuel production systems.

Technology 1.1: solar energy

Technologies for converting solar radiation into electricity or heat. Includes PV systems (crystalline silicon, thin-film, organic and emerging PV technologies); solar thermal collectors for heating applications; concentrated solar power systems; solar tracking and mounting systems; and PV-thermal hybrid systems.

Technology 1.2: wind energy

Technologies for generating electricity from wind resources. Includes horizontal-axis and vertical-axis wind turbines; onshore and offshore wind systems; wind turbine components (blades, towers, generators, control systems); and wind farm layout and operation technologies.

Technology 1.3: hydropower

Technologies for generating electricity from flowing or stored water. Includes conventional hydroelectric dams and turbines; run-of-river systems; pumped hydro storage; tidal energy devices; wave energy converters; and ocean current energy systems.

Technology 1.4: geothermal energy

Technologies that exploit geothermal heat from the Earth for electricity generation and heating. Includes geothermal power plants; ground source heat pumps; deep drilling technologies for geothermal access; and heat exchange systems for geothermal applications.

Technology 1.5: bioenergy

Technologies for producing energy from biomass, biogas and biofuels. Includes biomass combustion systems; anaerobic digestion for biogas production; fermentation for bioethanol; transesterification for biodiesel; gasification and pyrolysis of biomass; and technologies for producing energy from agricultural residues, forestry waste and dedicated energy crops.

Technology 1.6: hydrogen production, storage, distribution and fuel cells

Technologies across the hydrogen value chain. Includes hydrogen production methods (electrolysis, steam reforming, thermochemical processes); hydrogen storage systems (compressed, liquid, solid-state and metal hydride); hydrogen distribution infrastructure; and fuel cells for converting hydrogen to electricity (proton exchange membrane (PEM), solid oxide, alkaline and other fuel cell types).

Technology 1.7: nuclear energy

Technologies for nuclear energy generation. Includes conventional fission reactors (pressurized water reactors, boiling water reactors, advanced reactor designs); small modular reactors; fast breeder reactors; nuclear fuel cycle technologies; reactor safety and control systems; and emerging nuclear fusion concepts.

Sector 2: energy efficiency, conversion and storage (8 technology fields)

This sector comprises technologies that reduce energy consumption or optimize energy conversion and use. It includes efficiency improvements in buildings, industrial processes, power systems and end-use applications, as well as technologies that optimize energy generation, storage, transmission and utilization.

Technology 2.1: building envelope and HVAC

Technologies improving the energy performance of buildings through enhanced insulation; advanced building materials; high-efficiency heating, ventilation and air-conditioning systems; heat pumps; and building thermal management.

Technology 2.2: efficient lighting

Energy-saving lighting technologies. Includes light-emitting diodes (LEDs); organic LEDs (OLEDs); intelligent lighting controls; daylight harvesting systems; and other high-efficiency lighting technologies.

Technology 2.3: efficient electrical machines

High-efficiency motors, generators, transformers and related drive systems used in industrial, commercial and household applications. Includes permanent magnet motors; variable-speed drives; superconducting machines; and efficiency-enhancing motor control technologies.

Technology 2.4: smart energy management, smart grid and transmission

Technologies that optimize energy generation, distribution and consumption. Includes smart meters; grid automation and control systems; demand response technologies; advanced transmission systems (such as high-voltage direct current (HVDC)); power flow optimization; energy management systems for buildings and industrial facilities; and vehicle-to-grid integration.

Technology 2.5: efficient combustion

Technologies that improve combustion efficiency and reduce emissions in engines, boilers and industrial furnaces. Includes advanced fuel injection systems; combustion control and optimization; exhaust gas recirculation; turbocharging and supercharging; combined cycle systems; and low-NOx burners.

Technology 2.6: energy storage (batteries)

Electrochemical energy storage technologies. Includes lithium-ion batteries; lead-acid batteries; nickel-metal hydride batteries; solid-state batteries; flow batteries; and supercapacitors. Covers battery cells; modules; packs; battery management systems; and manufacturing technologies for stationary and mobile applications.

Technology 2.7: energy storage (other)

Non-battery energy storage technologies. Includes mechanical storage (flywheels, compressed air energy storage, pumped hydro when used for storage); thermal energy storage (phase-change materials, molten salt, hot water storage); and other emerging storage concepts.

Technology 2.8: thermal energy

Technologies for efficient generation and use of thermal energy. Includes combined heat and power (CHP and cogeneration) systems; waste heat recovery systems; heat exchangers; district heating and cooling; thermal cogeneration; and industrial process heat integration.

Sector 3: sustainable mobility (8 technology fields)

This sector encompasses technologies that reduce the environmental impact of transportation systems. Primary focus is reducing greenhouse gas emissions through electrification; alternative fuels; efficiency improvements; and modal shifts, while also addressing air quality and other environmental concerns from transport.

Technology 3.1: electric vehicles (EVs)

Road vehicles powered exclusively by electricity stored in batteries. Includes battery electric cars, trucks, buses and motorcycles, as well as vehicle-specific electric propulsion systems, power electronics, charging infrastructure and battery integration for EVs.

Technology 3.2: hybrid vehicles

Road vehicles combining internal combustion engines with electric propulsion. Includes hybrid electric vehicles (HEVs); plug-in hybrid electric vehicles (PHEVs); hybrid control strategies; energy management systems; regenerative braking; and hybrid powertrain architectures.

Technology 3.3: fuel cell vehicles (FCVs)

Vehicles powered by fuel cells, typically using hydrogen or reformed hydrocarbon fuels. Includes FCV architectures; onboard hydrogen storage; fuel cell stack integration; power management for FCVs; and refueling infrastructure.

Technology 3.4: EV charging infrastructure

Technologies and systems for charging electric vehicles, including charging stations, on-board charging and grid integration solutions.

Technology 3.5: sustainable aviation

Technologies reducing environmental impacts of aircraft. Includes electric and hybrid aircraft propulsion; sustainable aviation fuels; aerodynamic improvements; lightweight aircraft structures; efficient aircraft engines; laminar flow control; and aviation efficiency innovations.

Technology 3.6: sustainable maritime transport

Technologies reducing emissions and improving efficiency in shipping and marine transport. Includes electric and hybrid ship propulsion; alternative marine fuels (liquefied natural gas (LNG), methanol, ammonia, hydrogen); ship hull efficiency and hydrodynamics; wind-assisted propulsion (rotor sails, kites); and energy recovery systems for ships.

Technology 3.7: rail and public transit

Technologies for low-emission rail and public transportation. Includes electric trains and locomotives; light rail and trams; electric and fuel cell buses; battery-powered rail vehicles; catenary-free electric transit; maglev systems; and energy-efficient mass transit technologies.

Technology 3.8: micromobility

Technologies supporting sustainable urban mobility through electric bicycles; electric scooters; personal mobility devices; bicycle infrastructure and components; cargo bikes; and related micro-mobility technologies.

Sector 4: pollution control, recycling and water treatment (7 technology fields)

This sector includes technologies aimed at preventing, reducing, monitoring or remediating environmental pollution and managing resources more sustainably. It covers air, water and soil protection; waste management and recycling; circular economy solutions; and monitoring technologies that support environmental protection.

Technology 4.1: wastewater and sewage treatment

Technologies for treating domestic, municipal and industrial wastewater. Includes physical treatment methods (sedimentation, filtration, membrane processes); biological treatment (activated sludge, biofilms, constructed wetlands); chemical treatment; nutrient removal (nitrogen, phosphorus); disinfection; and advanced treatment for water reuse.

Technology 4.2: waste management

Technologies for collecting, sorting, treating and disposing of solid waste. Includes waste collection systems; mechanical and automated sorting technologies; waste-to-energy systems; landfill technologies with gas capture; composting; and integrated waste management systems.

Technology 4.3: recycling

Technologies for recycling and recovering materials from waste streams. Includes mechanical recycling (plastics, metals, paper, glass); chemical recycling; electronic waste recycling; battery recycling; construction and demolition waste recovery; textile recycling; and technologies for material separation and purification.

Technology 4.4: soil and ground remediation

Technologies for cleaning contaminated soil and land. Includes bioremediation; soil washing; thermal desorption; chemical treatment; phytoremediation (plant-based remediation); excavation and containment systems; and *in situ* and *ex situ* treatment methods.

Technology 4.5: carbon capture and storage

Technologies for capturing CO_2 from industrial sources, power plants or the atmosphere, and either storing it geologically or utilizing it in products. Includes post-combustion capture; pre-combustion capture; oxy-fuel combustion; direct air capture; CO_2 transport and injection; geological storage; and CO_2 utilization in chemicals, fuels and materials.

Technology 4.6: air pollution control

Technologies for controlling air pollutants from stationary and mobile sources. Includes particulate matter control (filters, electrostatic precipitators); nitrogen oxide (NOx) reduction; sulfur oxide (SOx) removal; volatile organic compound (VOC) control; catalytic converters for vehicles; and industrial emission monitoring and control systems.

Technology 4.7: bioplastics, natural materials and green packaging

Technologies for producing environmentally preferable materials. Includes bioplastics and biodegradable polymers; materials from renewable feedstocks; natural fiber composites; sustainable packaging materials; compostable materials; and bio-based alternatives to conventional plastics.

Sector 5: agriculture, forestry and industry (6 technology fields)

This sector covers technologies enhancing sustainability in primary production (agriculture and forestry) and key industrial sectors. It includes technologies reducing environmental impacts of farming; supporting sustainable forest management; and enabling low-carbon production in major industrial processes.

Technology 5.1: smart irrigation

Technologies optimizing water use in agriculture. Includes drip irrigation; micro-irrigation systems; irrigation scheduling and control; soil moisture monitoring; rainwater harvesting for agriculture; and precision water application technologies.

Technology 5.2: biopesticides and biocontrol

Alternatives to synthetic chemical pesticides. Includes microbial pesticides (bacteria, fungi, viruses); biochemical pesticides (plant extracts, pheromones, natural substances); beneficial insects for biological control; integrated pest management systems; and pest-resistant plant varieties.

Technology 5.3: biofertilizers and soil enhancement

Biological alternatives and supplements to synthetic fertilizers. Includes nitrogen-fixing bacteria (rhizobia); phosphate-solubilizing microorganisms; mycorrhizal fungi; composting systems; organic fertilizers; soil conditioners; and microbial inoculants enhancing nutrient availability.

Technology 5.4: forestry

Technologies supporting environmentally sustainable forest management and utilization. Includes reforestation and afforestation technologies; sustainable logging equipment minimizing forest damage; forest monitoring systems; improved wood processing reducing waste; forest fire prevention and detection; and technologies for forest carbon sequestration.

Technology 5.5: low-carbon cement and concrete

Technologies reducing greenhouse gas emissions from cement manufacturing. Includes alternative cement formulations (geopolymer cements, calcium sulfoaluminate cements); use of supplementary cementitious materials (fly ash, slag); carbon capture in cement plants; energy efficiency in clinker production; and alternative fuel use in cement kilns.

Technology 5.6: low-carbon steelmaking

Technologies reducing emissions from iron, steel and metal production. Includes hydrogen-based direct reduction of iron; electric arc furnaces using renewable electricity; carbon capture in blast furnaces; increased scrap recycling; alternative reducing agents; and energy efficiency improvements in metal production.

Table A1 lists all technologies and the associated IPC codes. If a specific IPC class, subclass or group is listed, all the hierarchically lower subclasses, main groups and subgroups that belong to the listed code are also included.

Table A1. WIPO Green Technology Inventory for Statistical Use (WIPO–GTIS)

Sector	Number	Technology	IPC codes
Clean energy	1.1	Solar energy	C01B 33/02, C01B 33/03, C01B 33/021, C01B 33/023, C01B 33/025, C01B 33/027, C01B 33/029, C01B 33/031, C01B 33/033, C01B 33/035, C01B 33/037, C01B 33/039, C23C 14/14, C23C 14/16, C23C 14/18, C23C 14/20, C23C 16/24, C30B 29/06, E04D 13/18, F03G 6/00, F21L 4/00, F21S 9/03, F22B 1/00, F24D 3/00, F24D 11/00, F24D 17/00, F24D 18/00, F24D 19/00, F24J 2/00, F24S, F24V 30/00, G02B 7/183, G05F 1/67, H01G 9/20, H01L 25/00, H01L 27/30, H01L 27/142, H01L 31/00, H01L 51/42, H02J 7/35, H02S, H10K 30/00, H10K 39/10, H10K 39/12, H10K 39/15, H10K 39/18
	1.2	Wind energy	B60K 16/00, B60L 8/00, B60L 53/52, B63H 13/00, F03D, G06F 113/06, H02K 7/18, H02P 101/15, H02S 10/12
	1.3	Hydropower	E02B 9/00, F03B, F03C, F03G 7/05, H02J 15/10, H02P 101/10

	1.4	Geothermal energy	F03G 4/00, F03G 7/04, F03G 7/05, F24J 3/08, F24T, F25B 30/06, H02N 10/00
	1.5	Bioenergy	C02F 11/04, C02F 11/10, C07C 31/00, C07C 43/00, C07C 67/00, C07C 69/00, C08B 15/00, C08L 1/00, C10B 53/00, C10J, C10L 1/00, C10L 5/00, C10L 9/00, C11C 3/10, C12M 1/107, C12M 1/113, C12N 9/24, C12N 9/26, C12N 9/28, C12N 9/30, C12N 9/32, C12N 9/34, C12N 9/36, C12N 9/38, C12N 9/40, C12N 9/42, C12N 9/44, C12N 9/46, C12P, C21B 5/06, D21H, F23G 5/00, F23G 7/00
	1.6	Hydrogen and fuel cells	B60K 6/32, B60L 50/70, B60L 50/71, B60L 50/72, B63B 25/08, B63B 25/10, B63B 25/12, B63B 25/14, B63B 25/16, B63B 25/18, B63B 25/20, C01B 3/00, C07C 1/04, C07C 1/06, C07C 1/08, C07C 1/12, C07C 5/02, C07C 5/03, C07C 5/05, C07C 5/08, C07C 5/09, C07C 5/10, C07C 5/11, C07C 5/13, C07C 5/42, C07C 5/44, C07C 5/46, C07C 5/48, C07C 5/50, C07C 5/52, C07C 5/54, C07C 5/56, C07C 5/367, C10B 53/00, C10J, C25B 1/02, C25B 1/04, C25B 1/042, C25B 1/044, C25B 9/00, C25B 15/00, F17C, F25B 17/12, F25J 1/00, H01M 4/86, H01M 4/88, H01M 4/90, H01M 4/92, H01M 4/94, H01M 4/96, H01M 4/98, H01M 8/00, H01M 12/00
	1.7	Nuclear energy	G21B, G21C, G21D, G21G, G21H
Energy efficiency, conversion and storage	2.1	Building envelope and HVAC	E04B 1/62, E04B 1/64, E04B 1/66, E04B 1/68, E04B 1/70, E04B 1/72, E04B 1/74, E04B 1/76, E04B 1/78, E04B 1/80, E04B 1/82, E04B 1/84, E04B 1/86, E04B 1/88, E04B 1/90, E04B 1/92, E04B 1/94, E04B 1/98, E04B 1/682, E04B 1/684, E04B 1/686, E04B 2/00, E04B 5/00, E04B 7/00, E04B 9/00, E04C 1/40, E04C 1/41, E04C 2/284, E04C 2/288, E04C 2/292, E04C 2/296, E04D 1/28, E04D 3/35, E04D 13/00, E04F 13/08, E04F 13/09, E04F 13/10, E04F 13/12, E04F 13/14, E04F 13/15, E04F 13/16, E04F 13/18, E04F 13/075, E04F 15/18, E04F 15/20, E04H 9/14, E06B 3/263, E06B 3/267, E06B 3/273, E06B 3/277, F16L 59/00, F24D 3/18, F24D 11/02, F24D 12/02, F24D 15/04, F24D 17/00, F24D 18/00, F24F 11/46, F24F 11/47, F24F 12/00, F24H 4/00, F24T, F24V, F25B 27/00, F25B 30/00
	2.2	Efficient lighting	F21K 99/00, F21L 4/02, F21S 9/03, F21S 11/00, F21Y 115/10, F21Y 115/15, F21Y 115/20, H01L 33/00, H01L 51/50, H05B 33/00, H05B 45/00
	2.3	Efficient electrical machines	H02K 1/00, H02K 3/00, H02K 9/00, H02K 16/00, H02K 17/00, H02K 19/00, H02K 21/00, H02K 25/00, H02K 29/06, H02K 29/08, H02K 29/10, H02K 29/12, H02K 49/10, H02M 7/48, H02M 7/49, H02M 7/51, H02M 7/53, H02M 7/483, H02M 7/487, H02M 7/493, H02M 7/497, H02M 7/501, H02M 7/505, H02M 7/515, H02M 7/516, H02M 7/517, H02M 7/519, H02M 7/521, H02M 7/523, H02M 7/525, H02M 7/527, H02M 7/529, H02M 7/533, H02M 7/537, H02M 7/538, H02M 7/539, H02M 7/5375, H02M 7/5381, H02M 7/5383, H02M 7/5387, H02M 7/5388, H02M 7/5395, H02M 7/53838, H02M 7/53846, H02M 7/53854, H02M 7/53862
	2.4	Smart energy, grid and transmission	B60L 3/00, B60L 53/60, B60L 53/62, B60L 53/63, B60L 53/64, B60L 53/65, B60L 53/66, B60L 53/67, B60L 53/68, G01D 4/00, G01R 22/06, G01R 22/08, G01R 22/10, G01R 31/00, G06F 113/04, G06Q 50/06, H02J 1/00, H02J 3/00, H02J 4/25, H02J 5/00, H02J 9/00, H02J 13/00, H02J 50/00, H02J 101/00, H02J 103/00, H02J 105/00, H02J 107/00
	2.5	Efficient combustion	C10L 3/00, F01D 15/10, F01K 23/02, F01K 23/04, F01K 23/06, F01K 23/08, F01K 23/10, F02B 3/00, F02B 7/00, F02B 9/00, F02B 23/10, F02B 51/00, F02B 57/02, F02C 3/28, F02C 6/00, F02D 19/00, F02D 21/00, F02D 41/00, F02M 13/08, F23B 10/00, F23B 70/00, F23B 80/00, F23C 6/00, F23C 9/00, F23C 10/00, F23D 14/22, F23D 14/24, F23D 14/26, F23D 14/32, F23D 14/58, F23D 14/66, F23D 17/00, F23D 23/00, F23G 5/12, F23K 3/00, F23L 7/00, F23L 15/00, F23N, F23Q 1/04, F23R, F24V 30/00, F27B 1/26, F27B 1/28, F27B 3/28, F27B 5/18, F27B 7/42, F27B 9/40, F27B 13/14, F27B 14/20, F27D 19/00, F27D 21/00
	2.6	Energy storage (batteries)	B60K 1/04, B60K 6/28, B60L 50/40, B60L 50/51, B60L 50/52, B60L 50/53, B60L 50/54, B60L 50/55, B60L 50/56, B60L 50/57, B60L 50/58, B60L 50/59, B60L 50/60, B60L 50/61, B60L 50/62, B60L 50/63, B60L 50/64, B60L 58/00, B60R 16/04, B60R 16/033, B60W 10/26, H01G 11/00, H01M 2/00, H01M 4/00, H01M 8/18, H01M 10/00, H01M 12/00, H01M 50/00, H02J 7/00, H02J 15/00

	2.7	Energy storage (other)	B60K 6/10, B60K 6/12, B60K 6/30, B60L 50/30, B60L 53/56, C09K 5/00, F02C 6/16, F03D 9/12, F03D 9/17, F03G 7/08, F04B 41/02, F16H 33/02, F16H 33/04, F16H 33/06, F16H 33/08, F16H 33/10, F16H 33/12, F16H 33/14, F16H 33/16, F16H 33/18, F24H 7/00, F28D 20/00, H02J 1/16, H02J 3/30, H02J 15/00, H02K 7/02
	2.8	Thermal energy	C09K 5/00, C10J 3/86, F01K 17/00, F01K 19/00, F01K 23/02, F01K 23/04, F01K 23/06, F01K 23/08, F01K 23/10, F01K 27/00, F01N 5/00, F02C 6/18, F02G 5/00, F22B 1/02, F22B 1/04, F22B 1/06, F22B 1/08, F22B 1/10, F22B 1/12, F22B 1/14, F22B 1/16, F22B 1/18, F24H 7/00, F24S 60/00, F25B 27/02, F27D 17/00, F28D 17/00, F28D 20/00
Sustainable mobility	3.1	Electric vehicles (EVs)	B60K 1/00, B60K 6/00, B60K 16/00, B60L 7/10, B60L 7/12, B60L 7/14, B60L 7/16, B60L 7/18, B60L 7/20, B60L 7/22, B60L 8/00, B60L 9/00, B60L 11/00, B60L 15/00, B60L 50/00, B60L 58/00
	3.2	Hybrid vehicles	B60K 6/00, B60W 20/00, F16H 3/00, F16H 48/00
	3.3	Fuel cell vehicles (FCVs) and hydrogen-combustion engines	B60L 50/70, B60L 50/71, B60L 50/72, B60L 50/75, B60L 58/30, B60L 58/31, B60L 58/32, B60L 58/33, B60L 58/34, B60L 58/40, B60W 10/28, F02B 43/00, F02M 21/02, F02M 21/04, F02M 21/06, F02M 27/02
	3.4	EV charging infrastructure	B60L 53/00, B60L 55/00
	3.5	Sustainable aviation	B64B 1/00, B64C 27/30, B64D 27/24, B64U 10/30, B64U 50/30, B64U 50/31, B64U 50/32, B64U 50/33, B64U 50/34, B64U 50/35, B64U 50/36, B64U 50/37, B64U 50/38, B64U 50/39
	3.6	Sustainable shipping	B63B 1/16, B63B 1/18, B63B 1/20, B63B 1/22, B63B 1/24, B63B 1/26, B63B 1/28, B63B 1/30, B63B 1/34, B63B 1/36, B63B 1/38, B63B 1/40, B63B 3/24, B63H 8/40, B63H 9/00, B63H 13/00, B63H 16/00, B63H 19/02, B63H 19/04, B63H 21/17, B63H 21/18
	3.7	Rail and public transit	B61C 3/00, B61D 17/02, B61F 3/14
	3.8	Micromobility	B62K 1/00, B62K 3/00, B62K 5/00, B62K 7/00, B62K 9/00, B62K 13/00, B62K 15/00, B62K 17/00, B62K 19/00, B62K 21/00, B62K 23/00, B62K 25/00, B62K 27/00, B62M 1/00, B62M 3/00, B62M 5/00, B62M 6/00
Pollution control, recycling and water treatment	4.1	Wastewater and sewage treatment	B63B 35/32, B63J 4/00, C02F, C09K 3/32, E02B 15/04, E02B 15/06, E02B 15/08, E02B 15/10, E03C 1/12, E03C 1/14, E03C 1/16, E03C 1/18, E03C 1/20, E03C 1/22, E03C 1/23, E03C 1/24, E03C 1/26, E03C 1/28, E03C 1/29, E03C 1/30, E03C 1/32, E03C 1/33, E03C 1/122, E03C 1/126, E03C 1/181, E03C 1/182, E03C 1/184, E03C 1/186, E03C 1/232, E03C 1/242, E03C 1/244, E03C 1/262, E03C 1/264, E03C 1/266, E03C 1/282, E03C 1/284, E03C 1/286, E03C 1/288, E03C 1/292, E03C 1/294, E03C 1/295, E03C 1/296, E03C 1/298, E03C 1/302, E03C 1/304, E03C 1/306, E03C 1/308, E03C 1/322, E03C 1/324, E03C 1/326, E03C 1/328, E03F
	4.2	Waste management	A61L 11/00, A62D 3/00, A62D 101/00, B09B, B65B 55/24, B65F, D21B 1/08, D21B 1/10, D21B 1/32, G21F 9/00
	4.3	Recycling	A43B 1/12, A43B 21/14, B03B 9/06, B22F 8/00, B29B 7/66, B29B 17/00, B62D 67/00, B65H 73/00, C04B 18/00, C08J 11/00, C09K 11/01, C10G 1/10, C10G 17/10, C10G 19/08, C10G 25/12, C10M 175/00, C11B 13/00, C11D 19/00, C14C 3/32, C22B 7/00, C22B 19/30, C22B 25/06, D01G 11/00, D21C 5/02, H01B 15/00, H01J 9/52, H01M 6/52, H01M 10/54
	4.4	Soil and ground remediation	A01G 11/00, B09C, C09K 17/00, E02D 3/00, F23G 7/14
	4.5	Carbon capture and storage	B01D 53/02, B01D 53/04, B01D 53/06, B01D 53/08, B01D 53/10, B01D 53/12, B01D 53/14, B01D 53/18, B01D 53/22, B01D 53/047, B01D 53/053, B01D 53/62, B65G 5/00, C01B 31/20, C01B 32/50, C01B 32/55, E21F 17/16, F25J 3/02, F25J 3/04

	4.6	Air pollution control	B01D 45/00, B01D 46/00, B01D 47/00, B01D 49/00, B01D 50/00, B01D 53/00, B03C 1/00, B03C 3/00, B60W 20/16, C01B 17/60, C09K 3/22, C10B 21/18, C10L 10/02, C10L 10/06, C21B 5/06, C21B 7/22, C21C 5/38, C21C 5/40, E21F 5/00, F01N 3/00, F01N 9/00, F01N 11/00, F02B 75/10, F23B 80/02, F23C 9/00, F23G 7/06, F23G 7/07, F23G 7/08, F23J 15/00, F27B 1/18, F27B 15/12, G01M 15/10, G01N 33/00, G08B 21/12, G08B 21/14, G08B 21/16
	4.7	Bioplastics, natural materials and green packaging	B01F 17/50, B01J 39/22, B01J 41/16, B27K 7/00, B27K 9/00, B27L, B65D 65/46, C08L 3/02, C08L 3/04, C08L 3/06, C08L 3/08, C08L 3/10, C08L 3/12, C08L 3/14, C08L 3/16, C08L 3/18, C08L 3/20, C08L 5/00, C08L 93/00, C08L 97/00, C08L 101/16, C09J 103/02, C09J 103/04, C09J 103/06, C09J 103/08, C09J 103/10, C09J 103/12, C09J 103/14, C09J 103/16, C09J 103/18, C09J 103/20, C09J 105/00, C09J 193/00, C09J 197/00, C09K 23/50
Agriculture, forestry and industry	5.1	Smart irrigation	A01C 23/04, A01G 25/00, A01G 27/00, E02B 13/00
	5.2	Biopesticides and biocontrol	A01M 1/00, A01M 3/00, A01M 5/00, A01M 7/00, A01M 9/00, A01M 11/00, A01M 13/00, A01M 17/00, A01M 19/00, A01N 25/00, A01N 27/00, A01N 29/00, A01N 31/00, A01N 33/00, A01N 35/00, A01N 37/00, A01N 39/00, A01N 41/00, A01N 45/00, A01N 47/00, A01N 49/00, A01N 51/00, A01N 53/00, A01N 55/00, A01N 57/00, A01N 59/00, A01N 61/00, A01N 63/00, A01N 65/00
	5.3	Biofertilizers and soil amendments	C05F, C05G 3/00, C09K 17/00
	5.4	Agriculture and forestry	A01G 23/00, B64U 101/40, G05D 105/15, G06Q 50/02, G16Y 10/10
	5.5	Low-carbon cement and concrete	C04B 7/24, C04B 7/26, C04B 7/28, C04B 7/30, C04B 18/00
	5.6	Low-carbon steelmaking	C21C 5/38, C21C 5/40, C21C 5/52, C21C 5/54

Note: IPC codes ending in '/00' (e.g., A61K 31/00) cover the entire main group, including all subgroups below. Codes shown at subclass level (e.g., H02S), class level (e.g., G21) or section level cover all IPC entries beneath that level. All other codes refer only to the specific subgroup listed.

Source: WIPO, June 2026.

Limitations and areas for further refinement

The proposed taxonomy provides a harmonized, lean and analytically robust framework for classifying green technologies. However, its development also revealed several limitations, primarily related to the structure and granularity of the IPC. Some technologies could not be included, others could only be partially covered, and, in certain cases, IPC-based identification remains imperfect. Discussing these limitations enhances transparency and highlights areas for future refinement.

Technologies excluded due to insufficient IPC coverage

Several technology areas were considered during the development process but ultimately excluded because the available IPC codes did not permit sufficiently precise identification. One example is energy-efficient devices. Although energy efficiency is a central component of green innovation, many energy-saving products are classified according to their functional application rather than their efficiency characteristics. As a result, no consistent set of IPC codes could reliably distinguish energy-efficient devices from conventional alternatives across different sectors.

A similar challenge arose for precision agriculture. While precision agriculture can reduce resource use and environmental impacts, the underlying technologies are typically classified within broader categories, such as agricultural machinery, sensors, data processing and control systems. The available IPC codes do not allow a clear and consistent separation of precision agriculture technologies from conventional agricultural technologies. To avoid excessive noise and misclassification, this field was not included in the taxonomy.

Traffic control technologies were also considered because improved traffic management and related innovations, such as autonomous driving, may contribute to emission reductions by reducing congestion and improving traffic flow. However, these environmental benefits are generally indirect and not the primary objective of the inventions. While the former WIPO IPC Green Inventory included the entire G08G subclass (traffic control systems), this approach was considered too broad for the present taxonomy as it would capture many patents without a clear environmental focus. The field was therefore excluded. More broadly, this reflects a recurring challenge for digital and software-based technologies, where environmental contributions are often indirect and difficult to identify using IPC codes alone.

Technologies included despite imperfect IPC precision

For some technologies, inclusion was considered important despite limitations in IPC precision. In these cases, a trade-off was made between coverage and specificity. Carbon capture and storage (CCS) illustrates this challenge. Several IPC codes associated with carbon capture (including B01D 53/02, B01D 53/14, B01D 53/22 and B01D 53/34) cover gas-separation processes more generally and are not limited to carbon dioxide. Consequently, patent sets derived from these codes include inventions related to the capture of other gases that are not directly associated with CCS. Despite this limitation, these codes were retained because excluding them would omit a substantial number of relevant CCS patents. This decision reflects a deliberate preference for broader coverage while acknowledging the resulting level of noise. More granular IPC codes specifically targeting carbon dioxide capture would substantially improve analytical precision in this field.

Technologies only partially covered

Some technologies could only be partially captured because IPC codes exist for specific aspects of the technology but not for its most important or emerging components. Sustainable aviation is one example. In the present taxonomy, the field is represented by a limited number of highly specific IPC codes, such as those relating to drag-reducing airplane designs. Consequently, patent counts are relatively low. Many important innovations in sustainable aviation – including alternative propulsion systems, low-carbon fuels and more efficient airplane turbines – remain classified under broader IPC categories that cannot be isolated with sufficient precision.

A similar issue arises for rail and public transit technologies. In some existing classifications, including the IPC Green Inventory and CNIPA's taxonomy, most rail-related technologies are considered green because rail transport generally generates lower emissions than other modes of transport. The present taxonomy adopts a more restrictive approach, focusing on technologies that directly improve environmental performance, such as electrification and drag-reducing designs. While this improves conceptual precision, it also results in relatively low patent counts. Whether a broader definition would be preferable depends on the analytical objective. However, broader inclusion would risk diluting the environmental focus of the taxonomy. More granular IPC codes would help distinguish general rail technologies from those providing specific environmental benefits.

Implications for future work

These limitations highlight the extent to which the analytical value of green patent classifications depends on the structure and level of detail of the IPC system. As green technologies continue to evolve and policy interest increasingly focuses on specific sustainability-oriented innovations, further refinement of IPC codes could significantly improve the precision and usefulness of patent-based analyses. The proposed taxonomy is designed to be transparent and adaptable, allowing future revisions as classification systems evolve and more suitable IPC codes become available.

Annex B. Main categories of green technology classification systems

CNIPA

Fossil energy carbon-reduction

Energy conservation and energy recovery

Clean energy

Energy storage

Greenhouse gas capture, utilization and storage

EPO

Climate change adaptation technologies

Buildings and end-user applications

Carbon capture, storage, sequestration and disposal of greenhouse gases

ICT technologies reducing their own energy consumption

Energy generation, transmission and distribution with climate mitigation benefits

Climate-friendly industrial production and agriculture

Low-carbon transportation technologies

Wastewater treatment and waste management

Smart grid systems supporting power generation, transmission, and distribution

Smart grid management of end-user stationary applications and local distribution

Smart grid applications for transportation (e.g., EV charging and interoperability)

ICT and market-operation aspects of smart grids

JPO

Energy supply

Energy demand

Energy storage

CO_2 reduction in non-energy sectors

Greenhouse gas capture, storage, utilization and removal

In addition, four cross-sectoral categories: (a) control and adjustment; (b) measurement and monitoring; (c) business-related technologies and services; and (d) ICT-related technologies

OECD

Environmental management

Water-related adaptation

Climate change mitigation technologies related to energy generation, transmission or distribution

Climate change mitigation technologies related to transportation

Climate change mitigation technologies related to buildings

Climate change mitigation technologies related to wastewater treatment or waste management

Climate change mitigation technologies in production or processing of goods

Capture, storage, sequestration or disposal of greenhouse gases

Technologies specific to climate change adaptation

WIPO IPC Green Inventory

Alternative energy production

Transportation

Energy conservation

Waste management

Agriculture and forestry

Administrative, regulatory or design aspects

Nuclear power generation

WIPO Green Technology Inventory for Statistical Use (GTIS)

Clean energy

Energy efficiency, conversion and storage

Sustainable mobility

Pollution control, recycling and water treatment

Agriculture, forestry and industry

References

Acemoglu, D., P. Aghion, L. Bursztyn and D. Hemous (2012). The environment and directed technical change. *American Economic Review*, 102(1), 131–166. https://doi.org/10.1257/aer.102.1.131.

Angelucci, S., F. Javier Hurtado-Albir and A. Volpe (2018). Supporting global initiatives on climate change: the EPO's "Y02–Y04S" tagging scheme. *World Patent Information*, 54, 85–92. https://doi.org/10.1016/j.wpi.2017.04.006.

Dechezleprêtre, A., M. Glachant, I. Haščič, N. Johnstone and Y. Ménière (2011). Invention and transfer of climate change mitigation technologies: a global analysis. *Review of Environmental Economics and Policy*, 5(1), 109–130.

European Patent Office (EPO) and International Energy Agency (IEA) (2020). *Innovation in Batteries and Electricity Storage: A Global Analysis Based on Patent Data*. EPO and IEA. www.epo.org/en/news–events/in–focus/battery–storage–patents.

European Patent Office (EPO) and International Energy Agency (IEA) (2023). *Hydrogen Patents for a Clean Energy Future: A Global Trend Analysis of Innovation Along Hydrogen Value Chains*. EPO and IEA. https://www.epo.org/en/news–events/in–focus/hydrogen–patents.

European Parliament and Council of the European Union (2020). Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088. *Official Journal of the European Union*, L 198, 13–43. https://eur–lex.europa.eu/legal–content/EN/TXT/?uri=CELEX:32020R0852.

European Patent Office (EPO), United Nations Environment Programme (UNEP) and International Centre for Trade and Sustainable Development (ICTSD) (2010). *Patents and Clean Energy: Bridging the Gap Between Evidence and Policy – Final Report*. EPO, UNEP and ICTSD. https://link.epo.org/web/patents_clean_energy_study_en.pdf.

Favot, M., L. Vesnic, R. Priore, A. Bincoletto and F. Morea (2023). Green patents and green codes: how different methodologies lead to different results. *Resources, Conservation & Recycling Advances*, 18, 200132. https://doi.org/10.1016/j.rcradv.2023.200132.

Government of Canada (2024). *Clean Technology Data Strategy*. Innovation, Science and Economic Development Canada. https://ised–isde.canada.ca/site/clean–growth–hub/en/clean–technology–data–strategy.

Griliches, Z. (1990). Patent statistics as economic indicators: a survey. *Journal of Economic Literature*, 28(4), 1661–1707.

Haščič, I. and M. Migotto (2015). Measuring environmental innovation using patent data. *OECD Environment Working Papers No. 89*. https://www.oecd.org/en/publications/measuring-environmental-innovation-using-patent-data_5js009kf48xw-en.html.

HM Treasury (2025). *UK Government Green Financing Framework 2025*. His Majesty's Treasury. https://www.gov.uk/government/publications/uk-government-green-financing-framework-2025.

Intergovernmental Panel on Climate Change (IPCC) (2023). *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report*. Geneva: IPCC. https://www.ipcc.ch/report/ar6/syr/?.

International Energy Agency (IEA) (2024a). *World Energy Employment 2024*. Paris: IEA.

International Energy Agency (IEA) (2024b). *World Energy Investment 2024*. Paris: IEA.

International Energy Agency (IEA) (2025). *Energy and AI*. Paris: IEA. https://www.iea.org/reports/energy-and-ai.

Japan Patent Office (JPO) (2022). Green Transformation Technologies Inventory (GXTI). https://www.jpo.go.jp/e/resources/statistics/gxti.html.

Johnstone, N., I. Haščič and D. Popp (2010). Renewable energy policies and technological innovation: evidence based on patent counts. *Environmental and Resource Economics*, 45(1), 133–155.

Organisation for Economic Co-operation and Development (OECD) (2011). *Towards Green Growth*. OECD Green Growth Studies. Paris: OECD Publishing. https://doi.org/10.1787/9789264111318–en.

Organisation for Economic Co-operation and Development (OECD) (2015). *The Economic Consequences of Climate Change*. Paris: OECD Publishing. https://doi.org/10.1787/9789264235410–en.

Popp, D. (2002). Induced innovation and energy prices. *American Economic Review*, 92(1), 160–180.

Popp, D., I. Haščič and N. Medhi (2011). Technology and the diffusion of renewable energy. *Energy Economics*, 33(4), 648–662.

Schmookler, J. (1966). *Invention and Economic Growth*. Cambridge, MA: Harvard University Press.

Statistics Canada (2025a). Environmental and Clean Technology Products Economic Account (ECTPEA). https://www150.statcan.gc.ca/n1/daily-quotidien/251219/dq251219c-eng.htm.

Statistics Canada (2025b). Reference Guide for the Survey of Environmental Goods and Services (SEGS). https://www150.statcan.gc.ca/n1/pub/16-511-x/16-511-x2025001-eng.htm.

United Nations Statistics Division (UNSD) (2023). *Classification of Environmental Purposes (CEP)*. New York: UNSD. https://unstats.un.org/unsd/classifications/Meetings/UNCEISC2023/6-2-Classification-of-environmental-purposes-(CEP).pdf.

Veefkind, V., J. Hurtado-Albir, S. Angelucci, K. Karachalios and N. Thumm (2012). A new EPO classification scheme for climate change mitigation technologies. *World Patent Information*, 34(2), 106–111. https://doi.org/10.1016/j.wpi.2011.12.004.

World Intellectual Property Organization (WIPO) (2021). *WIPO GREEN: The Sustainable Technology Marketplace*. Publication No. 1058E/21. Geneva: WIPO.

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