Accelerating China's Green Transition Through Zero-Carbon Industrial Parks

The technical, business, and institutional innovations that are helping China power high-quality economic growth

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Contents

1. Industrial Parks as Engines for Zero-Carbon Development

Industrial parks are vital hubs for national production, producing vast amounts of energy and essential infrastructure services while also serving as significant sources of carbon emissions. China hosts over 15,000 industrial parks, which contribute more than 30% of GDP.[1] Of these, 2,543 national and provincial level parks are listed in the China Development Zone Review Announcement Catalog (2018), accounting for over 50% of the country's total industrial output.[2] At the same time, industrial parks are major national energy consumers and carbon emitters. Researchers estimate that greenhouse gas emissions from industrial parks accounted for over 30% of the national total in 2015.[3] Referencing the National Zero-Carbon Park Construction Indicator System, reducing the average carbon emissions intensity of industrial parks by 50% from current levels could avert approximately 1.95 billion tons of CO_2 emissions.[i] If all industrial parks in China ultimately meet zero-carbon targets (0.2–0.3 ton CO_2 per metric ton of standard coal equivalent), this would avoid approximately 3.3 billion to 3.5 billion tons of CO_2 emissions, making a significant contribution to achieving China's dual carbon goals.

Developing low-carbon and zero-carbon parks supports the low-carbon transformation of energy systems and promotes regionally coordinated green industrial development.[ii] It also provides a platform to pilot initiatives critical to the energy transition, such as demonstration of integrated green technology innovations and power sector reforms.

First, zero-carbon parks support the low-carbon transformation of energy systems, particularly by promoting the consumption of renewable energy. In recent years, China's expansion of new energy installations has far outpaced the development of ultra-high-voltage transmission and power regulation, leading to increased curtailment of wind and solar power. For instance, from 2023 to March 2025, Gansu Province's solar curtailment rate rose from 5% to 12.4%, while Hebei Province's wind curtailment rate increased from 5.7% to 13%.[4] Leveraging zero-carbon parks to achieve a high proportion of local consumption for renewable energy — through an integrated "source-grid-load-storage" model that combines distributed solar photovoltaic (PV), wind power, energy storage, and load management into a self-sustaining energy system — represents one potential approach for overcoming transmission bottlenecks, increasing the share of renewable energy consumption, and accelerating the green and low-carbon energy transition.[5]

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i This estimate is based on the proportion of carbon emissions from industrial parks relative to the national total (31%) calculated in *Research on Low-Carbon Development Pathways for China's Industrial Parks* by Guo Yang, et al. (2021). Due to the lack of recent data reflecting the total emissions of all industrial parks, this estimate assumes that the current proportion of total park emissions remains close to this value. This study, based on data analysis from 213 national-level economic and technological development zones in 2015, can be regarded as the rough proportion of total industrial park carbon emissions in national carbon emissions.

ii A "zero-carbon park" refers to a park that reduces CO_2 emissions from production and daily activities to near-zero levels through planning, design, technology, and management, and also possesses the conditions to achieve net-zero status.

At the same time, zero-carbon parks can drive the development of green supply chains and promote green production. These parks serve as ideal testing grounds for direct green electricity supply, facilitating the certification of green electricity consumption and advancing the “green-for-green” model — where green energy consumption, green technology application, and green product manufacturing are mutually reinforcing. By adopting traceable energy supply systems and comprehensive carbon footprint management, zero-carbon parks help enterprises track energy consumption and raw material carbon emissions across all activities. This enables targeted improvements in production processes and technological equipment to enhance environmental sustainability, significantly reducing product carbon footprints. Such proactive measures not only prepare for potential regulatory requirements but also secure long-term economic viability.

Zero-carbon parks also serve as vital platforms for driving high-quality regional economic development and guiding industrial decarbonization and upgrading. On one hand, traditional sectors such as steel, building materials, nonferrous metals, petrochemicals, and chemicals require steady reductions in carbon emissions. These industrial parks act as key vehicles for exploring low-carbon production models centered on green energy and fostering low-carbon industrial clusters.[6] On the other hand, emerging industries such as lithium batteries, photovoltaics, electric vehicles, computing centers, and data centers have become new economic growth drivers. The industrial upgrades, supply chain synergies, and digital empowerment enabled by zero-carbon parks can give emerging industries an advantage in their green development.

2. China's Industrial Parks Advancing toward Zero Carbon

2.1 Evolution of industrial park policies from green and low carbon to zero carbon

Industrial parks have long served as sites for advancing environmental governance, ecological construction, and low-carbon initiatives in China. Carbon reduction efforts at the industrial park level have progressed through three distinct phases: ecological exploration, low-carbon piloting, and deepening zero-carbon objectives.

- **Ecological Exploration Phase (2007–10):** China launched the Ecological Demonstration Park Program in 2007. By 2010, ecological park development was upgraded, formally incorporating low-carbon economics into ecological industrial demonstration park construction while emphasizing circular economy and environmental protection.

- **Low-Carbon Piloting Phase (2010–24):** Since 2010, the National Development and Reform Commission (NDRC) has launched three rounds of low-carbon provincial and municipal pilot programs, where industrial parks served as components in low-carbon city development. In 2013, the NDRC and the Ministry of Industry and Information Technology (MIIT) jointly initiated national-level low-carbon industrial park pilot projects. The 13th Five-Year Plan (2016) first proposed the Demonstration Project for Near-Zero Carbon Emission Zones.

- **Zero-Carbon Goal Deepening Phase (2024–present):** In 2024, the Central Economic Work Conference first proposed "establishing several zero-carbon parks." In March 2025, the Government Work Report proposed establishing several zero-carbon parks and factories. In July 2025, the NDRC, MIIT, and the National Energy Administration (NEA) issued the Notice on Promoting Zero-Carbon Park Construction, launching the application process for national-level zero-carbon parks, releasing an assessment indicator system, and coordinating funding support for park development. A national proposal released in October 2025 listed building zero-carbon factories and parks as a key task for decarbonization in the next five years.[6]

Zero-carbon parks introduce two new requirements in institutional design:

1. **Clear Zero-Carbon Park Assessment Criteria:** The core evaluation metric for zero-carbon parks is carbon emissions per unit of energy consumption. For industrial parks with total annual energy consumption between 200,000 and 1 million tons of standard coal, carbon emissions must be ≤0.2 ton/ton of standard coal. For industrial parks exceeding 1 million tons of standard coal, emissions must be ≤0.3 ton/ton of standard coal. Currently, the national average carbon emissions per unit of energy consumption in industrial parks is approximately 2.1 tons/ton of standard coal. The zero-carbon parks standards represent a reduction of around 90% compared with the national average. Additionally, guiding indicators set requirements for the proportion of clean energy consumption,

energy consumption per unit of output from park enterprises, utilization rate of industrial solid waste, and utilization of waste heat/cold/pressure.

2. **Strategies for Systematically Building Zero-Carbon Parks:** Zero-carbon parks necessitate adopting multisystem solutions during construction. Achieving zero-carbon status requires integrating measures across energy supply, consumption, management, and non-energy aspects (e.g., infrastructure, industrial structure, circular economy). This involves transforming energy consumption patterns, reducing energy use and carbon emissions, optimizing industrial structure, promoting material efficiency, upgrading infrastructure, applying advanced and applicable technologies, enhancing energy and carbon management capabilities, and innovating mechanisms and models.

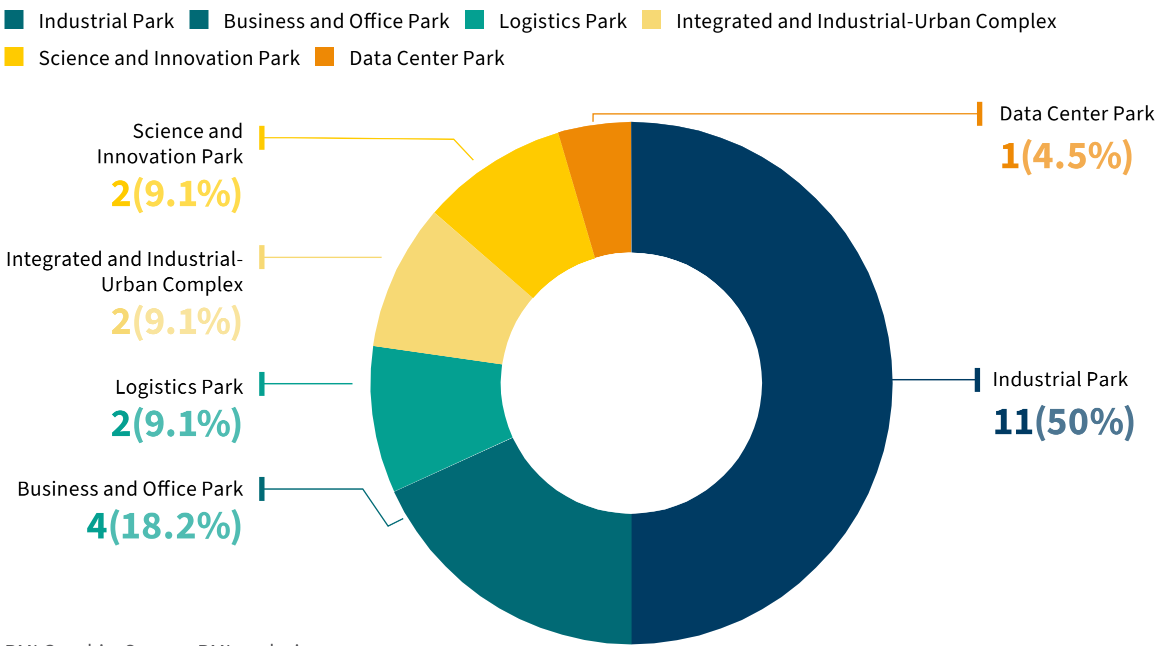
2.2 Accelerating the development of zero-carbon park standards and project implementation

China's zero-carbon park standard system has established a preliminary framework which is undergoing refinement. As of August 2025, four local standards and nearly 30 group standards related to zero-carbon parks had been released nationwide. The national standard Guidelines for Zero-Carbon Park Construction, led by the China National Institute of Standardization and others, is under development and will be the first national-level standard for zero-carbon parks. Multiple group standards for zero-carbon park evaluation have been released, such as the Technical Specifications for Zero-Carbon Park Evaluation issued by the China Energy Conservation Association and the Evaluation Standard for Zero-Carbon Parks issued by the China Investment Association.

Provinces and local governments are developing an array of regional construction plans, guidelines, and specifications for zero-carbon parks. Eastern coastal regions emphasize industrial synergy: Shandong Province adopted a quota-based pilot model to establish China's first comprehensive near-zero-carbon park evaluation system; Fujian Province emphasizes industrial circularity and urban coordination through a "nuclear-powered + zero-carbon smart" system demonstration. Jiangsu Province released detailed construction guidelines and launched a three-year action plan in Wuxi covering zero-carbon factories and virtual power plants (VPPs). In the Northwest and Southwest, the emphasis is on utilization of renewable energy, with Inner Mongolia issuing China's first zero-carbon park construction standards and Yunnan Province proposing to establish green energy systems leveraging hydropower and photovoltaic resources.

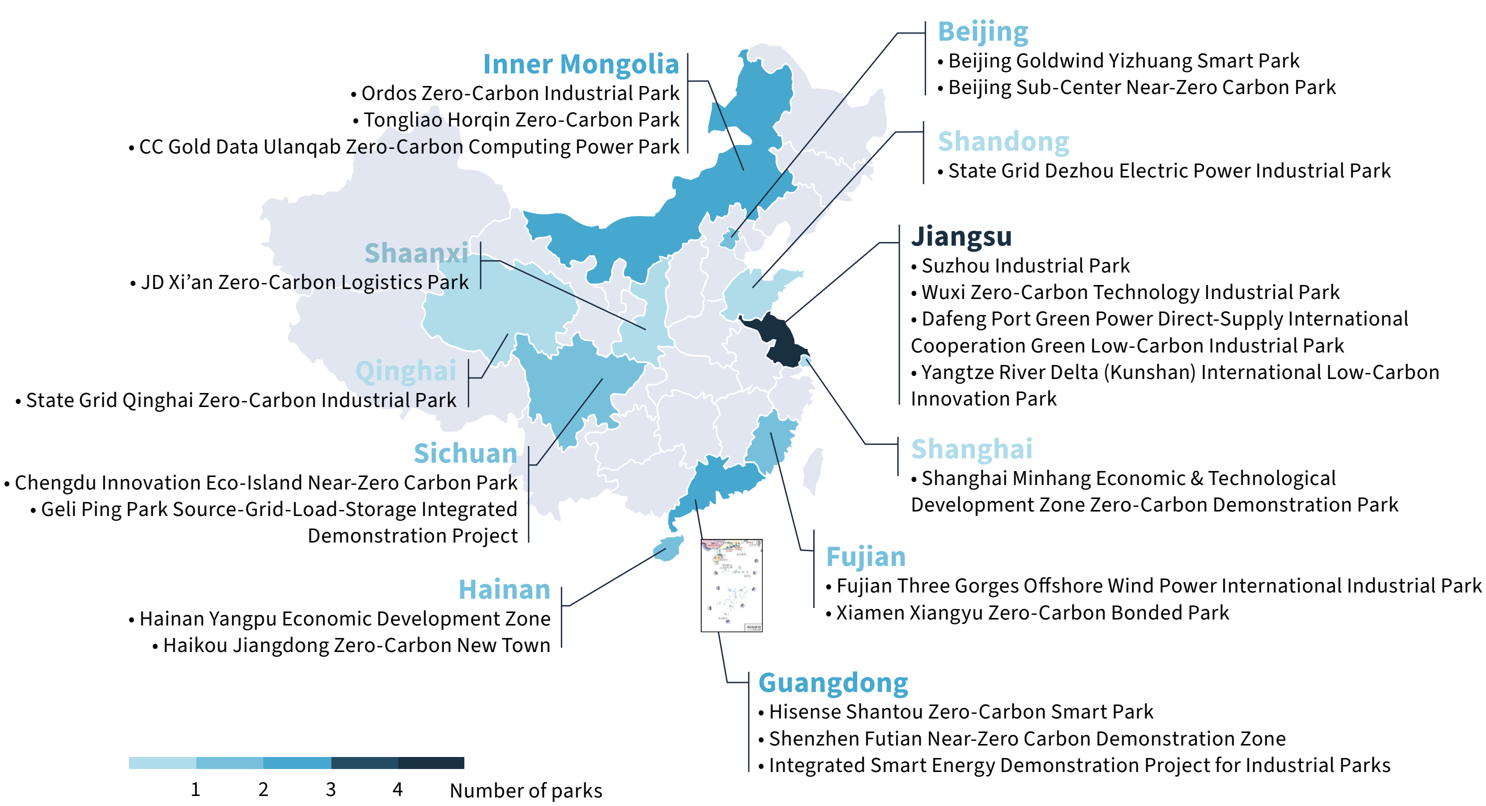
Currently, China's planned zero-carbon parks are primarily concentrated in industrial parks, particularly those specializing in manufacturing new-energy equipment such as wind turbines, photovoltaic components, and batteries (see Exhibit 1). These parks are located mainly in southeastern coastal provinces near major industrial hubs and in northwestern China where wind and solar resources are abundant (see Exhibit 2) and are developing along two basic pathways. One is a compliance-driven pathway in export-oriented coastal regions, where industrial parks must accelerate green transformation to meet international requirements regarding the use of green electricity and carbon footprints in products The other is a resource-driven pathway in northwestern regions, where parks leverage abundant wind and solar resources to promote local consumption of green electricity and synergistic industrial growth, aiming to effectively transform renewable resource advantages into manufacturing upgrades.

Exhibit 1 **Statistical breakdown of typical "zero-carbon" parks in China**



RMI Graphic. Source: RMI analysis

Exhibit 2 **Distribution of "zero-carbon" park projects in China**



Note: Industrial parks labeled "zero-carbon" in Exhibits 1 and 2 are either publicly disclosed as such or planned for zero-carbon development. RMI has not conducted third-party verification of these parks as zero-carbon, nor does this indicate completion of national zero-carbon park project approvals. This analysis aims to showcase existing planned zero-carbon park development practices across regions.

RMI Graphic. Source: RMI analysis

2.3 Zero-carbon park development strategy: Multisystem integration and categorized approaches

Achieving zero-carbon parks relies not only on breakthroughs in individual technologies but also on the coordinated operation of multiple systems, including energy systems, industrial structures, infrastructure, and resource utilization. Based on current policy directions and typical practices, the implementation pathways for zero-carbon parks can be summarized by three major strategies (see Exhibit 3).

Strategy 1: Building green energy systems

Decarbonizing the energy structure is widely recognized as a core element of achieving zero-carbon parks. Based on local conditions, industrial parks can accelerate the transition in energy consumption by developing green power supply models — such as on-site self-generation for self-use, direct green power supply, and integration of nearby renewable energy into local distribution grids. Industrial parks can also consider encouraging enterprises to participate in green certificate trading and green power transactions and establish park-level clean electricity consumption mechanisms to increase green power use. They can adopt biomass boilers and electric heat pumps to provide zero-carbon heat, replacing traditional gas heating. Furthermore, they can use green electricity to produce green hydrogen for industrial production and transportation, achieving deep decarbonization of end-use energy. Infrastructure development can consider prioritizing green construction, systematically advancing the green upgrading of power, heat, hydrogen, water supply/drainage, and wastewater treatment systems while enhancing capabilities for multi-energy coordination, centralized energy supply, and intelligent allocation. Transformation can also be accelerated by using green building methods and adopting low-carbon transportation.

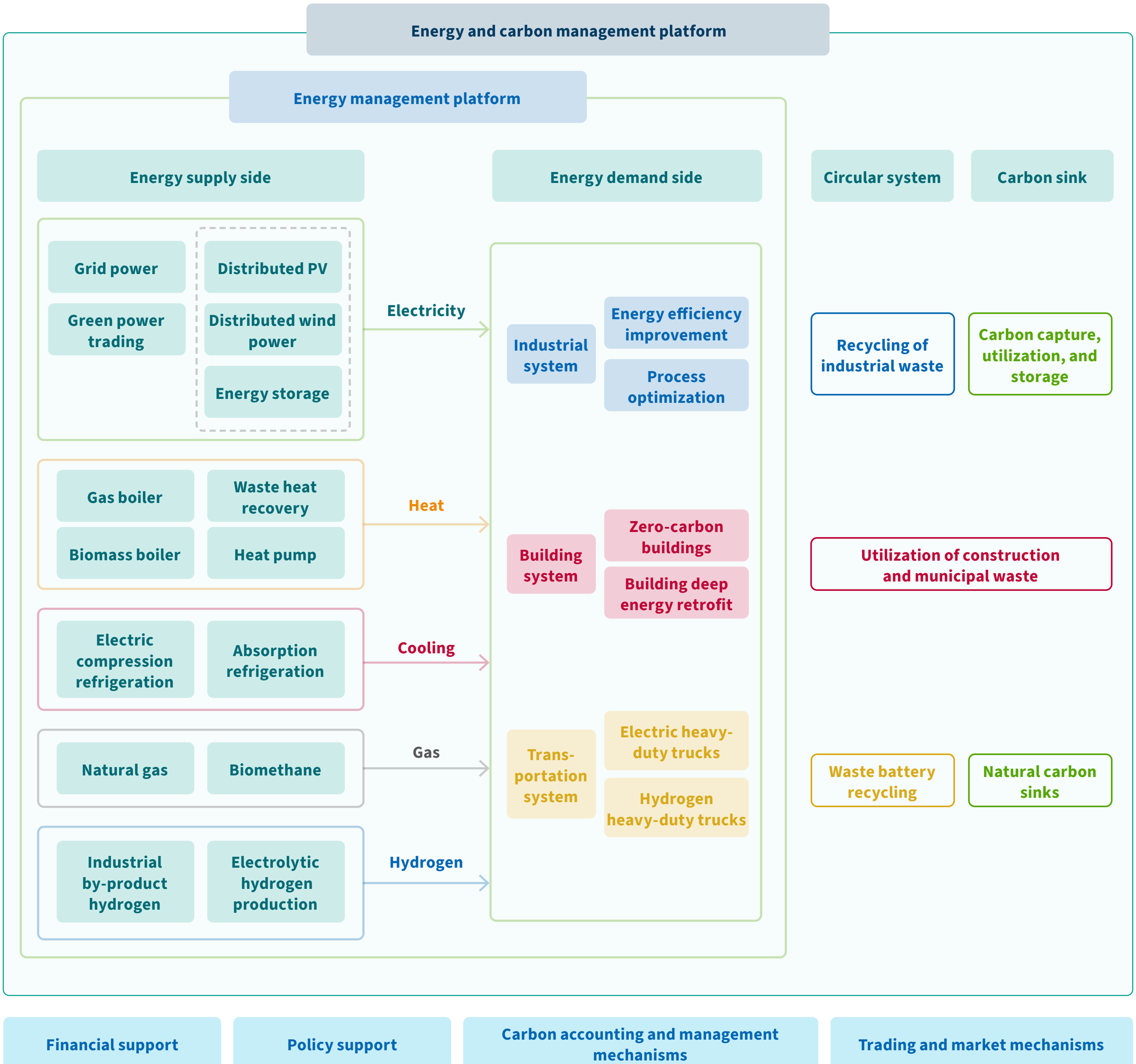
Strategy 2: Upgrading industrial structures and applying technological innovation

Industrial structure typically determines an industrial park's total carbon emissions and intensity. Industrial parks can guide traditional high-energy-consuming industries to transition toward low-carbon, intelligent, and high-value-added transformations, while promoting the establishment of green industries such as next-generation information technology, high-end equipment, and new materials. Industries with high energy consumption can encourage technological upgrades and process improvements to reduce energy intensity. Many zero-carbon industrial parks have promoted and applied advanced and applicable technologies, encouraging the demonstration of new technologies such as hydrogen energy, energy storage, and carbon capture. Furthermore, parks can consider exploring ways of integrating green technology R&D with industrial development and promote joint innovation platforms between research institutions and park enterprises to cover the full chain from technology incubation to commercialization and application.

Strategy 3: Enhancing carbon management and innovating business models

Achieving zero carbon for industrial parks requires establishing a refined, intelligent carbon-emissions management system that covers major energy-consuming enterprises. This system enables real-time monitoring of energy consumption and carbon emissions, load forecasting, and intelligent dispatch. It facilitates dynamic optimization of the industrial park's energy system and precise carbon emissions management, enhances carbon traceability, and provides systematic support for carbon accounting, source-grid-load-storage coordination, power demand response, multi-energy complementarity, and resource recycling. At the same time, through collaboration among governments, power generation companies, grid operators, and integrated energy service providers, the industrial park can explore pathways to a high proportion of renewable energy supply and consumption. Participating in power markets via VPPs and load aggregation enhances energy resource allocation efficiency and system flexibility, fostering replicable and scalable low-carbon models of operation.

Exhibit 3 **Decarbonization framework of a zero-carbon park**



RMI Graphic. Source: RMI analysis

Implementation strategies for zero-carbon parks vary depending on industrial park types. Industrial parks fall into seven categories according to their primary functions: industrial parks, logistics parks, technology parks, commercial office parks, tourism parks, data center parks, and integrated industrial-urban complexes (see Exhibit 4). It is important to note that industrial parks of different types, in different climate zones, with varying resource endowments also vary widely in carbon emissions structures and reduction potential. Their decarbonization pathways will focus on different systems.

Exhibit 4 **Decarbonization strategies for main types of zero-carbon parks**

Note: This exhibit evaluates the relative importance of six systems — energy, industry, buildings, transport, carbon sinks, and circularity — for different types of zero-carbon parks. A higher score for any system indicates the importance of prioritizing it when designing decarbonization pathways for that specific park type.

RMI Graphic. Source: RMI analysis

- Energy consumption in **industrial parks** is primarily concentrated in industrial processes, transportation, and district heating, exhibiting relatively high energy intensity and concentrated carbon emissions. Key carbon reduction efforts should focus on decarbonizing energy systems, optimizing industrial processes, promoting green industrial coupling, and establishing circular utilization systems. Industrial parks dominated by heavy industry can prioritize transforming industrial processes and adopting green energy solutions, particularly clean alternatives for high-temperature heat sources such as green hydrogen, biomass, and high-temperature waste heat recovery. Manufacturing-focused industrial parks can prioritize technologies such as direct green power supply, distributed photovoltaics, energy storage, and industrial heat pumps to decarbonize electricity and medium- to high-temperature heat sources. It is also helpful to improve energy efficiency. And industrial parks can fully tap the resource potential of waste heat, wastewater, exhaust gases, and industrial waste.

- Decarbonization of **logistics parks** primarily involves achieving zero carbon for warehousing facilities and goods transfer vehicles within terminals. Their reduction strategies focus on electrifying energy used in buildings, electrifying transfer vehicles, and achieving zero-carbon electricity consumption. Emphasis can also be placed on optimizing freight transportation and supporting the transition to new-energy vehicles for freight transport. This includes deploying charging/battery-swapping and hydrogen refueling infrastructure, establishing integrated multimodal transport dispatch systems (e.g., road-to-rail, road-to-water), and developing supporting infrastructure.

- In **technology parks** and **commercial office parks**, carbon emissions are relatively concentrated in building energy consumption, so decarbonizing the building system is the primary focus. This involves advancing ultra-low energy and zero-carbon building standards, deploying smart lighting and energy-efficient HVAC systems, and building automation controls to enhance operational efficiency. Key approaches include integrating renewable energy supply, leveraging the potential of building energy storage, and constructing grid-interactive buildings with integrated photovoltaic-storage-direct-flexible systems.

- **Tourism parks** focus their carbon reduction efforts on building systems, transportation systems, and the development of natural carbon sinks. While reducing emissions from accommodation, reception facilities, and exhibition halls, they can optimize visitor transportation by developing electric sightseeing vehicles, shared transportation options, and rail transit shuttle systems. Natural scenic areas have significant potential to develop as natural carbon sinks. These can be enhanced by conservation and nature-based carbon sink systems to boost the park’s carbon removal capacity.

- **Data center parks** primarily generate carbon emissions from electricity consumption. Key reduction strategies include improving energy efficiency — such as adopting advanced liquid-cooling technologies, AI-driven load balancing, and high-efficiency power use effectiveness systems — and accelerating the deployment of clean energy sources like wind power, photovoltaics, and energy storage to enable integrated zero-carbon energy solutions.

- **Integrated industrial-urban complexes** are large-scale integrated development models that combine industrial, residential, commercial, educational, and healthcare functions to achieve work-life balance, with carbon emissions characterized by multiple sources and high complexity. Decarbonization requires integrated planning across energy, building, transportation, and recycling systems. This involves promoting green building clusters, low-carbon transportation networks, and low-carbon smart energy systems; reducing industrial energy consumption and process emissions; enhancing reclaimed water and waste resource utilization; and establishing a coordinated urban-industrial carbon-reduction system.

3. China's Zero-Carbon Park Development: Four Major Innovations Drive Systematic Transition

China's zero-carbon park development remains in its early stages. Four core challenges have been identified in policy and industry discussions. (1) resolving renewable energy supply-demand mismatches and system constraints to achieve high renewable energy consumption and decarbonization of the energy mix; (2) strengthening material flow carbon management to enable efficient industrial coupling and high circular economy integration;
(3) fostering investment, financing, and business model innovation to scale up large-investment projects and ensure sustainable operations; and (4) enhancing the traceability and transparency of carbon emissions data to meet core requirements for both external trade and internal low-carbon governance within the park. Breakthroughs in these four areas will support the implementation of zero-carbon parks and establish replicable models.

3.1 Zero-carbon energy: Integrated energy solutions

The foremost task in developing zero-carbon parks is to transform the energy structure. Achieving zero-carbon energy requires deep decarbonization on the supply side, strenuously developing and utilizing zero-carbon energy sources, while also implementing integrated management across multiple energy carriers — such as electricity, gas, cooling, heating, and hydrogen — covering supply, transmission, use, and storage, as well as coordination across sectors including industry, buildings, and transportation.

Achieving high green electricity consumption is the most critical measure for decarbonizing the park's energy mix. Statistics from certain industrial parks indicate that electricity consumption typically accounts for over 50% of energy end use, with highly concentrated load profiles.[7] Pathways for industrial parks to obtain green electricity fall into two categories: **local consumption** and **market transactions**. The former includes three methods — on-site self-generation for self-use, nearby integration of renewable energy into distribution grids, and green electricity direct supply — enabling local or direct consumption of green electricity. The latter pathway relies on green electricity trading and green power certificate subscription mechanisms to acquire green electricity through the market (see Exhibit 5).

Exhibit 5 **Pathways for green electricity acquisition in industrial parks**

	Model	Description	Advantages	Challenges	Suitable parks
Local consumption	**On-site self-generation for self-use**	Users generate electricity for self-use by installing photovoltaic and wind power systems	Reduces dependence on external power grids and lowers electricity costs	Limited by roof area and generation capacity, making it difficult to meet industrial loads	Logistics and warehousing parks with abundant rooftop resources
	Integration of nearby renewable energy into distribution grids	Renewable energy sources are connected to the local grid within the industrial park and managed uniformly by the incremental distribution system operator	Reduces electricity cost burden to consumers	Lacks a sustainable development mechanism, with a long investment payback period	Industrial parks with numerous enterprises, significant variations in electricity consumption, and diverse forms of distributed energy generation
	Green power direct supply	Renewable energy is not directly connected to the public grid but supplied to a single power user via direct connection lines	Strong physical traceability, suitable for export-oriented enterprises	High initial investment, imperfect cost-sharing mechanisms, and inherent uncertainties	Export-oriented industrial parks, especially those facing battery legislation requirements
Market trading	**Green electricity trading**	Users purchase green electricity from renewable energy generators through power market trading platforms while obtaining corresponding green certificates	Meets enterprises' demand for sourcing green electricity and facilitates compliance with foreign trade order requirements	Supply shortages in some regions, and upper limits on the proportion of green electricity required in zero-carbon parks	Enterprises with a willingness to engage in green electricity trading
	Green Power Certificate subscription	Users purchase green power certificates (GPCs) separately through the trading platform	Market supply is ample, and acquisition is convenient	Certain trade rules and lead enterprises do not recognize (or only partially recognize) GPCs in some countries, and zero-carbon parks impose upper limits on the proportion of GPCs	Enterprises with a willingness to subscribe to green power certificates

RMI Graphic. Source: RMI analysis based on relevant policy documents

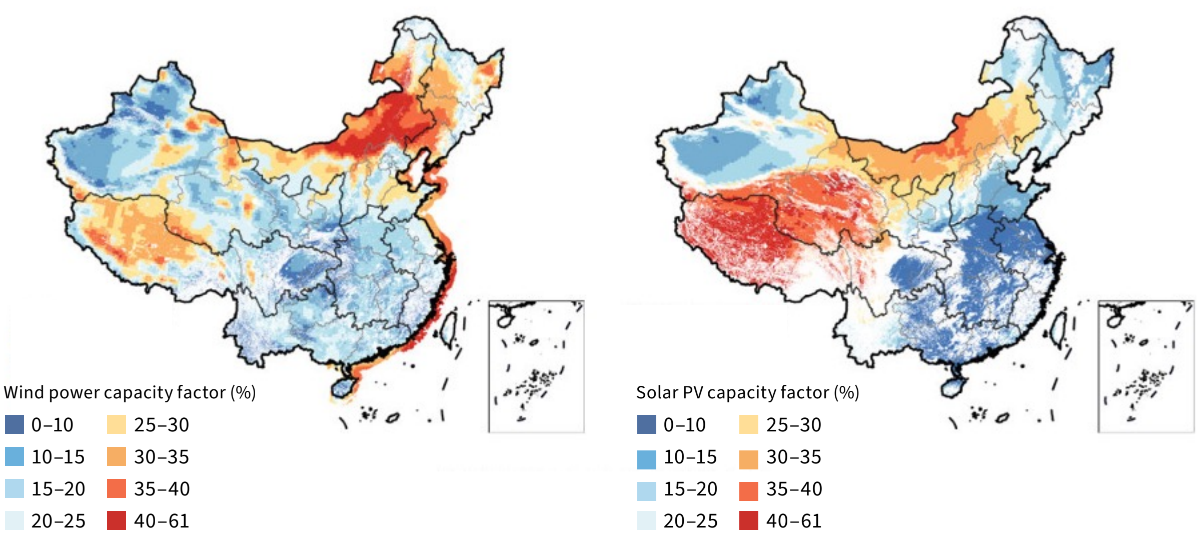
Under the zero-carbon park policy requirements, the local consumption model for green electricity is the most critical approach for such parks. However, under current policy conditions, local consumption faces three key challenges:

- **Exploring optimized industrial layout to build local synergistic advantages of renewable energy and industrial parks.** China's industrial parks are primarily concentrated in its central and eastern regions, whereas renewable energy resources are mainly distributed in the northwestern (wind and solar) and southeastern coastal areas (wind) (see Exhibit 6). In regions with exceptionally abundant wind and solar resources, such as Qinghai and Inner Mongolia, the marginal cost of green electricity production is significantly lower than areas that are not rich in renewable resources. For instance, the cost per kilowatt-hour for photovoltaic projects in Qinghai can be as low as RMB 0.28, more than RMB 0.3 less than comparable projects in eastern regions.[8] Although the southeast coastal areas possess 2.78 billion kilowatts of exploitable offshore wind power potential, actual utilization rates remain below 0.9% due to complex cross-departmental approvals and high construction costs.

  To promote local consumption of green electricity, coordinated development between renewable energy-rich regions and high-energy-consuming industries can be considered. Industries like aluminum smelting, polysilicon production, and data centers have stable electricity demand and are price-sensitive, making them suitable for on-site green electricity consumption. For instance, the Alashan photovoltaic project in Inner Mongolia supplies power directly to nearby aluminum smelters, increasing annual utilization hours from under 1,800 to 2,200 and reducing curtailment rates.[7] This localized model of matching green power supply to industrial demand allows resource-rich regions to attract energy-intensive industries and production capacity transfers, driving synergistic development between new energy and the economy.

Exhibit 6 **Distribution of wind and photovoltaic capacity in China**

Distribution of wind power capacity factors in China | **Distribution of solar PV power capacity factors in China**



Note: Graphic excludes unavailable land areas.
Source: Institute for Carbon Neutrality, Tsinghua University

- **Accelerating the adoption of new technologies, particularly energy storage, to enhance the technical and economic viability of self-balancing through local consumption of green electricity.** On the demand side, electrification of industrial park energy use expands the consumption space for green electricity, providing a stable load for local consumption of new energy. The installed capacity of new energy sources must align with the scale of the industrial park's electricity consumption. Under current requirements, self-consumption of locally generated electricity must account for at least 60% of total generation and at least 30% of total consumption, with the self-consumption ratio increasing to at least 35% by 2030. Furthermore, local consumption requires the industrial park grid to possess self-balancing capabilities. Wind and solar power generation exhibit randomness, volatility, and intermittency, making it difficult to perfectly align with load curves. Therefore, energy storage systems must be integrated to smooth generation fluctuations. Combined with advanced control and digital monitoring technologies, this enables coordinated dispatch of generation, load, and storage.

  Energy storage costs remain relatively high, with electrochemical storage systems currently priced at approximately RMB 400 to RMB 800 per kWh.[9] However, driven by policy incentives and expanding demand, storage equipment costs continue to decline. In 2024, winning bid prices for lithium-ion battery storage systems and vanadium flow battery systems decreased by about 44% and 20%, respectively, compared with 2023,[10] laying the foundation for the technical and economic viability of local green electricity consumption and self-balancing. At the same time, advancing VPP development — aggregating controllable loads through digital platforms — enables more efficient electricity utilization and enhances grid self-balancing capabilities within industrial parks.

- **The identification of entities responsible for local consumption of green electricity and the cost-sharing mechanism have taken initial shape but require concrete implementation.** Projects for local consumption of renewable energy possess dual attributes of both generation and consumption, making the delineation of interfaces and responsibilities directly relevant to the operational feasibility of policy implementation. Disputes over cost allocation primarily center on the billing methods for transmission and distribution fees and system operation costs.

  The newly issued Notice on Improving Price Mechanisms to Promote Local Consumption of New Energy Power Generation clarifies that power sources, loads, and energy storage must be integrated as a unified entity to establish clear physical and responsibility boundaries. Transmission and distribution fees are charged based on grid connection capacity, while system operation fees are temporarily calculated by electricity volume, with a future transition to capacity-based billing. Local consumption projects qualify as power generation entities to enter the electricity market and enjoy market status equivalent to industrial and commercial users when functioning as electricity consumers. Refining the pricing mechanism will enhance the economic viability and regulatory certainty of direct green power connections. However, the investment cost pressures and actual operational effectiveness of energy storage configurations and flexible regulation in these projects require further evaluation. Local governments can consider establishing operational rule systems clarifying key details — such as metering standards, criteria for valid consumption, and procedures for participating in spot electricity markets and ancillary service markets — to ensure policy implementation and model promotion.

Beyond electricity, the heating sector is a major contributor to energy consumption and carbon emissions within industrial parks. Coordinated efforts can help optimize the energy mix of heating systems and support the transition to zero-carbon alternatives. Achieving zero-carbon transformation of heating systems involves using clean energy sources such as renewable electricity, waste heat, and biomass. The preferred pathway for this transition is heat pumps and natural heat sources or waste heat.

The core approach involves classifying heating systems based on heat density, temperature (pressure), and application scenarios, thereby matching them with appropriate technological solutions. For low-temperature, low-density demands — such as decentralized building heating and domestic hot water — the natural heat source/heat pump solution is suitable. For high-density demands — such as centralized heating in northern cities and contiguous industrial heating —the heat pump and waste heat (e.g., from thermal power units, industrial processes, or data centers) approach may be adopted. This can integrated with district heating networks and cross-seasonal thermal storage to resolve spatial and temporal mismatches between heat sources and consumption.

In medium- to high-temperature applications, industrial heat pump technology efficiently meets drying, preheating, and cleaning processes (50°C–120°C) in industries like food and electronics, as well as low- to medium-pressure steam (saturated pressure <1 megapascal) requirements for light industries such as papermaking and textiles. For high-temperature and high-pressure applications, such as the high-pressure steam (saturated pressure >1 megapascal) needed in the chemical industry, zero-carbon fuels like biomass briquettes, biogas, biomethane, and green hydrogen are suitable options for clean replacement.

Furthermore, feedstock and fuels are pivotal to low-carbon transformation, necessitating the promotion of green hydrogen and biomass to replace fossil fuels. In heavy industry, green hydrogen-based steelmaking can replace traditional blast furnace steelmaking based on coke, achieving near-zero-emissions steel manufacturing. Cement production can extensively use alternative fuels derived from biomass and municipal solid waste, achieving over 60% substitution for coal combustion. In the chemical sector, integrating green hydrogen with Power-to-X technologies can effectively address the high carbon-to-hydrogen ratio inherent in traditional fossil feedstocks, significantly reducing carbon emissions in chemical reactions.

However, these pathways still face challenges. First, significant resource and deployment constraints exist, such as the geographical distribution and spatial limitations of biomass, geothermal, and industrial waste heat. Second, some technological costs remain high, requiring scaled breakthroughs in hydrogen storage and resource exploration. Third, safety concerns and low societal acceptance persist, requiring enhanced safety oversight and public awareness initiatives during hydrogen energy deployment. Although feedstock substitution holds immense potential, achieving large-scale application necessitates sustained efforts in resource security, cost control, and technological safety.

From the energy-use perspective, process transformation and energy efficiency improvements are fundamental for achieving deep emissions reductions. Introducing low-carbon technologies into energy-intensive industries such as steel, cement, and petrochemicals requires large-scale modifications to existing processes. For instance, the green hydrogen direct reduced iron process can reduce carbon emissions by over 70% compared with the traditional blast furnace-converter process, but its cost per ton of steel is more than 20% higher. Its widespread adoption depends on decreasing the cost of wind, solar, and hydrogen storage. Meanwhile, energy electrification is a significant low-carbon pathway. Replacing traditional fuels with electricity generated from renewable energy sources can enhance energy efficiency while reducing carbon emissions. In non-heavy-industrial sectors like equipment manufacturing, textiles, and food processing, the combined potential of electrification and energy efficiency improvements is even greater. Taking the electronics manufacturing industry as an example, energy efficiency measures — such as optimizing energy management, upgrading to high-efficiency equipment, and implementing smart control systems — can unlock energy savings of up to 30%.[11]

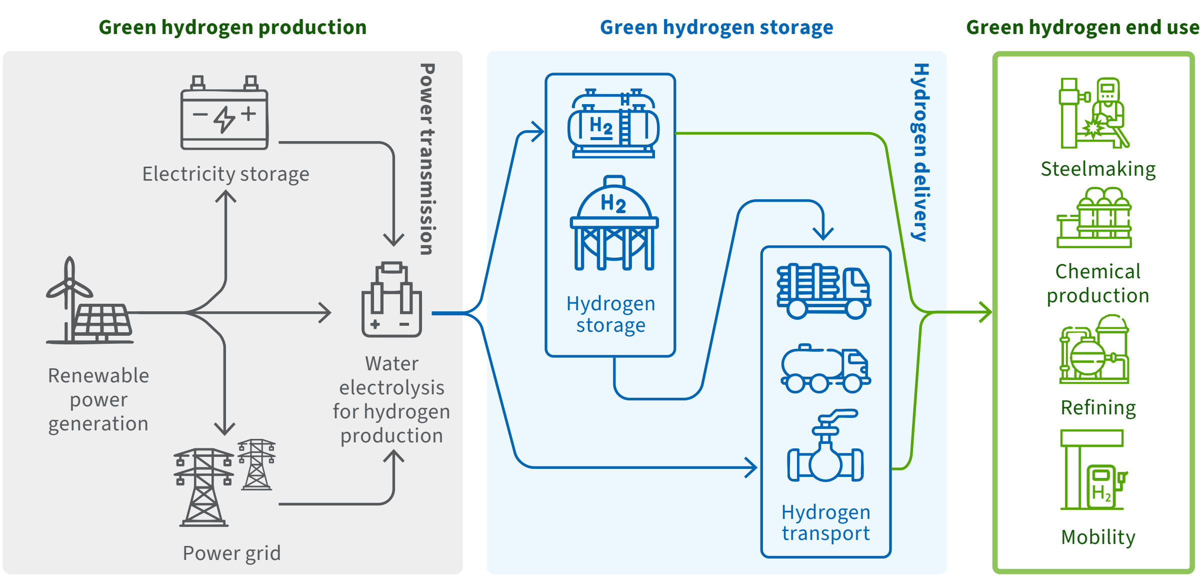
Industrial parks also need to leverage smart energy management systems to oversee every stage of green energy production, storage, transportation, and utilization. Under traditional industrial park energy management models, the decentralized operation of various equipment leads to invisible energy consumption data, low energy efficiency, and high operating costs. An integrated energy management system enables intelligent monitoring, data collection, and analysis of energy flows. It reduces energy costs through energy allocation; minimizes energy accident rates via real-time Internet of Things (IoT) monitoring; adjusts energy structures using big data energy analysis; and mitigates grid impacts through energy storage for peak shaving and frequency regulation.

3.2 Low-carbon materials and molecules: Industrial symbiosis, circular economy, and embodied carbon management

Building on low-carbon energy systems, zero-carbon parks should also strengthen material flow carbon management. This involves promoting upstream-downstream material recycling through industrial coupling, encouraging closed-loop material recovery and circular economy practices within the park and along supply chains, enhancing efficient utilization of waste resources (e.g., exhaust gases, scrap, slag, and wastewater), and prioritizing low-carbon materials and equipment with low-carbon life-cycle features.

First, zero-carbon parks should prioritize internal industrial material flow coupling, including upstream-downstream material integration. The primary form of industrial coupling is cluster-based development centered on green resources such as green hydrogen, green electricity, CCUS, and solid waste. During the low-carbon and zero-carbon industrial transition, taking the utilization of continuous, stable green hydrogen as an example, a typical layout for regions enabling cluster-based development integrates industrial production capacity with related low-carbon and zero-carbon resources (green electricity, green hydrogen) and their infrastructure, along with organic coordination among these elements (see Exhibit 7). Zero-carbon parks should tailor their approaches to local conditions, selecting appropriate industrial production pathways based on capacity and resource availability. They should coordinate resource allocation — including energy and byproducts — among enterprises, fully leverage locally available low-carbon and zero-carbon resources, and install or upgrade necessary infrastructure.

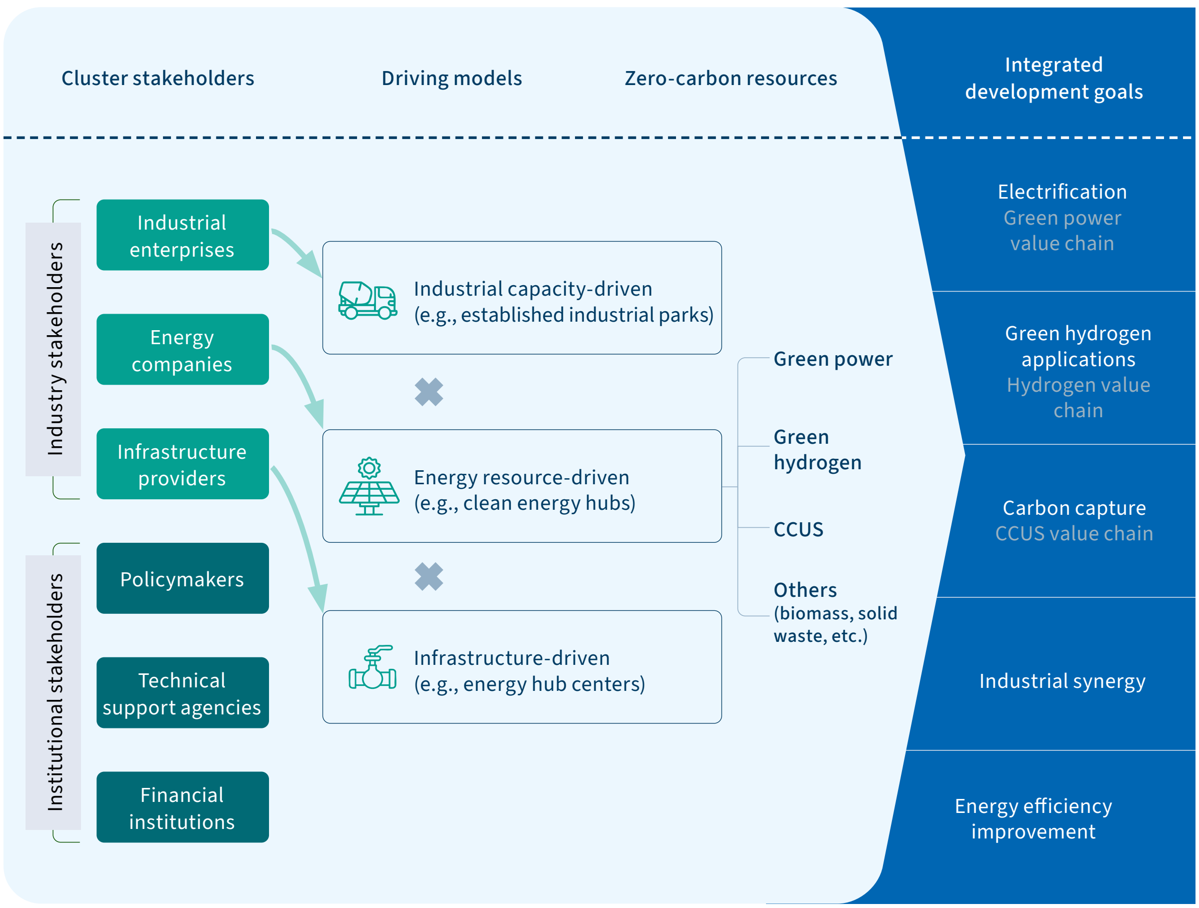
Exhibit 7 **Pathways to a continuous and stable green hydrogen supply**



RMI Graphic. Source: RMI analysis

The cluster model also requires viable business models to coordinate the distribution of industrial capacity and green resources, bringing together multiple stakeholders involved in the production, storage, transportation, and utilization of green resources to achieve effective risk management and mitigation. The primary drivers for forming low-carbon and zero-carbon industrial clusters include industrial-capacity-driven, energy-resource-driven, and infrastructure-driven approaches (see Exhibit 8). Existing industrial parks can be retrofitted to facilitate low-carbon and zero-carbon energy and resource applications, avoiding large-scale stranding of existing capacity. Infrastructure-driven approaches leverage existing natural gas pipelines, storage facilities, and other infrastructure to catalyze new zero-carbon parks. New industrial parks should also optimize industrial layouts based on regional renewable energy distribution and industrial conditions. High-energy-consuming industries should be located in areas rich in renewable energy, creating new zero-carbon parks through re-siting and rebuilding.

Exhibit 8 Driving models for low-carbon and zero-carbon industrial clusters



RMI Graphic. Source: RMI analysis

Second, zero-carbon parks should strive to develop a circular economy by promoting closed-loop recycling within the park and along the industrial chain, as well as the efficient use of recycled resources. The potential for carbon reduction through recycled resource use is significant. From 2016 to 2020, it accounted for 25% of China's carbon emissions reductions; from 2021 to 2025, it will contribute 30%, rising to 35% by 2030. Recycled resource production has significant potential. By 2050, recycled steel is projected to make up 60% of total steel production, recycled plastics 55%, and recycled aluminum 60%.[12] The carbon reduction potential of recycling can be realized in the short to medium term, given the relatively high degree of technology readiness. Scalable implementation requires only the establishment of appropriate mechanisms. Leading enterprises in the industrial park can leverage their position as supply chain anchors to develop viable, replicable circular-economy business models based on robust supply chain management. The industrial park can also convert food waste, kitchen scraps, construction debris, and scrap materials into resources, energy, and recycled products needed for urban development, contributing to industrial and lifestyle transformations beyond its boundaries.

Finally, although current zero-carbon park policies do not explicitly cover Scope 3 emissions**, from a full life-cycle zero-carbon perspective, industrial parks can lower embodied carbon by using low-carbon materials and construction methods.** Embodied carbon emissions refer to CO_2 generated during the production, transportation, and construction of building materials, and broadly encompass material carbon emissions inherent in any equipment or product. As hubs for new construction projects, zero-carbon parks are well suited to serve as concentrated demonstration sites for low-carbon building materials. Reducing embodied carbon in industrial parks requires low-carbon procurement mechanisms for building materials. Incorporating embodied carbon limits early in project evaluation and establishing product carbon accounting, labeling, and procurement platforms will help scale the use of low-carbon building materials.

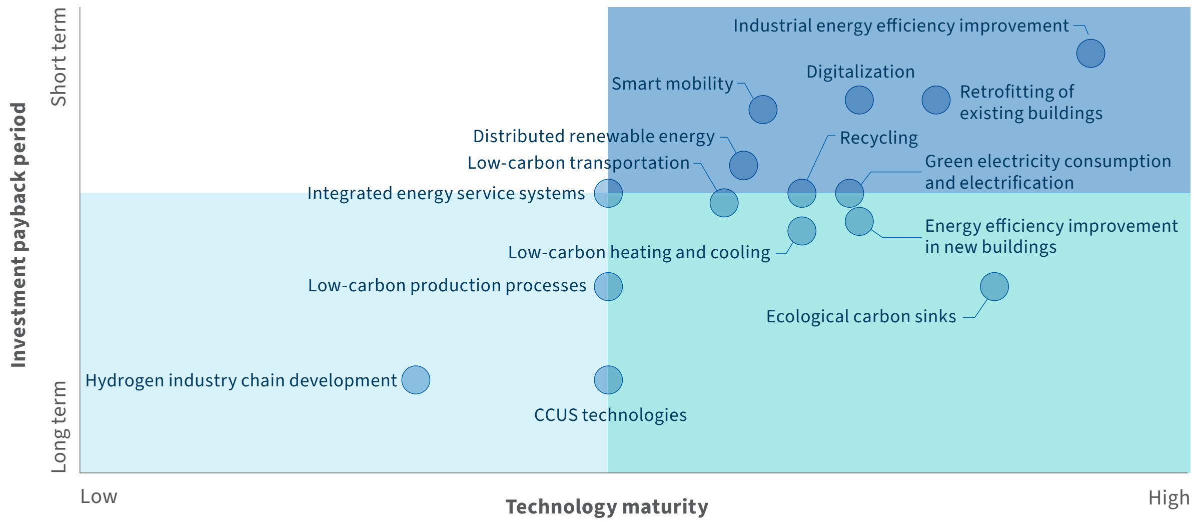
3.3 Investment, financing, and business models: Activating capital for scaling up

From an investment perspective, zero-carbon park development faces challenges in four main areas: funding scale, investment returns, financing channels, and the economic viability of carbon reduction benefits.

- **Significant capital investment is required for new construction or retrofits.** Zero-carbon park development requires large investments not only in clean energy facilities such as solar panels, wind power, and energy storage, but also in building smart energy management platforms, multi-energy complementary systems, carbon emissions monitoring systems, and green retrofitting of existing buildings. Such infrastructure is capital-intensive, often requiring investments ranging from hundreds of millions to billions of renminbi. Compared with traditional parks, zero-carbon parks incur significant incremental costs, necessitating business models that turn up-front investments in energy and digital assets into market value.

- **The investment return cycle is lengthy with uncertain returns.** Zero-carbon parks primarily rely on long-term benefits from energy conservation, reduced consumption, carbon emissions cuts, and green power use. Revenue streams include energy sales, asset appreciation, carbon quota and China Certified Emission Reduction (CCER) trading, and integrated energy service fees. As green power and carbon market mechanisms are still developing, there is significant price volatility, leading to high uncertainty in revenue forecasting. Additionally, emerging technologies such as hydrogen energy, carbon capture, and long-duration energy storage lack mature business models and have unclear profit pathways, further extending investment payback periods and amplifying uncertainty (see Exhibit 9).

Exhibit 9 Technology maturity and payback periods for key technologies in zero-carbon parks



RMI Graphic. Source: RMI analysis

- **Green financing channels for industrial parks remain limited.** Although China has established a preliminary green finance system in recent years, specialized financial instruments to reduce industrial park emissions remain scarce. For instance, there is a lack of customized financial products closely aligned with the investment cycles, technical risks, and carbon market policies of zero-carbon parks. Existing green loans and bonds often require high credit ratings and substantial collateral, creating significant financial barriers for park enterprises, especially small and medium-sized enterprises (SMEs). At the same time, financial institutions lack mature methods and standards for evaluating the risks of zero-carbon park projects, making it difficult to accurately quantify their environmental value and future returns. This, in turn, limits the financing options available to project developers.

- **Currently, zero-carbon parks still lack pathways to turn carbon emissions reductions into economic benefits and market incentives.** From a carbon market perspective, industrial parks themselves are not eligible to participate in carbon trading. Even if enterprises within these parks could participate in the carbon market, the current carbon price remains insufficient to incentivize large investments in emissions reduction. Established carbon revenue mechanisms — such as carbon trading, downstream buyers paying premiums for green products, Certified Voluntary Emission Reductions (CVERs), and expanding product markets overseas — primarily operate at the enterprise level with companies as the main beneficiaries. Parks struggle to capture actual revenue from carbon reductions, resulting in a lack of effective incentive mechanisms.

Achieving scalable breakthroughs for zero-carbon parks depends on developing innovative investment and financing strategies, as well as business models, to expand funding sources and reduce investment risks.

- **Business model innovation can enable zero-carbon parks to deliver cost-saving and efficiency-enhancing services through multi-energy integration.** Integrated energy service providers offer one-stop solutions tailored to enterprises' production, living, and management needs within the park. These solutions encompass energy planning and design, engineering investment and construction, multi-energy operation services, and investment and financing services. They address users' diverse energy consumption requirements and service demands, helping industrial parks reduce costs, increase efficiency, and meet low-carbon goals. Integrated energy service providers deliver a suite of high-value-added services throughout the energy systems life cycle. The Energy Performance Contracting (EPC/EMC) model, one of the primary revenue streams, involves sharing profits generated from energy efficiency improvements. The Energy-as-a-Service (EaaS) model operates on a subscription or leasing basis, transferring asset ownership and maintenance responsibilities from the customer to the service provider. Service providers can also leverage their data platforms and aggregation capabilities to participate in electricity markets, generating additional value-added returns. Integrated energy service providers play a pivotal role in zero-carbon park development — from technology integration to capital organization — establishing a cooperative framework based on shared costs and shared benefits for all stakeholders.

- **Innovative green financial instruments could expand financing channels for zero-carbon parks.** Current green bond and loan instruments operate mainly at the project level. Industrial park owners, developers, and financial institutions can explore park-specific green bonds and loans that link carbon-reduction performance with financing terms, thereby incentivizing decarbonization measures across the park. For new industrial parks with zero-carbon plans and implementation measures, annual green loans and bonds can be issued based on their planning and progress. Transition finance taxonomies could be expanded to explicitly support zero-carbon industrial park projects. As product carbon footprints are subject to increasing market scrutiny and represent a key outcome of zero-carbon park development, complementary incentive mechanisms are also needed. For example, project financing processes could be streamlined or prioritized for industrial parks or products that have already achieved credible zero-carbon certification, thereby improving access to capital and strengthening market signals for low-carbon investment.

- **Innovative trading models can integrate dispersed resources and generate economic value for zero-carbon parks.**

  - **Distributed energy aggregation** for energy trading involves pooling numerous small-scale distributed energy sources through an aggregator or VPP, enabling them to participate in electricity market transactions as a unified, dispatchable entity. This approach improves grid flexibility and stability, lowers market barriers, promotes renewable energy integration, and provides new revenue streams for users with distributed PV, energy storage, and electric vehicles, incentivizing investment. Industrial parks can participate in trading by establishing VPPs, either as self-operated VPP operators or by commissioning professional aggregators, effectively transforming dispersed energy resources into electricity commodities.

  - **The book and claim mechanism** is an accounting and trading model for tracking and allocating sustainability attributes (such as carbon emissions reductions). It allows clean fuel or material producers to "book" the emissions reductions generated by their products in one location, while customers can purchase and "claim" these reductions elsewhere for climate disclosure purposes. When physical procurement channels are absent or complex, the book and claim mechanism connects willing buyers and sellers to jointly achieve value chain decarbonization. As procurement scales up, it encourages producers to reduce costs. This mechanism has seen initial application in corporate procurement of renewable aviation fuels, green steel, and building materials, and it can serve as a business model for large-scale green energy and material procurement in industrial parks.

3.4 Emissions transparency: Traceability and disclosure for low-carbon governance

The traceability and transparency of industrial park carbon emissions have become fundamental to addressing the low-carbon governance of the park as well as international trade requirements. Data transparency is driven by two main factors: policy compliance and market competitiveness. Both the national carbon market and dual-control policies rely on accurate data to support total emissions control. Multinational corporations incorporate carbon footprints into supply chain access criteria, making credible data essential for park enterprises to enter green supply chains; enhance environmental, social, and governance performance; and elevate brand value. Additionally, data transparency supports internal optimization and financial innovation. Real-time, traceable data systems help parks identify high-emissions processes, drive energy-saving upgrades, and optimize energy scheduling. Transparent data further underpins green credit, green bonds, and carbon market transactions, forming a cycle linking data, emissions reduction, financial revenue, and reinvestment.

Strengthening innovation in green and low-carbon mechanisms within industrial parks is a critical enabler for regional and corporate emissions reduction. Systematic implementation of carbon budgeting, emissions monitoring, and information disclosure should serve as foundational carbon management systems. These practices provide quantitative evidence for policy formulation and guide enterprises and parks in adopting scientifically grounded mitigation measures. However, practical implementation faces significant challenges in the traceability of energy and emissions data within parks, as well as the consistency of carbon accounting rules, including:

- **Boundary delineation:** Industrial parks typically comprise diverse enterprises, public facilities, and transportation systems, with energy and materials frequently flowing between different entities. This often leads to ambiguous emissions boundaries and data duplication or omission. For instance, there is a lack of unified accounting rules for allocating emissions from centralized heating and power supply between the park level and the enterprise level.

- **Data collection capacity and data quality:** Since carbon emissions data spans multiple segments, including electricity, gas, steam, cooling water, and waste treatment, the data is dispersed across various enterprises and service providers, lacking a unified platform for collection and integration. SMEs often lack digital management capabilities, typically providing only rough statistical data.

- **Information disclosure:** Enterprises often limit the disclosure of emissions data related to core business activities, leading to information silos within industrial parks. In the absence of independent third-party verification, parks face challenges in demonstrating the completeness and reliability of their aggregated emissions data, which can weaken their credibility within green and low-carbon supply chains.

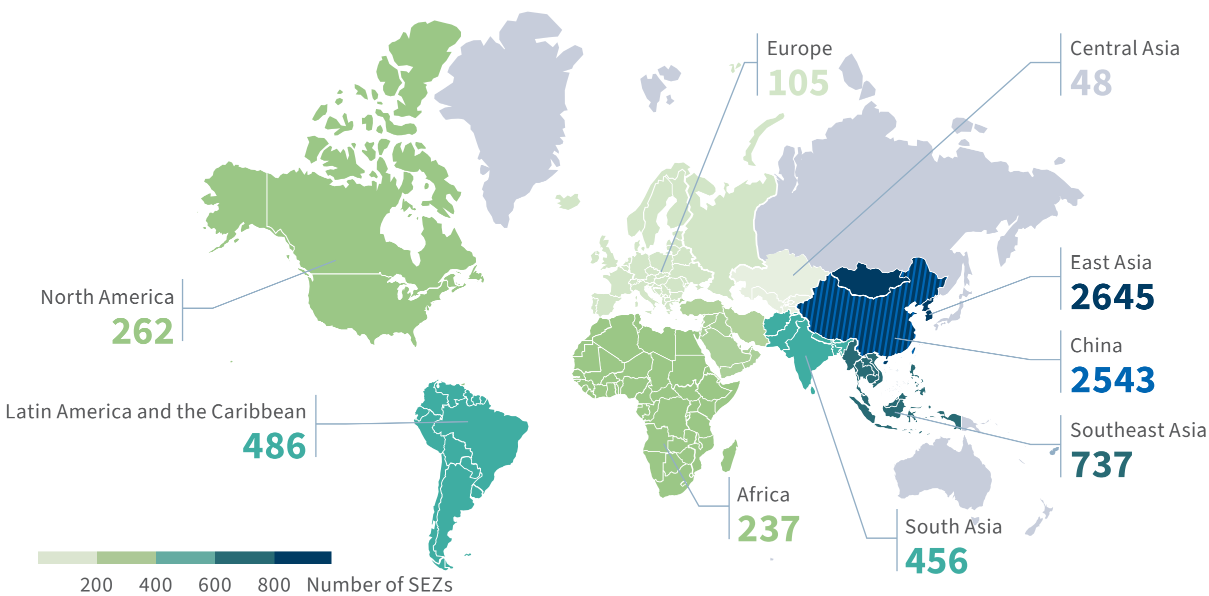
- **Standards system:** Internationally, product-level carbon accounting methodologies remain under continuous refinement, exhibiting differences in system boundaries, data quality requirements, and life-cycle boundary definitions, with relatively complex rules. Due to the complexity and technical nature of these standards, many enterprises struggle to conduct carbon accounting independently. Establishing a unified carbon accounting and management platform at the industrial park level can provide enterprises with methodological support and data management services, helping them meet carbon accounting and disclosure requirements.

4. Industrial Parks in Global Green Industrial Development

4.1 Industrial park development in developing countries

In the process of industrialization and industrial restructuring in developing countries, industrial parks and special economic zones (SEZs) have become important sites for driving growth and sustainability due to their advantages in resource and industrial clustering. As of 2019, there were 5,383 SEZs globally, with the vast majority (4,772 of them, or approximately 89%) located in developing economies, 374 in developed economies, and 237 in transition economies (see Exhibit 10). In terms of regional distribution, Asia has the highest concentration of SEZs, accounting for over three-quarters of the global total.[13]

Exhibit 10 **Number of SEZs worldwide (2019)**



RMI Graphic. Source: RMI analysis of UNCTAD and Adrianople Group data

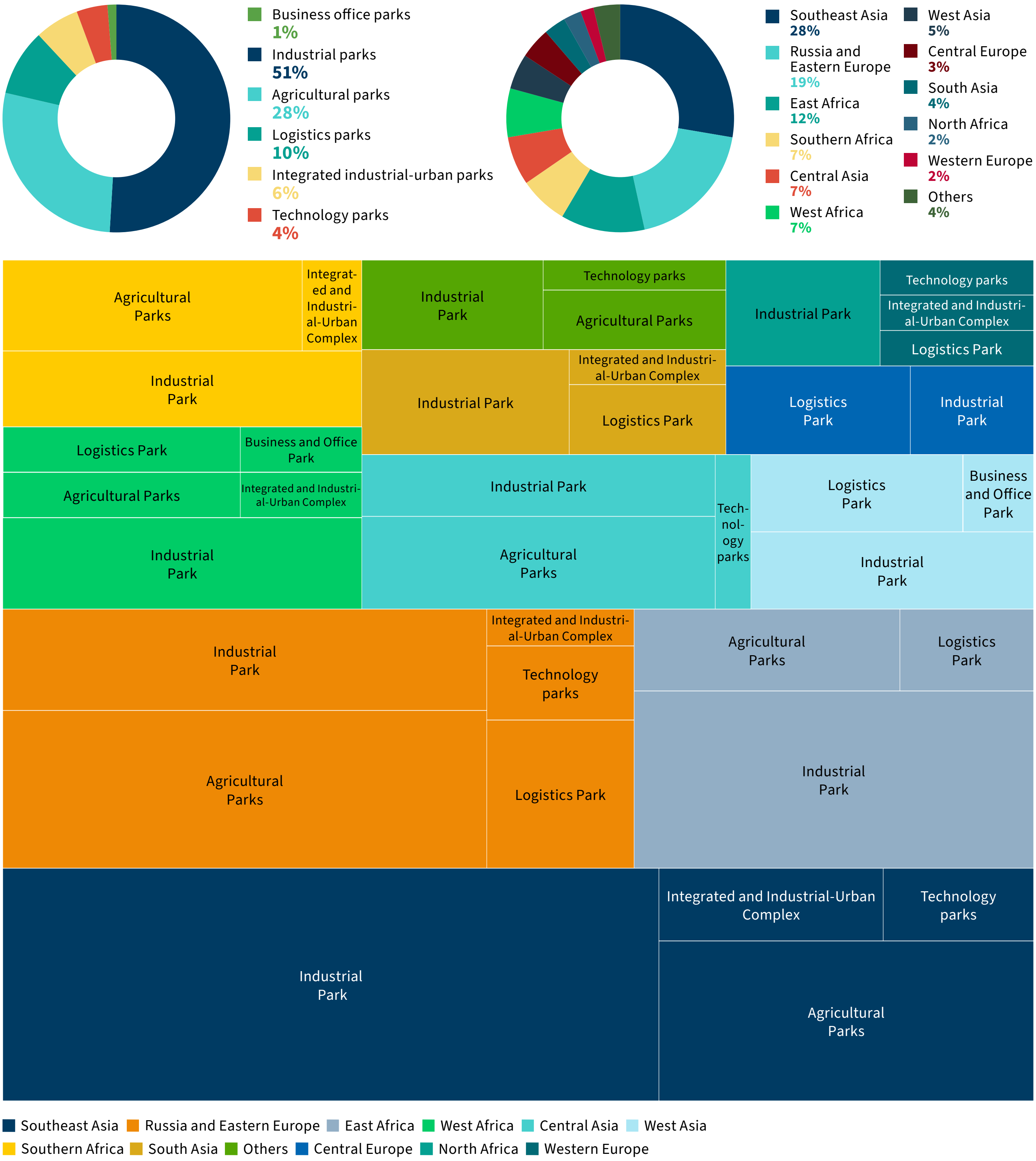
SEZs evolve in distinct ways across economies at different income levels. In high-income economies, SEZs are commonly developed as platforms supporting cross-border supply chains, with logistics hubs and innovation or science parks as the dominant models. Upper-middle-income economies typically deploy SEZs to facilitate the transition toward more service-oriented and technology-intensive growth, attract high-tech industries, and strengthen innovation capacity; prevalent forms include technology parks, specialized zones targeting high value-added industries or specific value-chain segments, and service-oriented zones. In middle-income economies, SEZs are primarily used to promote industrial upgrading and deeper integration into global value chains, with an emphasis on technology diffusion and spillover effects; common types include specialized zones serving Global Value Chain-intensive (GVC-intensive) industries such as automotive and electronics, as well as service zones such as business process outsourcing. In low-income economies, SEZs are often leveraged to catalyze early-stage industrialization, attract foreign direct investment, and generate employment, with multi-activity zones and resource-based zones designed to support processing industries being the most prevalent.

As more developing countries adopt sustainable development agendas, they are accelerating the greening and ecological transformation of industrial parks by establishing relevant policy frameworks and demonstration zones. Although most countries have formulated high-level policies in support of renewable energy adoption, circular economy practices, and resource efficiency, the majority of developing countries are still in the early stages or have yet to establish low-carbon park targets tied to carbon-emissions metrics.

Industrial parks are also serving as an important platform for Chinese enterprises to "go global" and a key vehicle for integrating with local industries and technologies. From 1992 to 2022, a total of 159 Chinese overseas industrial parks were established and remained operational as of 2022.[14] Most parks have played a role in enhancing local value chains, upgrading manufacturing productivity, and attracting investment through infrastructure development, manufacturing upgrades, and supply chain integration. As the platform-based integrated model advances, dominant overseas industrial park types are shifting from traditional processing and manufacturing hubs to platforms driven by innovation, R&D, and services, becoming bridges for international cooperation, industrial support network development, and joint innovation.[15]

Chinese overseas investment in industrial parks totaled RMB 652.3 billion in 54 countries across six continents with a total area of approximately 6,772 km^2 (see Exhibit 11). Parks for the industrial sector are the dominant type, accounting for 51% of the total number, with the highest proportion in Southeast Asia, Africa, West Asia, and South Asia. Parks for the agricultural sector are second-most numerous, accounting for 28% of the total, and are the dominant type in Russia, East Asia, and Central Asia. Science and technology innovation parks and business office parks make up a small portion of the total — 4% and 1%, respectively. Most of these overseas industrial parks were established after 2000, with 63% constructed after 2013.

Exhibit 11 Type, regional distribution, and regional composition of China's overseas industrial parks



RMI Graphic.

Source: Ministry of Commerce website, the websites of the respective industrial parks, the "Go Global" public service platform, the China Council for the Promotion of International Trade, the All-China Federation of Industry & Commerce website, MOFCOM's Country (Region) Guides for Foreign Investment and Cooperation, and development reports on outbound cooperation released by local governments

Chinese stakeholders are playing an increasingly important role in the development of industrial parks in Southeast Asia. Representative industrial parks include the Indonesia Morowali Industrial Park, Indonesia Weda Bay Industrial Park, the Malaysia-China Kuantan Industrial Park, the Sihanoukville Special Economic Zone in Cambodia, and the Thailand-China Rayong Industrial Park. Most are jointly developed by Chinese and host country enterprises, with the number of resident companies ranging from 20 to 300, mainly involved in export industries such as metal smelting and processing, automotive manufacturing, solar cell component production, and electronics manufacturing.

These industrial parks have created tens of thousands of local jobs, boosted the development of local supply chains, facilitated the introduction of more advanced manufacturing capacity and environmental protection technology, and built infrastructure such as power plants, ports, and roads, improving living conditions in surrounding communities. However, the environmental and social impacts of industrial parks have also drawn considerable attention. For instance, carbon emissions from coal-fired power plants within Indonesia's metal smelting industrial parks have received significant international scrutiny in recent years. Stakeholders and external observers have pointed to cleaner energy procurement and emissions controls as factors that can influence perceptions, community acceptance, and exposure to scrutiny.

Among China's overseas industrial parks, commercial projects explicitly targeting low-carbon development remain relatively rare. Low-carbon initiatives are primarily aid projects and have demonstrated some positive effects on local low-carbon development. [13] In 2015, China established the RMB 20 billion China South-South Cooperation Fund for Climate Change and pledged to launch 10 low-carbon demonstration zones in developing countries starting in 2016.[14] In July 2020, China and Laos signed a cooperation agreement to jointly develop the Vientiane-Saysettha Low-Carbon Demonstration Zone, agreeing that China would provide Laos with relevant low-carbon and energy-saving materials and jointly develop a planning scheme for the demonstration zone. In 2021, China donated five sets of environmental monitoring equipment and 2,000 solar-powered LED streetlights to the demonstration zone. In 2022, it gave 28 new-energy vehicles — including 12 all-electric buses and eight all-electric trucks — marking the first batch of all-electric commercial vehicles in the region.[16] For relatively less developed countries and regions, aid-driven low-carbon projects hold significant value in demonstrating best practices and cultivating local markets.

4.2 Opportunities and challenges for developing countries to leapfrog to low-carbon industrial park development

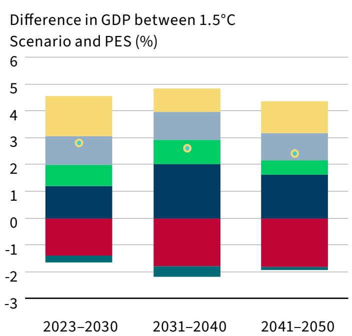
Many developing countries leverage industrial parks as key platforms for manufacturing, services, and emerging industries, reflecting urgent economic development needs. They also provide significant opportunities for low-carbon transition. Many developing countries and regions in Southeast Asia, Africa, and Latin America possess abundant renewable energy resources. Large parts of Africa, Latin America, and South Asia have some of the world's greatest photovoltaic power generation potential per unit area. Regions with the highest wind power potential are concentrated in North Africa and Central Asian countries.[17] These resources provide a favorable renewable energy setting for low-carbon industrial park development. If developing countries can promote the construction of low-carbon parks as a standard, integrating low-carbon concepts from the planning stage, it can allow them to avoid locking in traditional high-carbon systems. It can also help drive systemic policy and institutional reforms that support development and use of renewable energy and the low-carbon transformation of industries, bring new opportunities for low-carbon industries, improve the environmental performance of products, and drive the upgrading of economic structures.

Leveraging low-carbon industrial parks to drive the energy transition also has the potential to yield significant economic and social benefits. For example, according to IRENA's research, by 2050, energy transition actions aligned with the 1.5°C target could increase Southeast Asian countries' annual GDP growth rate by a yearly average of 2.6% compared with the Planned Energy Scenario (PES) and create approximately 3.3 million net new jobs in the energy sector (see Exhibit 12). The economic gains from transition-related investments, improved trade position, lower energy intensity, and greater efficiency would offset declining investments in and reduce dependence on fossil fuel imports. Job growth in renewable energy, energy efficiency, hydrogen, and infrastructure for e-mobility will substantially exceed employment decline in the fossil fuel sector. The environmental benefits, public health gains, energy access improvements, and reduced regional disparities resulting from the energy transition will elevate Southeast Asia's overall social welfare by approximately 11%, IRENA projects.[18]

Exhibit 12 Economic and social benefits from an energy transition under the 1.5°C scenario compared with PES in Southeast Asia

Socio-economic benefits:
An annual average of 2.6% higher GDP growth

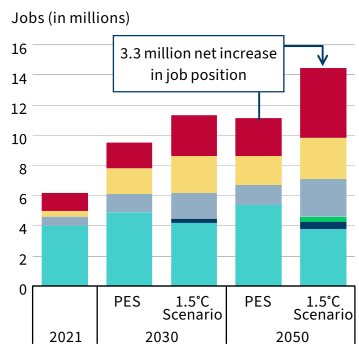
GDP additional gains



- Induced: aggregate prices
- Trade
- Investment and expenditure: public
- Investment: private
- Induced: social-directed payments
- Change in GDP
- Induced and indirect: other

Job creation:
Create approximately 3.3 million new jobs by 2050, offsetting employment losses in the phase-out of fossil fuels.

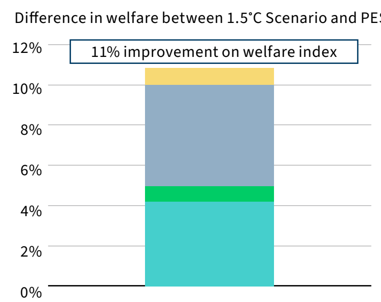
New jobs in the energy sector



- Renewables
- Energy efficiency
- Power grids and energy flexibility
- Vehicle charging infrastructure
- Hydrogen
- Fossil

Social welfare gains:
Enhance public health, reduce both indoor and outdoor air pollution

Welfare increase



- Access
- Social
- Distributional
- Economic
- Environmental

Note: Southeast Asia here includes Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. The data is based on IRENA's calculations using the E3ME model, measured in real GDP. The baseline scenarios reflect the governments' energy plans, as well as other targets and policies planned before 2020, resulting in a projected compound annual real GDP growth rate of approximately 4.7% from 2023 to 2050.

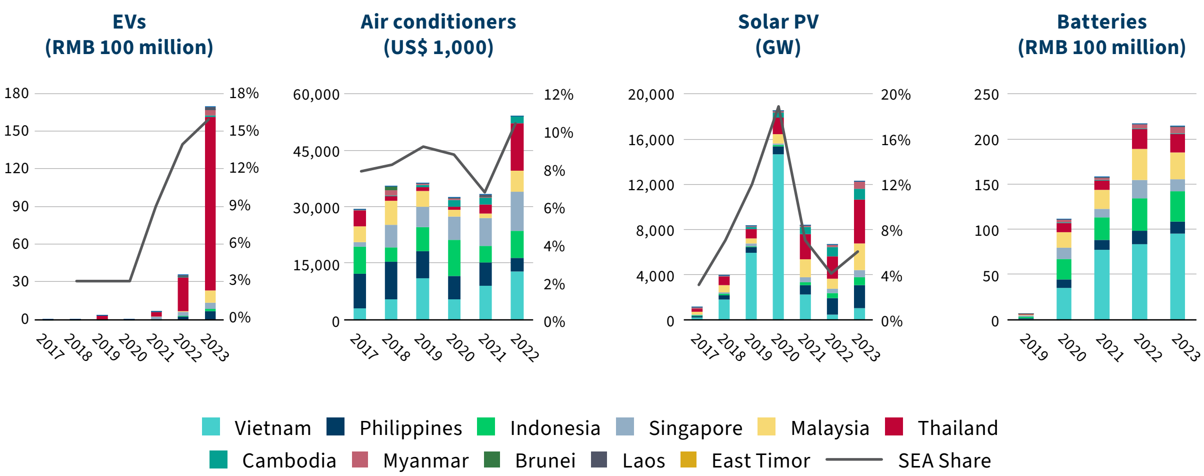
Source: IRENA

The development of low-carbon industrial parks also offers significant opportunities for cross-regional cooperation. Many developing countries use SEZs as platforms to attract foreign investment. Through industrial clusters with foreign investment, developing countries can leverage mature international low-carbon technologies and accelerate the construction of low-carbon infrastructure. (See Exhibit 13 on the strong demand for green products, using Southeast Asia [SEA] as an example.) In addition, through technology sharing, standards coordination, financial support, and market linkage — such as regional green supply chain development, green technology matching, joint research and development, and green investment and financing cooperation — developing countries can leverage their complementary advantages to jointly promote low-carbon parks and overall decarbonization.

Exhibit 13 **Southeast Asia's market for clean energy products and imports of clean energy products from China**

EVs	Air conditioners	Solar PV	Batteries
+4% SEA EV market CAGR 2025-2029	**+7.2%** SEA air conditioner market CAGR 2023–2030	**+10.2%** SEA solar energy market CAGR 2025–2030	**+6.8%** SEA battery market CAGR 2025–2030
16% SEA's share of China's EV export in 2023	**10%** SEA's share of China's air conditioner export in 2022	**19%** SEA's share of China's solar PV export in 2020	**7.3%** SEA's share of China's battery export in 2023

Clean energy products exported from China to SEA (2017–2023)



RMI Graphic.
Source: RMI analysis of data from Yuan Xinguo, et al., 2020, CPCA 2023, WITS, Statista, IEA, Mordor Intelligence, and GACC

Despite the promising outlook for low-carbon industrial parks, the low-carbon transition of industrial parks in developing countries is still in an early stage and faces multiple challenges.

Many developing economies predominantly rely on low-value-added primary industries with insufficient motivation for low-carbon transition. Currently, the level of low-carbon technology adoption varies significantly across developing economies; local value chains remain relatively underdeveloped in many places, and initial costs of low-carbon technologies remain relatively high. The primary industrial sectors in these countries' industrial parks are also often resource-based industries and low-to-medium technology manufacturing with low added value. For example, many ub-Saharan African countries rely on mining and oil/gas extraction, with the manufacturing sector concentrated in agricultural processing, textiles/apparel, and assembly. Latin American countries depend largely on agricultural and mineral exports. Meanwhile, many Southeast Asian nations are gradually transitioning toward higher-value-added industries, though the industrial structure remains dominated by textiles, electronics assembly, and parts manufacturing.[19] Many enterprises face significant market price pressures on their products, necessitating cost control as their primary objective; industrial park developers prioritize tenant occupancy rates and infrastructure construction, and are reluctant to invest in green energy infrastructure. Enterprises also generally lack motivation to procure green electricity.

Investment and finance in low-carbon industrial parks is lacking in many developing countries. Governments in many developing countries have tight budgets. Public finance tends to prioritize basic livelihood and public services. As an emerging development concept, low-carbon industrial parks often struggle to secure sustained financial support, particularly during initial construction when significant investment is required. Green finance systems in many developing countries are still in the formative stage, with financial tools such as green bonds, carbon credit financing, and environmental funds not yet widely adopted. Financial institutions often lack adequate assessment capabilities for low-carbon projects, and financial products and services that could support these projects are insufficient. International climate finance falls far short and often comes with high application thresholds and complex procedures. In seeking financing, local governments and industrial park developers often encounter challenges due to low credit ratings, limited collateral, and long project payback periods.

At the implementation level, industrial parks in developing economies require many new technologies, talent, and management approaches to achieve low-carbon development. Achieving high renewable energy penetration is often challenging due to the lack of intelligent dispatch systems and cost-effective energy storage solutions, which makes it difficult to meet continuous industrial load demands. Renewable energy market entrance remains difficult in some developing countries, coupled with inadequate policies for secured offtake and grid connection for distributed energy resources. These barriers hinder the advancement of renewable energy deployment in industrial parks at scale. Furthermore, deficiencies in talent, standards, and policies across system planning, technological research, and monitoring result in high costs and inefficient matchmaking between low-carbon technologies providers and transition demand, constraining the green transition of industrial parks.

5. Leveraging Industrial Parks in Regional Low-Carbon Transition

Low-carbon and zero-carbon park development is emerging as an important strategy for countries to advance energy decarbonization and industrial green transformation. Achieving low-carbon development in industrial parks requires consideration of three factors: technological pathways, business models, and multi-stakeholder collaboration. This ensures that while reducing carbon emissions, industrial parks generate positive local economic, environmental, and social benefits, thereby fostering coordinated green and low-carbon transformation at both regional and cross-regional levels.

Considerations for early implementation of zero-carbon parks

China has explicitly identified zero-carbon industrial parks as a key pillar of its comprehensive green economic and social transformation. The central government has set a preliminary target of establishing around 100 national-level zero-carbon parks during the 15th Five-Year Plan period, signaling a shift toward systematic, large-scale implementation of zero-carbon park development. These policies indicate a clear shift toward developing high-quality, genuinely zero-carbon industrial parks with rigorous standards, and toward moving China's zero-carbon parks from pilot demonstrations to broad implementation. To support the scale-up of these practices, the following near-term actions can be considered:

Strengthen energy and carbon management foundations.

Industrial parks can be supported in establishing robust energy and emissions management systems, including standardized data collection, carbon accounting, and energy- and carbon-efficiency assessments. Building shared digital platforms that integrate enterprise, energy, and public-infrastructure data can improve transparency and data quality, while also reducing reporting burdens for SMEs. Clear data-sharing, quality-control, and privacy-protection arrangements are essential to ensure that information can be used credibly for decision-making and policy implementation.

Accelerate energy system transformation through integrated solutions.

Zero-carbon industrial park development requires coordinated planning of energy supply, demand, and intelligent management, both within and beyond park boundaries. Scaling solutions such as high shares of renewable energy, direct green power supply, energy storage, low-carbon heating, and demand-side flexibility can enable localized green energy use and improve system reliability. At the same time, innovative business and trading models — such as integrated energy services and aggregated green power purchasing — are needed to lower adoption barriers and create replicable pathways for wider implementation.

Align industrial layout with zero-carbon resources and finance.

Optimizing industrial structure is critical to long-term decarbonization. Industrial parks should better match energy-intensive industries with areas rich in renewable energy and other low-carbon resources, while promoting industrial symbiosis and cluster development. This transition can be supported by stronger integration of technology deployment and green finance, including targeted investment platforms, green bonds and loans, and clearer links between carbon-reduction performance and financing conditions. Connecting zero-carbon park development with low-carbon products and supply chains can further strengthen market incentives.

Enhance carbon accounting, verification, and certification systems.

Credible zero-carbon parks depend on scientifically sound, transparent, and internationally aligned carbon accounting frameworks. Building on existing pilot methodologies, systematic research and international benchmarking are needed to refine accounting scopes, emission factors, and indicators suited to China's industrial parks. Over time, the introduction of third-party monitoring, reporting, and verification, alongside market-oriented certification mechanisms, can improve data credibility, reduce greenwashing risks, and strengthen confidence in zero-carbon park claims among policymakers, investors, and global supply chains.

Strengthening regional collaboration through low-carbon parks

Leveraging China's renewable energy industries can accelerate low-carbon development through industrial parks in developing countries. China is a global leader in wind and solar manufacturing, with its technologies deployed in more than 200 countries and regions, making them a cost-effective and scalable foundation for decarbonizing industrial parks. Recent national initiatives — including the Belt and Road green energy cooperation plan, international clean-technology R&D platforms, and the release of the China Energy Solutions catalog — reflect stated objectives in national initiatives to sharing practical low-carbon solutions. By linking Chinese renewable technologies, green finance, and implementation experience with overseas industrial parks, China and other developing economies can build new regional partnerships that support industrial decarbonization through technology matching, experience and standards sharing, and joint investment.

Support green energy technology matching to accelerate industrial park upgrading.

Low-carbon transformation of industrial parks in developing economies depends on access to technologies and services that are well suited to local conditions. By leveraging China's strengths in renewable energy, smart energy management, and emissions control, dedicated technology–project–service matching platforms can more effectively align park-level demand with proven solutions. Integrating industrial park needs into green energy demand inventories and demonstration programs can lower adoption barriers, mobilize finance, and scale the deployment of renewables, energy storage, efficiency technologies, and electric mobility, enabling industrial parks to become hubs for green industrial upgrading.

Promote synergistic development through standards alignment and experience exchange.

China's extensive experience in developing green and low-carbon industrial parks provides valuable lessons for developing economies seeking to avoid high-emissions lock-in. At the same time, decarbonization technologies, resources, and practical experience from other developing countries can also strengthen China's own efforts to advance zero-carbon parks. Structured exchange mechanisms under regional cooperation frameworks can facilitate systematic knowledge sharing on planning, financing, incentive design, standards, and implementation pathways. Further advancing interoperability and mutual recognition of standards — particularly for green infrastructure, low-carbon products, and supply-chain carbon management — can reduce transaction costs, enable deeper cross-border collaboration, and accelerate the diffusion of low-carbon practices across regional industrial parks.

Strengthen financial cooperation to unlock green investment at scale.

Robust green and transition finance frameworks are essential for scaling low-carbon industrial park development. Building on existing bilateral and multilateral green finance initiatives, stakeholders can develop clear taxonomies, guidelines, and technology catalogs tailored to low-carbon industrial parks, improving project bankability and access to financing tools. Complemented by dedicated industrial park investment funds that combine public, development, and private capital, enhanced financial cooperation can mobilize long-term investment, reduce risks, and accelerate the rollout of green industrial parks across developing regions.

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