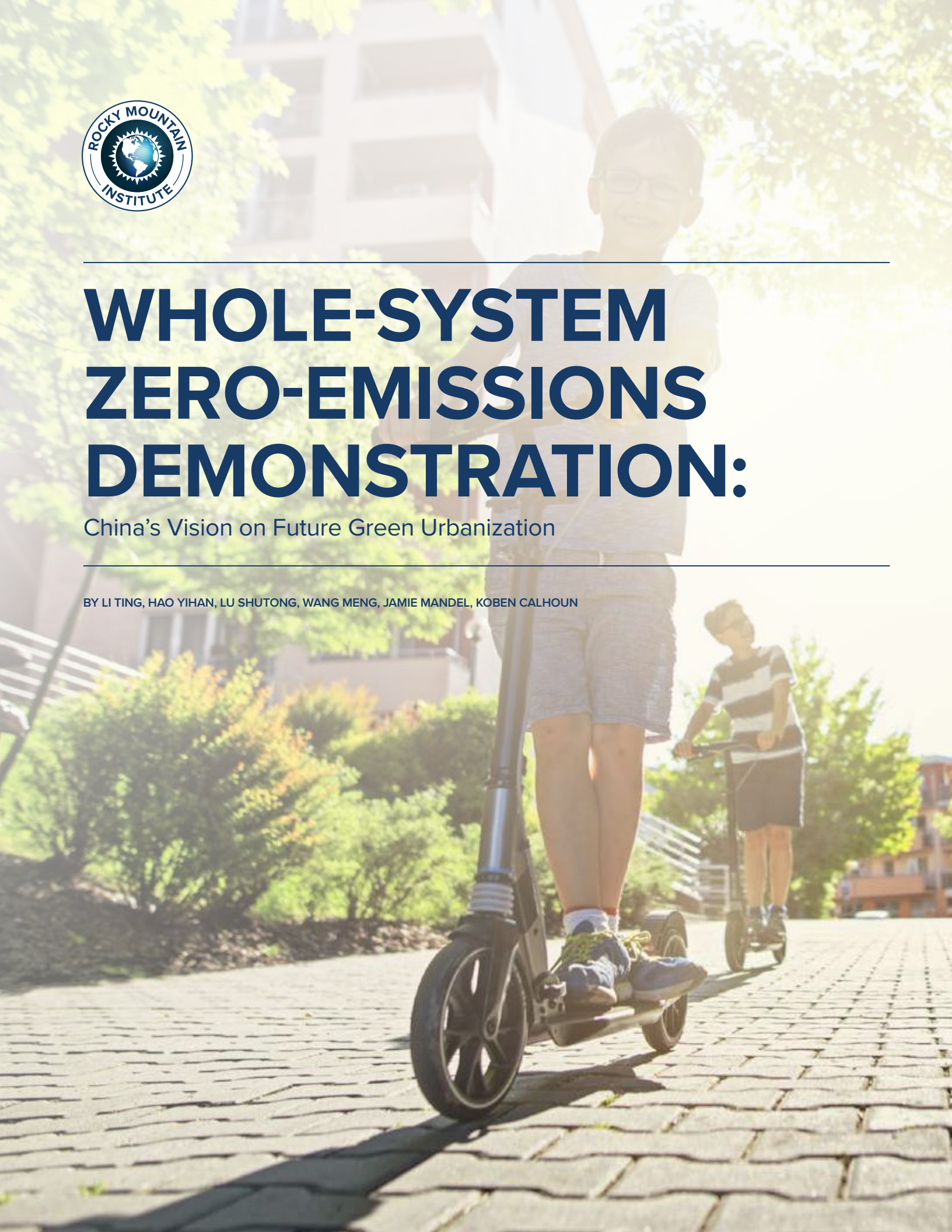

WHOLE-SYSTEM ZERO-EMISSIONS DEMONSTRATION:

China's Vision on Future Green Urbanization

BY LI TING, HAO YIHAN, LU SHUTONG, WANG MENG, JAMIE MANDEL, KOBEN CALHOUN

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ABOUT US

ABOUT ROCKY MOUNTAIN INSTITUTE

Rocky Mountain Institute (RMI)— an independent nonprofit founded in 1982—transforms global energy use to create a clean, prosperous, and secure low-carbon future. It engages businesses, communities, institutions, and entrepreneurs to accelerate the adoption of market-based solutions that cost-effectively shift from fossil fuels to efficiency and renewables. RMI has offices in Basalt and Boulder, Colorado; New York City; Oakland, California; Washington, D.C.; and Beijing

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INTRODUCTION

Whole-System Zero-Emissions Demonstration (WS-ZED) is an innovative concept proposed by Rocky Mountain Institute (RMI). WS-ZED is a green urbanization concept based on comprehensive governance, with a focus on decoupling economic development from carbon emissions, waste, and pollution on an economic basis. Under the national strategy of establishing ecological civilization, RMI focuses on the exploration of an innovative green urbanization model and a brand-new development model in the post-industrial civilization era.

At the beginning of 2020, the world experienced the most severe epidemic in a century, creating a relatively large negative impact on the economy. In order to respond to the impact of the epidemic and promote green recovery, new urbanization has become one of the key focuses of the government's recovery plan. As a member of the Special Policy Study (SPS) team on green urbanization for the China Council for International Cooperation on Environment and Development (CCICED), RMI has proposed this new concept of Whole-System Zero-Emissions Demonstration (WS ZED). The concept is based on China's best practices and international vision. Its goal is to help implement an innovative, actionable, and replicable global urbanization model.

China has accumulated rich experiences in the past 40 years in high-intensity urbanization processes and recent green urbanization-related practices. These cover complex natural geographical environments and diverse social conditions from coastal cities to administrative zones and from high-tech industrial parks to small towns. The WS-ZED concept takes this one step further and proposes a broader concept. The concept emphasizes setting systematic quantitative goals, drawing executable technical and economic roadmaps, and providing clear guidelines for action with interdisciplinary approach. WS-ZED is a concept with a global vision; it will set new benchmarks for global urbanization, especially for countries and regions experiencing rapid urbanization along with the Belt and Road Initiative.

BACKGROUND

To avoid catastrophic climate change risks, the Paris Climate Agreement made it clear that by the end of this century, the increase in global average temperature must be kept well below 2°C above pre-industrial levels. To combat climate change, human society needs to achieve a clean transformation in energy, including improving energy efficiency, adopting renewable energy, and achieving long-term carbon-free goals.

URBANIZATION IN CHINA

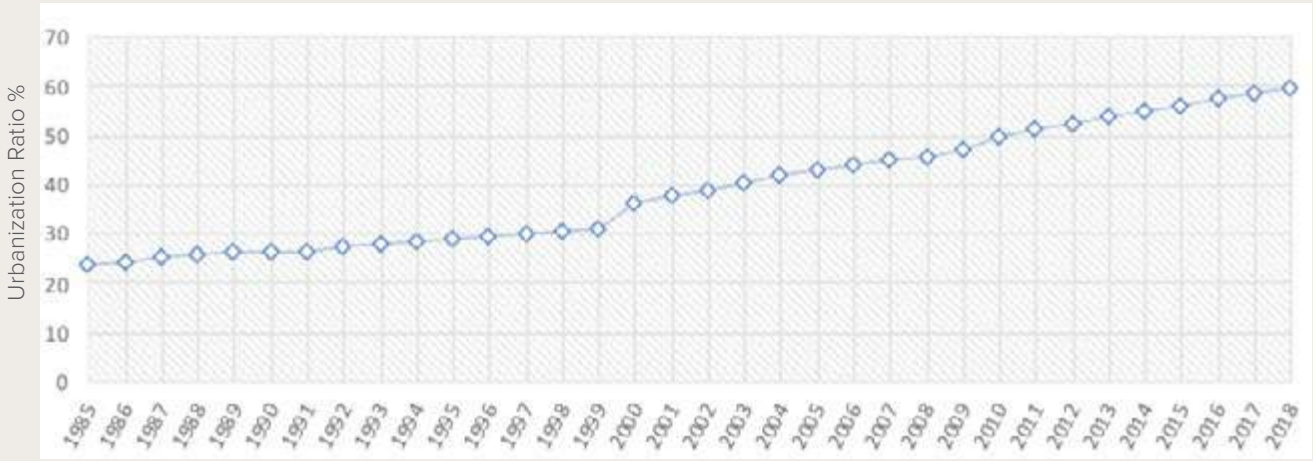
China has been in the process of rapid urbanization during the past four decades. As shown in Exhibit 1, China's urbanization rate increased from 24% to 60% from 1985 to 2018. The process of urbanization was mainly based on the growth model of industrial wealth and dependent on the expansion of consumerism and materialism, which has led to environmental pollution, ecological crises, and other social issues. By 2050, China's urbanization rate is expected to reach 75%.

Despite tremendous pressure for economic growth, China is determined not to follow the old path of "pollution first, treatment afterward" and will explore new models of urbanization.

China is taking the green urbanization path guided by the theory of ecological civilization—an innovative model of human civilization that China has committed to build since 2007, and a fundamental change in development, production, and lifestyle. To build an ecological civilization, the process of urban development must take the path of green urbanization, considering the capacity of resources and environment. In 2015, China's central government released the Opinions on Accelerating the Construction of Ecological Civilization, with the main goal of constructing a resource-saving and environment-friendly society. In terms of resource utilization and ecological environment, specific quantitative targets were proposed as shown in Exhibit 2.

EXHIBIT 1

China Urbanization Rate 1985–2018



Source: National Bureau of Statistics of China

China has been actively implementing green urbanization, which has been reflected in many national strategy documents and the government-initiated working plan. As stated in Thirteenth Five-Year Plan (2016–2020) and Energy Production and Consumption Revolution Strategy (2016–2030), China has further promoted high-quality development and has gradually formed a new type of urbanization pathway based on green development. China has brought forward new urbanization policy to continuously improve the quality of the urban environment, residents' quality of life, and urban competitiveness, and to create harmonious, livable, vibrant, and unique cities. In early 2020, China launched a "new infrastructure" policy as shown in Exhibit 3 with digital economy as its key focus, transforming the manufacturing industry with the latest information technologies, such as 5G, big data, and artificial intelligence.

China Government Work Report 2020 includes plans to improve public facilities and service capabilities to meet the increasing needs of "new urbanization." The specific plans include the retrofits of 39,000 old communities, supporting the installation of elevators, and developing diverse community services such as dining and cleaning. Furthermore, the State Council rolled out a three-year action plan for cleaner air in 2018 to strengthen environmental governance. China has outperformed the proposed targets, including sulfur dioxide emissions, nitrogen oxide emissions, chemical oxygen demand, and ammonia nitrogen emissions.

Due to the scale of the challenges and the stage of development, urban development must be tailored to local conditions in China. Under this context, RMI has proposed the new concept of Whole-System Zero-Emissions Demonstration (WS-ZED). In the process of exploring WS-ZED, there is no international precedent that can be directly applied. It is necessary to avoid path dependency, introduce an innovative model, and create a more advanced benchmark.

EXISTING TARGETS, INDICATOR SYSTEMS, AND CERTIFICATION PROGRAMS

Policymakers and the market have come to realize that net-zero/near-zero development can accelerate global energy transformation and stimulate new opportunities for socioeconomic development. Local governments, the private sector, and nonprofit organizations are actively exploring net-zero/near-zero development by deploying policy systems, quantitative indicator systems, and guidelines. There are many existing cases and ideas that can provide reference for our further exploration of WS-ZED.

EU 2020 Climate and Energy Targets

In 2007, EU leaders set up the EU 2020 energy and climate package. The plan is a set of binding legislations to ensure that the EU achieves its 2020 climate and energy goals. The EU 2020 energy and climate goals comprise three major components: (1) greenhouse gas emissions need to be reduced by 20% from 1990 levels, (2) 20% of the energy used in the EU needs to come from renewable sources, and (3) energy efficiency needs to increase by 20%.

The implementation of the EU's 2020 energy and climate goals has triggered a shift of interest in various regions of Europe to develop net-zero energy districts. Municipalities in all regions agreed that community energy transformation is an opportunity to solve local socioeconomic problems; therefore, most net-zero energy community projects have received public financial support and successfully mobilized large amounts of private-sector investment.

LEED (Leadership in Energy and Environmental Design)

LEED (Leadership in Energy and Environmental Design), a green building certification system recognized by the international community, was developed by the US Green Building Council (USGBC) to provide practical and quantifiable green solutions to all types of buildings. It has been applied in

EXHIBIT 2

Eco-Civilization Targets by 2020

Targets	Contents
Utilize Resources More Efficiently	• CO_2/GDP down by 40%-45% over 2005 level • Energy intensity further reduced • Resource productivity greatly increased • Total water consumption under 670 billion cubic meters • Water consumption/¥10,000 (US$1,494) of industrial added value under 65 cubic meters • Irrigation efficiency (effective utilization coefficient of farmland irrigation water) above 0.55 • Non-fossil energy reaching approximately 15% of primary energy consumption
Improve the Overall Quality of Ecological Environment	• Decline in the total discharge of sulphur dioxide (SO_2), nitrous oxide (NOx), chemical oxygen demand (COD), and ammonia nitrogen (NH_3-N) • Improvement in air quality and water quality of key watersheds and offshore areas • More than 80% of the key rivers/lakes/water functional areas meeting water quality standards • Continuous improvement in the safety and security of drinking water • Overall soil quality kept stable • Environmental risks effectively controlled • Forest coverage over 23% • Prairie's vegetation coverage reaches 56% • Minimum wetland areas at 533,333 square kilometers • More than 50% of the reclaimable desert reclaimed • At least 35% of the natural shoreline preserved • Speed of biodiversity loss under control and stability of nation-wide ecosystems clearly enhanced

Source: State Council, 2015

175 countries and regions, with more than 98,000 registration and certification projects. LEED inspects and evaluates registration projects from a set of rating systems for design, construction, operation, and maintenance, and it helps building owners and operators be environmentally responsible. Projects pursuing LEED certification earn points for various green building strategies across several categories based on the number of points achieved. Each project earns one of four levels: certification level (40–49 points), silver level (50–59 points), gold level (60–79 points), and platinum grade (80 points or higher).

To further improve LEED certification, the USGBC officially launched the LEED Zero certification project on November 14th, 2018. This certification represents the new goal of green buildings in the pursuit of sustainable development, with the addition of net-zero energy buildings. Moreover, the LEED program has further explored the areas of zero carbon, zero pollution, and zero waste, and it launched a series of certification programs, including LEED Zero Carbon and LEED Zero resources (energy, water, and waste).

EXHIBIT 3

2020 China New Infrastructure Investment at the Provincial Level

Province	Number of Projects	Total Investment (Billion RMB)	Annual Investment (Billion RMB)
Beijing	300		252.3
Hebei	536	1,883.31	241.01
Shanxi	248		
Shanghai	212		
Heilongjiang	300	885.6	200
Jiangsu	240		541
Fujian	1,567	3,840	
Shandong	321		
Henan	980	3,300	
Yunnan	525	5,000	440
Sichuan	700	4,400	600
Chongqing	924	2,700	340
Ningxia	80	226.8	51
NATIONAL TOTAL	10,326	33,830	2,790

Source: 21st Century Business Herald

EXHIBIT 4

The 20 Imperatives of the Living Community Challenge

Solutions beyond project footprint are permissible

	Living Community Challenge	
Place		01. LIMITS TO GROWTH
	SCALE JUMPING	02. URBAN AGRICULTURE
		03. HABITAT EXCHANGE
		04. HUMAN-POWERED LIVING
Water	SCALE JUMPING	05. NET POSITIVE WATER
Energy	SCALE JUMPING	06. NET POSITIVE ENERGY
Health and Happiness		07. CIVILIZED ENVIRONMENT
		08. HEALTHY NEIGHBORHOOD DESIGN
		09. BIOPHILIC ENVIRONMENT
		10. RESILIENT COMMUNITY CONNECTIONS
Materials		11. LIVING MATERIALS PLAN
		12. EMBODIED CARBON FOOTPRINT
		13. NET POSITIVE WASTE
Equity		14. HUMAN SCALE + HUMANE PLACES
		15. UNIVERSAL ACCESS TO NATURE & PLACE
		16. UNIVERSAL ACCESS TO COMMUNITY SERVICES
		17. EQUITABLE INVESTMENT
		18. JUST ORGANIZATIONS
Beauty		19. BEAUTY + SPIRIT
		20. INSPIRATION + EDUCATION

Source: International Living Community https://living-future.org/lcc/

International Living Community Challenge

The Living Community Challenge was initiated by International Living Future Institute, an international nonprofit organization. It encourages the construction of communities that cover all elements of healthy living. While encouraging the cultivation and promotion of everyone's healthy life, it pays attention to the protection of natural resources. The energy and water resources used need to be captured and processed in the communities. In addition, the design of the communities needs to adhere to the multi-element design concept to maximize resource usage.

Communities that apply for the challenge are evaluated in seven aspects: site selection, water resources application, energy utilization, healthy living, construction materials, community equality, and aesthetics. The challenge requires each community to meet all the performance requirements listed in Exhibit 4; certification is based on actual operating results, not the expected results demonstrated through modeling.

EcoDistricts

EcoDistricts is a certification program for sustainable communities aiming at achieving fairness, resilience, and climate and environmental protection by creating a set of design rules. Communities (1) formulate comprehensive roadmaps based on performance indicators, (2) support and coordinate the roadmaps' implementation with various stakeholders, and (3) create long-term sharing mechanisms to promote each EcoDistrict, reporting on their progress and sharing best practices. EcoDistricts focuses on six priority areas: community location, community prosperity, residents' health and well-being, the degree of connectivity within the community, living infrastructure, and recycling of resources within the community.

Guidelines for Evaluating the Environmental Performance of Urban Ecological Construction

In November 2015, China's Ministry of Housing and Urban-Rural Development released *Guidelines for Evaluating the Environmental Performance of Urban Ecological Construction.* with the aim of implementing the *Suggestions on the Promotion of Construction of Ecological Civilization* issued by the Chinese government. The guidelines encourage the evaluation of environmental performance of urban ecological construction in a scientific and objective manner, and they require urban planning and construction work to pay more attention to the environmental benefits. The guidelines draw on the development experience of urban ecological environment construction domestically and globally. With reference to existing standards and regulations, the guidelines establish clear indicators and regulations in land use, water resources protection, local meteorological and atmospheric quality, and biodiversity. The guidelines also encourage the use of third-party assessments to quantitatively evaluate the environmental impact of ecological cities, providing support for decision-making and modification of planning indicators.

IMPROVEMENT POTENTIALS IN EXISTING PROGRAMS

Various regions have made some efforts toward zero-emissions development. However, after research and multidirectional comparisons, we have found that in order to achieve the zero-emissions goal in the context of climate change, the current efforts of all parties are still insufficient and have room for further improvement.

A mechanism to coordinate different administrative departments is needed to support the implementation of quantitative objectives. The comprehensive and multi-angle net-zero goals mostly involve multiple departments. For example, the *Guidelines for Environmental Performance Evaluation of Urban Ecological Construction* covers various aspects, including land resources, water resources, meteorology, and environmental protection—and all of those are being managed by different administrative departments. Only a strong coordination of multiple departments can ensure the achievement of the overarching goal.

Indicator systems need to consider the importance of early intervention during the planning phase. Some existing indicator systems are results oriented, with little intervention during the planning phase. For example, the LEED Zero certification is based on the operation results of the community two years after its completion. The advantage of this kind of practice is that it guarantees the certification is made based on actual results rather than the simulated results. However, due to the lack of early design intervention, later operations normally require quite a lot of optimization, debugging, and even partial reconstruction, resulting in waste in the construction process. This may not only damage the economic benefits of net-zero community construction but also increase the difficulty of achieving goals from all aspects.

Some of the existing evaluation or indicator systems cover all aspects of community residents' activities but lack detailed guidance for particular items. For example, EcoDistricts pays attention to three areas: community fairness, community resilience, and climate protection. Although these areas are important when building an ecological community, a lack of detailed guidance for each item will hinder the implementation of a community's green ecological construction.

Indicator systems should focus more on the coordination of qualitative and quantitative indicators. Few of the systems and programs present clear guidelines for quantitative targets or technical requirements. In the absence of quantitative indicators, those systems cannot serve as substantive guides for early planning, and it is difficult to accurately consider whether the later operations meet the standards. Currently, most of the systems require only that the projects first make qualitative commitments and formulate implementation roadmaps based on that system's focus.

WHOLE-SYSTEM ZERO-EMISSIONS DEMONSTRATION

DEFINITION OF WHOLE-SYSTEM ZERO-EMISSIONS DEMONSTRATION

Whole-System Zero-Emissions Demonstration (WS-ZED) is a green urbanization innovation that supports economic development while reducing waste, pollution, and carbon dioxide emissions (see Exhibits 5 and 6). WS-ZED solves the environmental problems in the urban development process, with a whole-systems approach to improve the economy and protect air, water, soil, and the entire ecological system.

WS-ZED is an important measure for implementing the national strategy of ecological civilization. Guided by the conviction that "lucid waters and lush mountains are invaluable assets," WS-ZED explores practical ways to promote the harmonious development of humans and nature. WS-ZED targets near-zero carbon emissions, better waste management, and improved air quality on an economic basis. By creating a new pattern of modernization, WS-ZED can realize the harmony between wealth and ecology.

WS-ZED adopts the innovative methodology of quantification, aiming at better utilization of natural resources, greening the industrial sector, and revealing the values of ecological advantages. WS-ZED demonstrates China's best practice of ecological civilization construction and green urbanization. WS-ZED will set up new sustainable development benchmarks.

EXHIBIT 5

Whole-System Zero-Emissions Demonstration

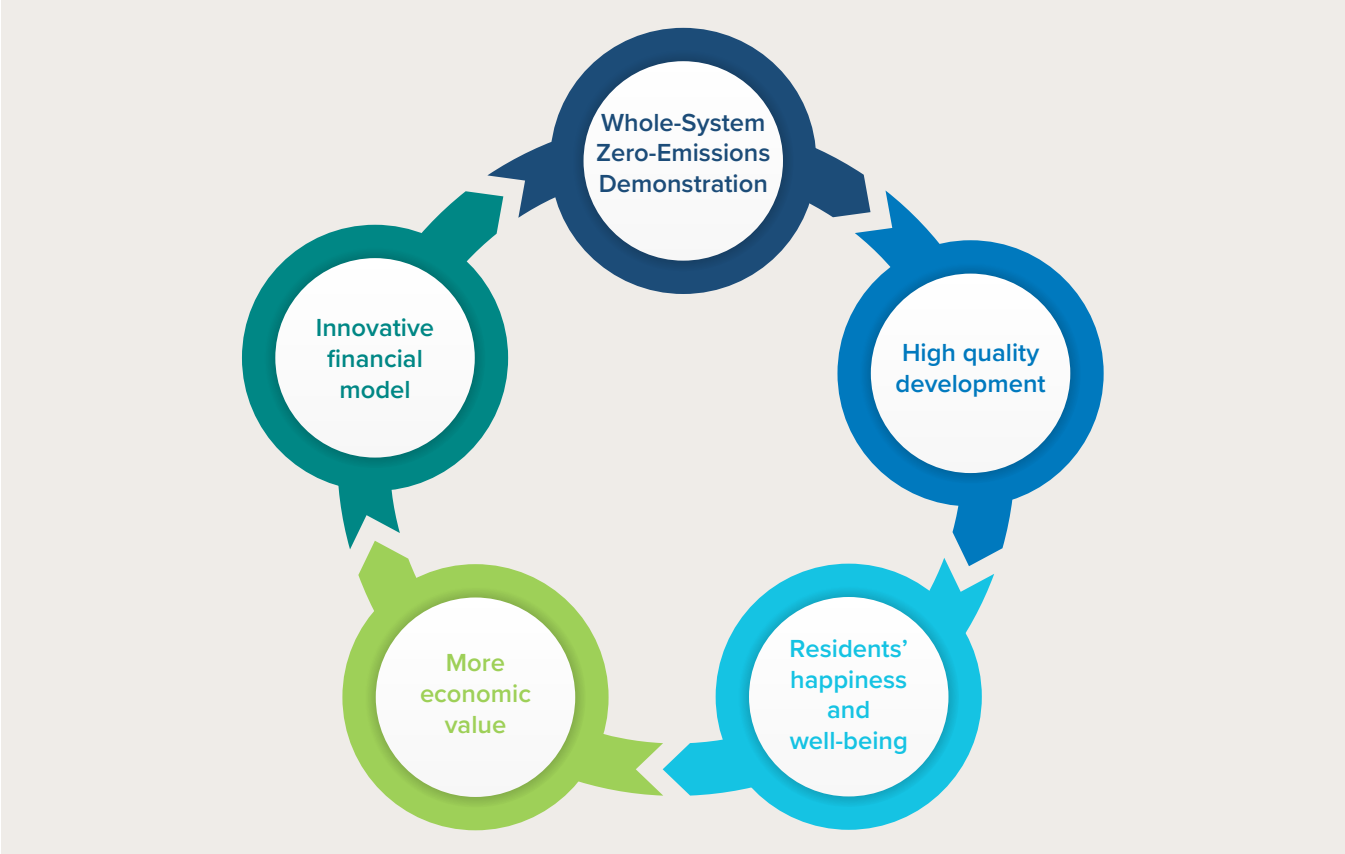
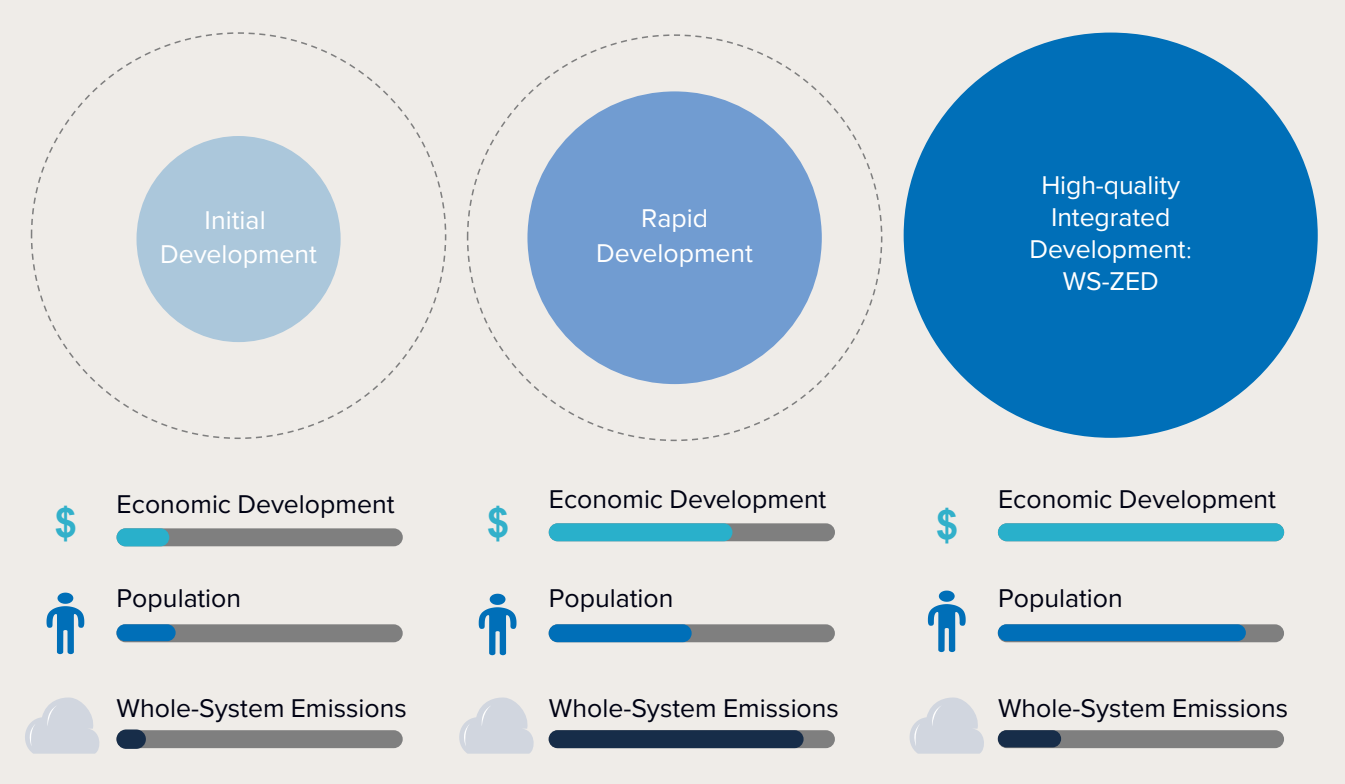


EXHIBIT 6

Whole-System Zero-Emissions Demonstration



WS-ZED can be applied to many cities and districts, such as new municipal cities, ports and docks, ecological cultural tourism areas, innovative industrial parks, comprehensive commercial new towns, and urban areas combining industry and cities. At present, there are as many as 3,500 new districts being planned in China, and the development and construction process needs to transform to green development and innovation.

INTERVENTION POINTS OF WS-ZED

WS-ZED is able to support better urban development, featuring a whole-systems approach, emissions indicators, up-front planning, and replicability.

Emphasis on the whole system. WS-ZED focuses on the whole-system approach, taking into account the protection of air, water, soil, and the ecosystem. Through reasonable planning, control, governance, monitoring, conversion, and other measures, as well as a collaborative use of quantitative indicators, it focuses on various types of pollution and emissions. Moreover, its emphasis on the establishment of management mechanisms and innovative business models to improve efficiency and realize value conversion allows it to explore more opportunities to achieve high-quality urban development.

Establishing emissions indicators and planning indicators. Emissions indicators refer specifically to results-based indicators in operations, mostly measurement results. Planning indicators refer specifically to the indicators commonly found in planning and design documents and land-transfer

contracts. WS-ZED comprehensively considers these two types of indicators and establishes a scientific evaluation system from the perspectives of source, process, and efficiency. The evaluation system includes a list of emissions sources, quantitative control objectives, quantitative governance measures, ecological value conversion, economic benefit accounting, business models, and competitiveness.

Highlighting the up-front planning. WS-ZED emphasizes intervention at the early planning phase and promotes the incorporation of green development, circular development, and low-carbon development concepts into the development process to the greatest extent. Moreover, it fills in the gaps in the governance system regarding standards, combines different concepts and frameworks, and develops a systematic management model to release more development momentum and dividends.

Replicability and scaling up. Innovation is at the core of WS-ZED. By creating a replicable model, WS-ZED is an industry-recognized, market-acceptable, bottom-up system that profoundly disturbs the eco-environment market and transforms high-quality development to become a new economic growth point.

WHOLE-SYSTEM ZERO-EMISSIONS DEMONSTRATION INDICATORS SYSTEM

INDICATORS AS IMPORTANT TOOLS

To effectively guide the construction of WS-ZED, it is important to establish a scientific indicator system. The Whole-System Zero-Emissions Demonstration Indicators System (WS-ZEDiS) covers the relevant core indicators in the process of urban development, construction, and operation, especially in low-carbon construction, waste treatment, and pollution mitigations. This chapter introduces the WS-ZEDiS, including the overall structure (see Exhibit 7), zero-carbon indicators system (see Exhibit 8), zero-waste indicators system (see Exhibit 9), and zero-pollution indicators system (see Exhibit 10).

EXHIBIT 7

Overall Structure of WS-ZEDiS

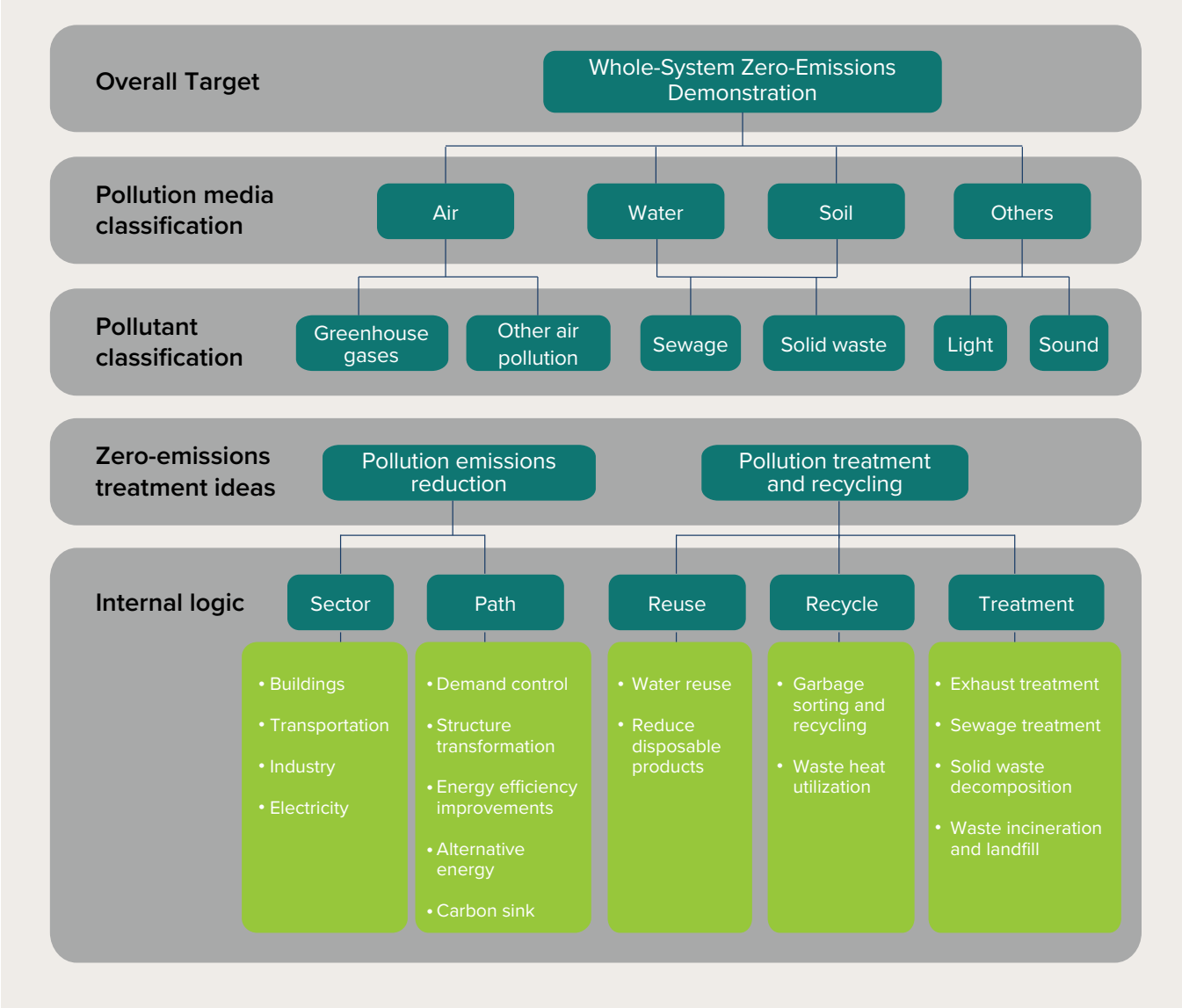


EXHIBIT 8

Zero-Carbon Indicators System

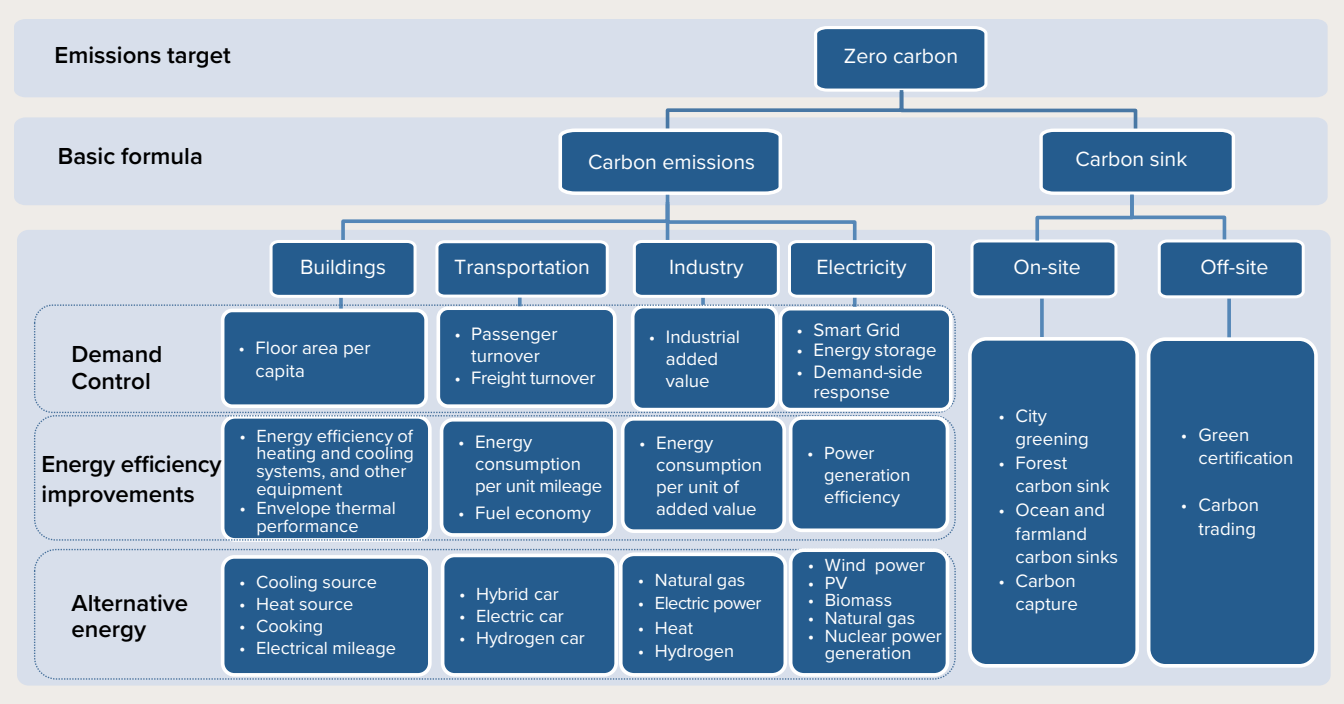


EXHIBIT 9

Zero-Waste Indicators System

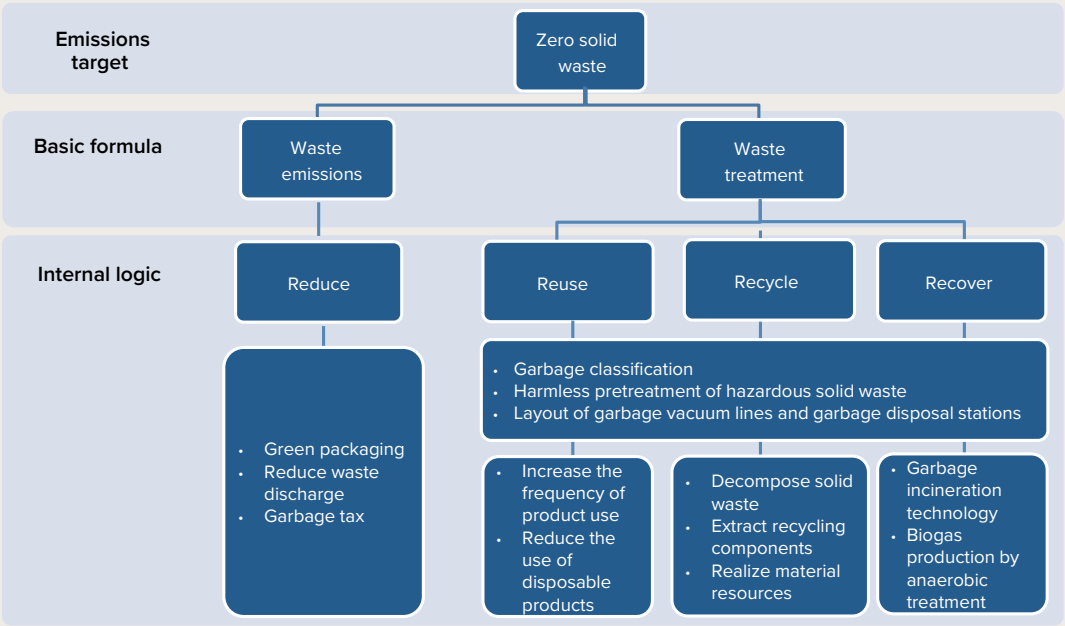
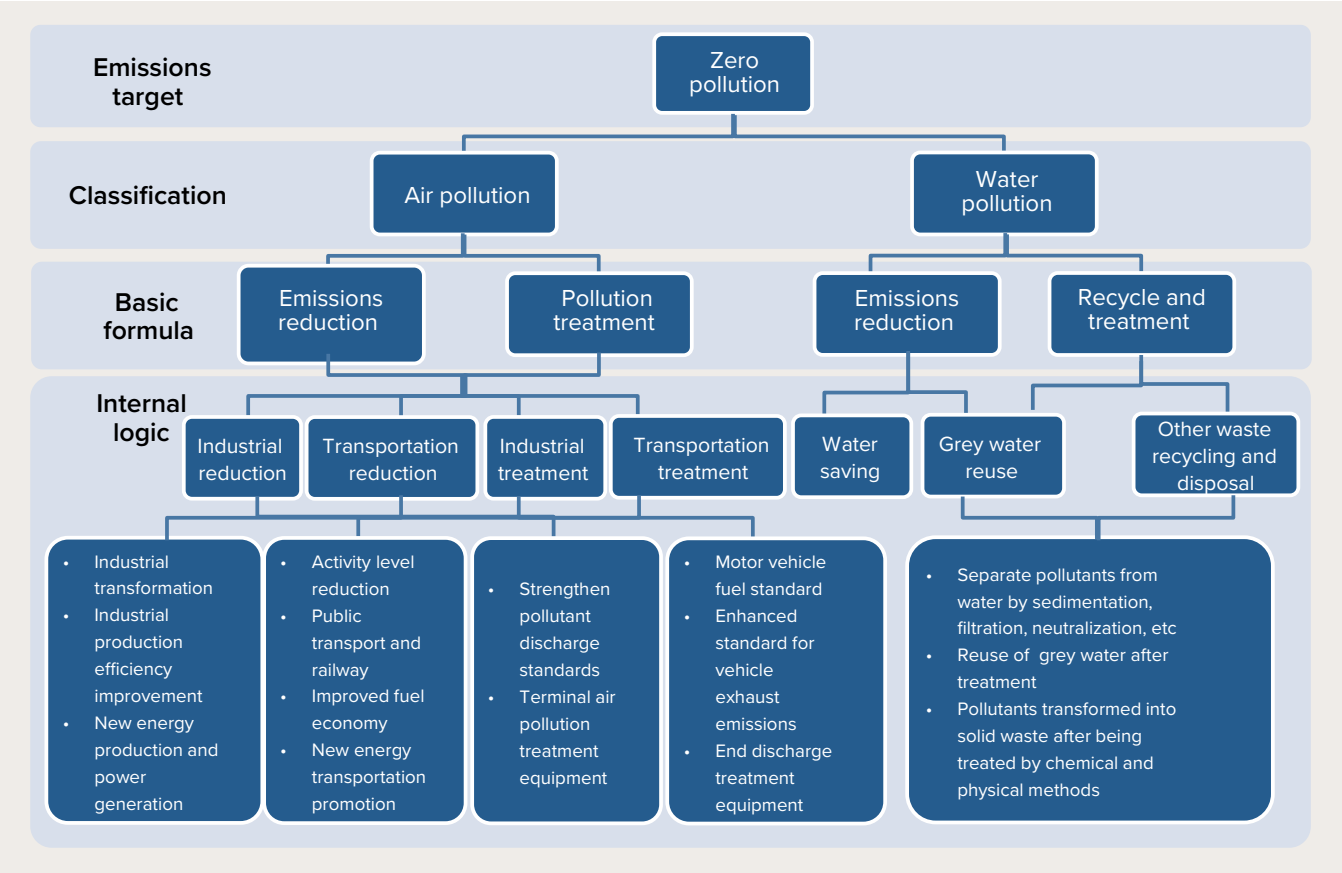


EXHIBIT 10

Zero-Pollution Indicators System



STRUCTURE OF WS-ZEDiS

The classification of polluting media under the zero-emissions target includes the atmosphere, water, soil, and other media such as sound and light. Among them, carbon emissions, solid waste, sewage, and air pollutants are the main concerns. Emissions reduction and recycling are the two major means to achieve zero emissions. In terms of emissions reduction, demand control, structural transformation, energy-efficiency improvement, and energy substitution are carried out for construction, transportation, industry, and power industry, respectively. In terms of recycling, waste is turned into treasure through repeated use, recycling, and end-of-life treatment.

Carbon emissions, solid waste, sewage, and air pollutants are the key concerns of WS-ZED. To achieve zero carbon, zero solid waste, and zero pollution, the relevant factors are comprehensively considered to form a set of feasible indicators systems.

Based on the above indicator system structure, WS-ZEDiS is a dual-indicator system that includes planning indicators and emissions indicators. WS-ZEDiS covers economy, land, industry, transportation, population, urban design, water, municipal facilities, agriculture, industry, and construction. See the Appendix for specific indicators.

APPLICATION METHODS AND CHARACTERISTICS OF WS-ZEDiS

WS-ZEDiS focuses on cross-department optimization to ensure compatibility, effectiveness, and advancement. The formulation of WS-ZEDiS adopts performance-based indicators that are results oriented and based on operation parameters, paying more attention to early planning. The research method focuses on quantitative technical and economic analysis and adopts real-time simulation and other technical means. WS-ZEDiS includes the following subsectors: social economy, industrial structure, land planning, energy, resources, ecology, waste, pollution, recycling, and lifestyle. The quantitative indicators' criteria take into account the technical feasibility, economic rationality, compliance with policies, and social acceptability through integrated planning. WS-ZEDiS features whole-process and dynamic correlation characters.

Whole process. By adopting integrated planning and governance measures for the whole ecosystem, whole production process, and whole value chain, WS-ZEDiS can unlock the full life-cycle value and achieve zero emissions in the process of supporting economic transformation and development.

Dynamic correlation. There are dynamic correlations and time correlations within the planning indicators. Adjusting one planning indicator can affect multiple emissions indicators and vice versa. WS-ZEDiS coordinates the quantitative indicators to improve the efficiency of energy conservation and emissions reduction and adopts a reasonable business model to reduce implementation costs

LANDSCAPING OF WS-ZED TECHNOLOGIES

WS-ZED provides an opportunity to implement early intervention technologies. From RMI's past pilot experience, we recognized that this is an opportunity to reshape urban infrastructure with innovative technologies. For example, 5G and big data technology could be used in smart city construction application scenarios, such as transportation, safety, environmental protection, and governance. A detailed list of technologies can be found in Exhibit 11.

EXHIBIT 11

Landscaping of WS-ZED Technologies

CLEAN ENERGY	EFFICIENT INDUSTRY AND GREEN MATERIAL	NEW MOBILITY SOLUTION	EFFICIENT BUILDINGS AND DISTRICTS	DIGITALIZATION AND INFORMATION TECHNOLOGY	INTEGRATED CITY GOVERNANCE TECHNOLOGY
• LNG Terminal Regasification Cooling Load Recycling • Wind and Solar Efficiency Breakthrough • Hydrogen Boiler • Hydrogen Production from Methane Pyrolytic Decomposition • Solar Hydrogen Production • Hydrogen Purification • Biogas Recycling • Carbon Capture/ Storage • Virtual Power Plants • DER Coordination Latency • Battery Chemistry • Battery Management System	• Electric Furnace Steel and Cement • Direct Reduced Iron w/Hydrogen • Innovative Kiln Cement • Power-to-X Tech for Petrochemical Industry • Low-Carbon Cement • Low-Carbon Smelting • Efficient PV Manufacturing • Lithium Extraction from Brines • Neodymium Recycling • Better Magnets • Industrial Waste Circular Use • General Equipment Efficiency • Super-Cool Material for Daytime Radiative Cooling • Graphene	• Full 5G Remote Control Sea Port • Electrified Cranes • Shore Power Charging • AI-Based Warehousing • Super Lightweight Vehicle • Low-Friction Coatings • Solid-State Lidar • Driverless Container Truck • New Adhesive and Joining for Dissimilar Materials • New Composites and Scale Production Process • Cold-Start Emissions Reduction • Battery Swapping • Second-Life Battery • Electric Aviation • Wireless Charging • Vehicle-to-Grid Technology • Hydrogen Heavy-Duty Truck	• Low-Cost Insulation Bolt • Thermochromic Windows • Vacuum-Insulated Windows • High-Emission/ Low-Absorption Coating • Infiltration Reduction Aerosols • Immersion Cooling for Data Centers • Plug Load Sequencing • Phase-Changing Material • Advanced Evaporative Cooling • Polymer Heat Exchanger • Hydrophobic Coating • CO_2 Refrigerant • District Heating and Cooling • Prefabrication • Engineered Bamboo and Wood • Absorption Heat Pump for District Waste Heat Recycling System	• 5G Technology for Smart Urban Energy System • Internet of Things for Demand Response and Energy Audit • Planning and Design Computer Software to Quantify Carbon Emissions at Early Design Phase • Big Data–Based Charging Station Mapping and Route Optimization • Block Chain for Distributed Energy Trading • Satellite Imaging and AI to Support Carbon Emissions Tracking • Unified Billing Platform for Energy and Water Bills	• Garbage Compression Treatment • Urban Pollution Emissions Monitoring Platform

RMI LOW-CARBON DEVELOPMENT CASE STUDIES

RMI has been committed to promoting the concept of low-carbon development and integrating the zero-carbon goal into regional development. After nearly 10 years of exploration, RMI has formed leading professional insights and established a rich project database throughout the United States, China, India, and Singapore. In this section we highlight projects that RMI has directly worked on.

Hazelwood Green Net-Zero Energy District

The district is located in Pittsburgh, Pennsylvania, USA. It was redeveloped from a 1 square kilometer steel mill site into a multipurpose urban comprehensive land project. Through RMI's support of the overall optimization analysis, the whole-process management model, and the innovative financing model, the goal of net-zero energy was achieved in an economically feasible way. The district has been attracting unicorn companies.

Singapore Green and Low-Carbon Port Project

RMI has worked with the Port Authority of Singapore to conduct in-depth technical and economic feasibility studies on low-carbon targets and renewable energy networks. The study helped the Port of Singapore identify economically viable green and low-carbon targets, providing an economic and technological roadmap. RMI made an in-depth analysis of the energy consumption and production situation of the port and made a detailed roadmap for the green and low-carbon integrated energy service.

Meishan Near-Zero Carbon Zone Project

With a total area of 330 square kilometers, Meishan is a typical “port-industry-city” development project. RMI has worked with the project management committee to realize a near-zero carbon zone by 2030 in a technically feasible, economically reasonable, and commercially innovative way. According to RMI’s analysis, by 2030 the economy of Meishan will grow by four times and the population will grow by three times, while the total carbon emissions will be able to be maintained at a level slightly lower than 2017. RMI has helped develop a technical and policy roadmap toward 2030, covering the energy supply side and demand side.

India Palava Sustainable City Project

RMI has developed action plans and technical support for the Palava community in terms of sustainability and emissions reduction. As of 2025, the plan will provide 500,000 people with multidimensional infrastructure such as zero-energy buildings, which will drive renewable energy, green mobility, and sustainable water resource utilization. RMI worked with local governments, developers, energy suppliers, and municipal suppliers to enhance the value and influence of the Palava community in all aspects.

Haikou Jiangdong New District

Haikou Jiangdong New District is located in the east coast area of Haikou, with a total area of 298 square kilometers. It has unique location advantages, a first-class ecological environment, and obvious leapfrog opportunities.

According to the strategic positioning, Jiangdong New District area will build a pilot area for comprehensively deepening reform and opening up a national ecological civilization pilot area, an international tourism consumption center, and a major national strategic service guarantee area ("three areas and one center").

Jiangdong New District strives to become a centralized exhibition area of the China Hainan Pilot Free Trade Zone. It aims to become a model for how to improve the economy, efficiency, and power reform, improving total factor productivity and establishing an open ecological service-oriented industrial system.

GLOBAL IMPACT

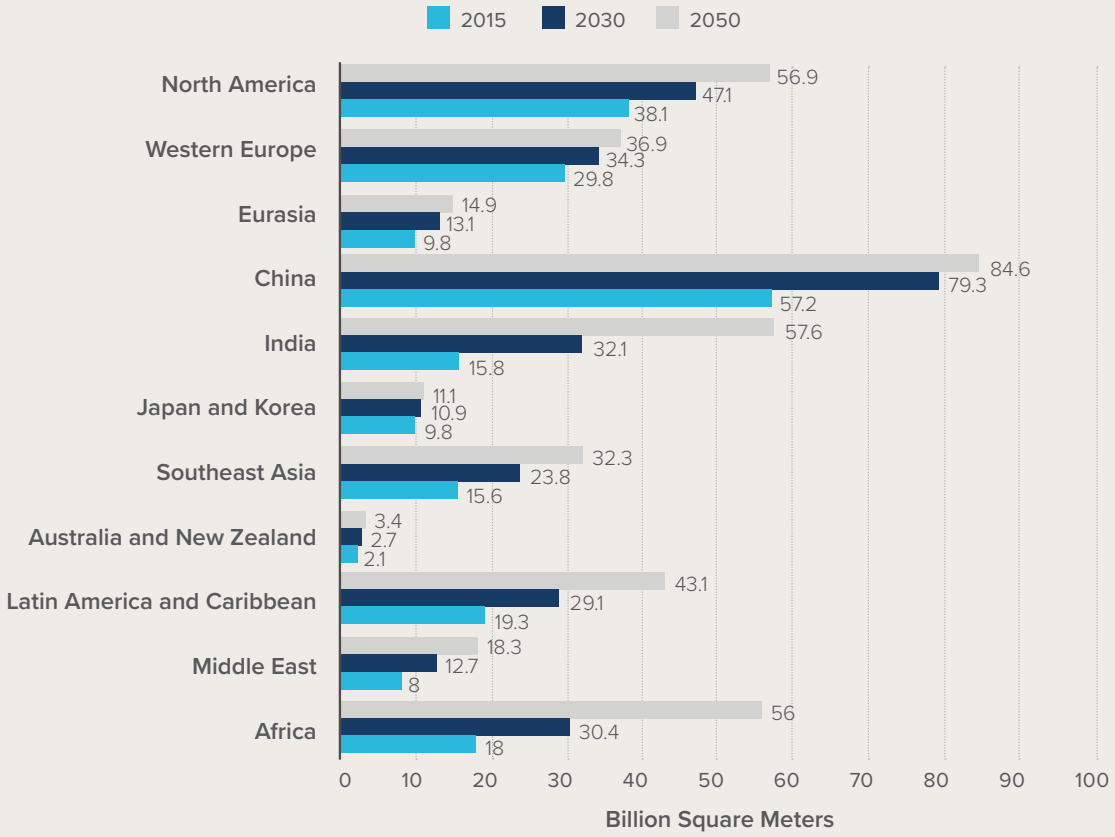
By 2050, the total global urban population is predicted to increase by 2.5 billion, and the amount of new construction related to cities is equivalent to building a New York City every day. China, India, Latin America, Africa, and other regions (Exhibit 11) are showing rapid urbanization, and the growth rate and total amount of urbanization are considerable. Adopting effective urban growth management policies in areas with the fastest urbanization is critical for the global response to climate change and the achievement of sustainable development goals.

A main driver of the new round of urbanization is the global division of labor and industrial transfer, which also makes the new urbanization present a complex situation. For example, 30% of the total carbon emissions from the main countries along the Belt and Road initiative come from their trade-related carbon emissions and hidden carbon exported to the United States, Western Europe, Japan, and South Korea. On the other hand, the negative impact of pollution and waste is usually domestic. This spatial mismatch between production and consumption has made it more difficult to manage carbon emissions, waste, and pollution in rapidly urbanized areas.

WS-ZED provides a new theoretical model for rapid urbanization, focusing on the relative relationship between economic development, resources, and environment in the process of urbanization. The Whole-System Zero-Emissions Demonstration provides a theoretical basis and a calculation framework for the decoupling of high-quality economic development and various types of emissions. Each project can develop a suitable zero-emissions roadmap according to specific circumstances and local conditions. WS-ZED is based on international best practices, looks at the future global urbanization process, and leads and contributes to the global green urbanization and ecological civilization process.

EXHIBIT 11

Projected Growth of Building Floor Area Worldwide from 2015 to 2050 by Region



Source: "Projected Growth of Building Floor Area Worldwide from 2015 to 2050, by Region," Statista, 2020, **https://www.statista.com/statistics/731858/projected-global-building-floor-area-growth-by-region/**

CALL FOR ACTION

Whole-System Zero-Emissions Demonstration is a cross-industry green innovation that requires the cooperation of multiple parties for implementation. In addition to continuing to improve the theoretical framework of WS-ZED, we should work on the pilot project and explore the formulation of quantitative policy objectives, innovative regional planning and design methods, more compatible planning management systems, and comprehensive innovative business models such as the integrated energy service provider model. RMI invites all relevant parties to work with us to promote and implement WS-ZED.

APPENDIX: WHOLE-SYSTEM ZERO-EMISSIONS DEMONSTRATION (WS-ZEDiS)

Planning Indicator			Emissions Indicator			
Classification	Detailed Classification	Main Indicators	Carbon Emissions	Water	Solid	Air
Social Economy	Population	Population density	Carbon emissions per capita	Water pollution per capita	Solid waste per capita	Indoor air quality per capita
	Economy	GDP	Carbon intensity per unit of GDP	Water pollution per unit of GDP	Solid waste per unit of GDP	Air pollution per unit of GDP
		Urbanization rate	Urban and rural carbon intensity	Urban and rural water pollution	Urban and rural solid waste	Urban and rural air pollution
Planning and Design	Land	Land utilization	Carbon intensity per kilometer	Water pollution per kilometer	Solid waste per kilometer	Air pollution per kilometer
	Industry	Industrial structure	Industrial emissions intensity	Industrial water pollution	Industrial solid waste	Industrial air pollution
		Added value of industry	Carbon emissions per unit of added value	Water pollution per unit of added value	Solid pollution per unit of added value	Air pollution per unit of added value
		Investment completion	Carbon emissions per unit investment	Water pollution per unit investment	Solid waste per unit investment	Air pollution per unit investment
		Gross output valuation	Total carbon emissions	Total water pollution	Total solid waste	Total air pollution
		Employee structure	Emissions intensity of individual position	Water pollution of individual position	Solid waste of individual position	Air pollution of individual position
	Transportation	Road density	Carbon emissions per kilometer	-	-	Air pollution per kilometer
		Travel-friendly road design	Walking and biking emissions reduction effect	-	-	Walking and biking emissions reduction effect
		Road surface material	Reduce the heat island effect and save energy	Permeable rate	-	Avoid dust and other pollution
		Public commute rate	Public commute emissions reduction effect	-	-	Public commute reduce air pollution
		Freight optimization	Freight efficiency reduce carbon emissions	-	-	Improved efficiency reduce pollution
		Renewable energy transportation planning	Renewable energy decarbonization and emissions reduction	-	-	New energy reduce exhaust emissions

Planning Indicator			Emissions Indicator			
Classification	Detailed Classification	Main Indicators	Carbon Emissions	Water	Solid	Air
Production and living	Urban Design	Work-life balance	Improve the efficiency of land use, promote economic activities, and improve the quality of life	Improve the efficiency of land use, unify sewage treatment	Improve the efficiency of land use, reduce the solid waste of construction	Relieve traffic pressure, reduce air pollution
		Floor area ratio	Carbon emissions intensity per square meter	Water pollution per square meter	Solid pollution per square meter	Indoor environmental pollution per square meter
		Height limit	-	Facade rainwater utilization	-	Light pollution
		Building density	Competition for area of building, greenery, transportation, municipal facilities, and others	Surface water utilization	Reduce construction solid waste	Light pollution
		Near-line rate	Emissions reduction benefits of travel-friendly	-	-	Light pollution
		Sunshine distance	Living friendly, energy saving, and emissions reduction, increasing productivity	-	-	Light pollution
		Main orientation	Living friendly, energy saving, and emissions reduction, increasing productivity	-	-	Light pollution
		Indoor environment and thermal comfort	Improve indoor comfort to increase productivity and attract talent	-	Reduce decoration waste	Indoor air quality
	Landscape and waterscape	Percentage of greenery coverage	Carbon sink, reduce heat island effect	-	-	Windproof and dustproof
		Vegetation species	Carbon sink	-	-	Windproof and dustproof
		Greenway planning	Living friendly and increases productivity	-	-	Windproof and dustproof
		Percentage of waterscape coverage	Carbon sink, reduce heat island effect	Water utilization	-	Windproof and dustproof

Planning Indicator			Emissions Indicator			
Classification	Detailed Classification	Main Indicators	Carbon Emissions	Water	Solid	Air
Production and living	Municipal facility	Municipal lighting	Lighting energy consumption	-	-	
		Landscape irrigation	Landscape energy consumption	Landscape water pollution	-	-
		Cleanliness of waters	Waterscape energy consumption	Water pollution	-	-
		Sanitation and waste disposal	Waste treatment energy consumption	Liquid waste	Solid waste	Dust pollution
		Sewage treatment	Waste treatment energy consumption	Sewage	-	-
		Water recycling	Waste treatment energy consumption	Recycling ratio	-	-
		Rainwater regulation	Waste treatment energy consumption	Rainwater utilization	-	-
		Energy storage	Peak shaving and emissions reduction	-	-	-
		Thermal storage	Heat regulation and emissions reduction	-	-	-
		Substation, boiler, heat, gas, telecommunication, and other conventional municipal facilities	Operational energy saving	Operational saving	-	-
		Pipe network	Pipeline comprehensive and land saving	-	-	-
Production and living	Agriculture	-	-	-	Soil pollution	-
	Industry	Construction industry	Construction energy consumption and emissions	Construction wastewater	Construction waste, decoration waste	Construction dust pollution
	Transportation	Passenger transportation efficiency	Passenger transportation carbon emissions			Exhaust gas pollution
		The efficiency of freight	Freight carbon emissions			Exhaust gas pollution
		Water transport efficiency	Water transportation carbon emissions	Water pollution	-	Exhaust gas pollution
		Intelligent scheduling	Traffic jam coefficient	-	-	Exhaust gas pollution

Planning Indicator			Emissions Indicator			
Classification	Detailed Classification	Main Indicators	Carbon Emissions	Water	Solid	Air
		Energy intensity of various buildings	Carbon emissions from the construction and buildings sector	-	-	-
		Passive design optimization	Carbon emissions from the construction and buildings sector	-	-	-
		Smart home	Peak building energy load	-	-	-
		Water usage indicators	-	Water saving in the construction and buildings sector	-	-
		Construction waste disposal	-	Household garbage	Household garbage	-
		Kitchen smoke exhaust	Kitchen energy management	Kitchen grease	Food waste	Restaurant air pollution
	Cross-sector circular economy	Low-grade heat utilization	Recycle and reduce emissions	-	-	Smoke utilization
		Waste cold utilization	Recycle and reduce emissions	-	-	-
		District energy station	Improve efficiency and reduce emissions	-	-	-
Supply Guarantee	Energy	Electricity	Electricity decarbonization	-	-	Coal to electricity to reduce air pollution
		Gas	Emissions reduction	Water pollution	-	Coal to electricity to reduce air pollution
		Coal	Coal control	-	-	-
		Oil	Replacement of new energy, biomass, etc.			
	Resource	Water	Energy-efficiency measures such as pump efficiency improvement and network design optimization	Water saving		

RESOURCES

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