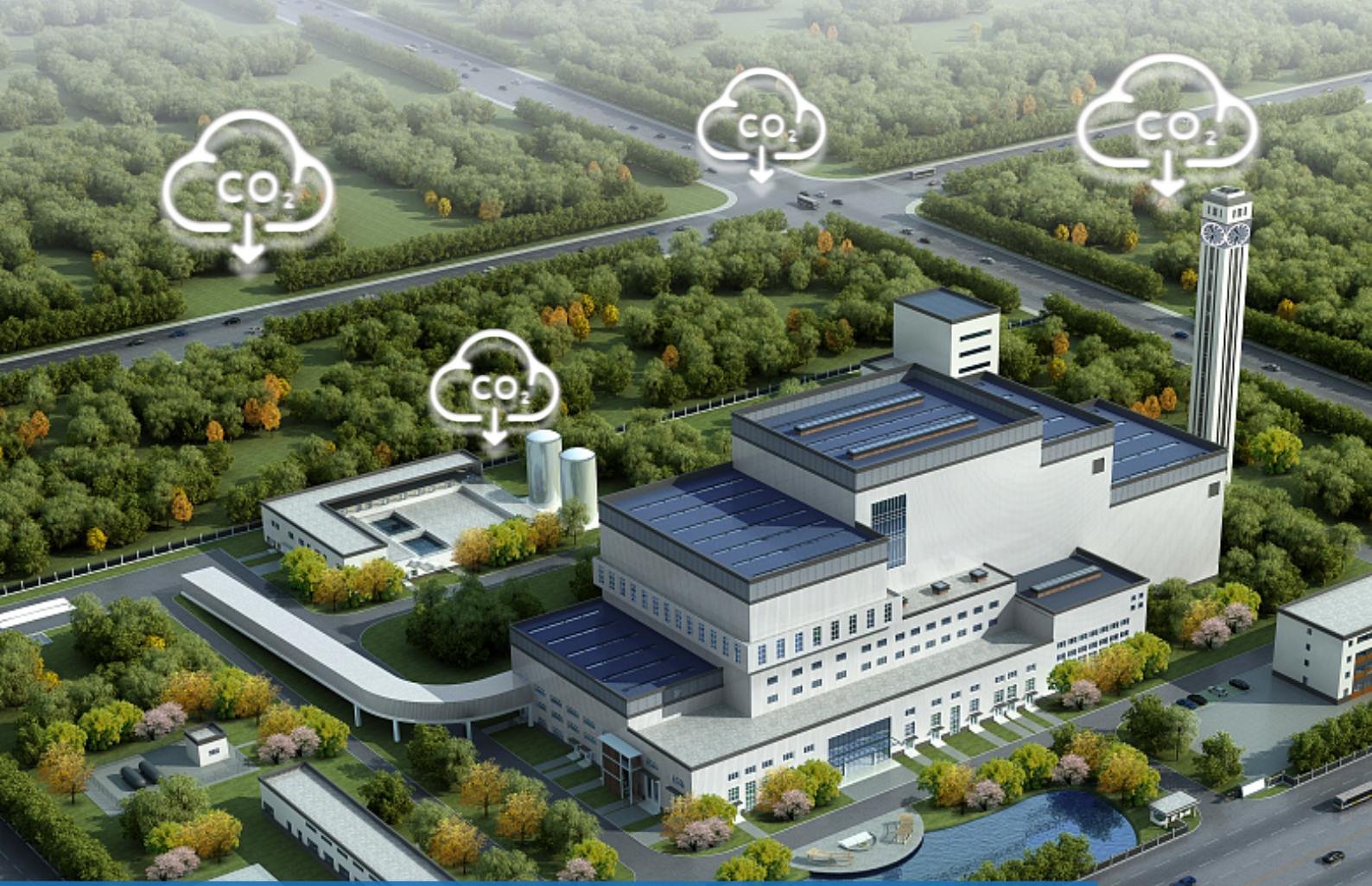

Policy Recommendations for Low/Zero-Carbon Energy Development of Lancang-Mekong Region Industrial Parks (Phase I Research)

November 2023

Working Committee, China Energy Research Society (CERS)
Lancang-Mekong Energy & Power Cooperation Research Center (LMERC)

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CONTENTS

Executive Summary

In 2022, the total final energy consumption (TFEC) of the five Lancang-Mekong countries (Laos, Myanmar, Thailand, Cambodia and Vietnam) reached 278 million tons of standard coal, with a fossil energy share of 60.5%; the consumption of electric power was about 485 billion kWh, accounting for about 21.4% of the share of final energy consumption, and the CO_2 emissions from the electric power industry will be more than 230 million tons. Industrial parks are important spatial carriers in economic development, and their contribution to the energy consumption and CO_2 emissions level of each country cannot be ignored. Therefore, it is urgent to clarify the path of CO_2 emission reduction in industrial parks and to promote effective CO_2 emission reduction measures, and it is also necessary for industrial parks to "take a step ahead" in green development.

The report "Low/Zero-Carbon Energy Development Pathway of Lancang-Mekong Regional Industrial Parks" (henceforth referred to as "this report") aims to provide reference for the sustainable development of industries and parks in Lancang-Mekong region. The research and follow-up work of this report will be divided into four stages. The first stage aims to put forward policy recommendations on low/zero-carbon energy development. During the second stage of the research, the phased implementation pathway of low/zero-carbon energy system in industrial parks will be put forward. The third stage will strive to promote the construction or pilot project of

low/zero-carbon energy in industrial parks of Lancang-Mekong region. The capacity building of low/zero-carbon energy development in industrial parks of Lancang-Mekong region is also a core to the follow-up work of this report.

As a conclusion of the first stage research, this policy recommendation paper examines industry distribution in five countries. It pointed out that the five countries in Lancang-Mekong region have enormous potential for industrial parks development. In the future, by leveraging resource endowment and geographic advantages, industries with differentiated advantaged will be developed. The green attributes and value will be added to the industrial output, forming a safe, efficient, and eco-friendly industrial parks and jointly building a globally competitive industrial cluster or industrial chain in the region. The low/zero-carbon development of industrial parks will serve as a positive exploration and provide valuable experience for Lancang-Mekong countries on their way to reach carbon neutrality. The vigorous development momentum of Lancang-Mekong region industrial parks will continue to stimulate strong energy consumption potential. However, restricted to the existing high emission energy consumption structure, the Lancang-Mekong region industrial parks will inevitably encounter policy pressure from international carbon tariff in the future, which will weaken the competitiveness of export commodities. Accelerating the pace of energy transition is urgent. Industrial parks in Lancang-Mekong region have favorable clean energy with enormous potential to build energy infrastructure. The continuous introduction of advanced energy manufacturing industry also strongly promotes the formation of green industrial chain in industrial parks. These favorable conditions provide a solid foundation for industrial upgrade and low/zero-carbon energy transition in industrial parks in Lancang-Mekong region.

The construction of low/zero-carbon pathway in Lancang-Mekong region also faces many challenges. Unbalanced industrial economic development affects industrial layout and development of industrial parks. The power infrastructure within industrial parks constrains the high-quality development of the industrial economy. The status of low/zero-carbon construction in industrial parks is mismatched with sustainable development. External factors are driving industrial upgrading and energy transition. The support and guarantee system still need further improvement.

The policy recommendations are summarized as followed:

- Accelerate the development and utilization of new energy in the industrial park, promote the orderly reduction of fossil energy;
- Exploit the energy-saving potential of the productive process of the park, promote the clean energy and power substitution of final energy consumption;
- Promote the application of low/zero-carbon energy technology in industrial park to create a construction benchmark;
- Strengthen the construction of industrial parks' energy platform and model mechanism innovation, improve the level of synergic optimization;
- Deepen energy cooperation in industrial parks, promote the integration of low/zero-carbon industrial consumption and production;
- Give full play to the leading role of economic development and low-carbon transition of industrial park, continue to promote local social development and industrial transition.

Chapter 1

Background

The United Nations IPCC"AR6 Synthesis Report: Climate Change 2023" states that global greenhouse gas emissions are steadily increasing, primarily driven by industrial and energy activities. Despite the efforts of countries worldwide to develop policies aimed at mitigating climate change, the emissions gap still exists between the expected output of these policies and those outlined in the National Determined Contributions (NDCs). To bridge this gap, it is essential for the international community to collaborate and adopt more robust measures to effectively slow the progress of climate change.

Lancang-Mekong region has experienced rapid economic development in recent years, but also has faced enormous challenges brought by climate change. This year's extreme high temperature has attracted widespread attention from the Lancang-Mekong countries, with some countries setting new historical high temperature records. Global warming has brought various problems to the Lancang-Mekong River Basin, including water shortage, food insecurity, sea level rise, biodiversity decline, and salinization. Frequent droughts and floods pose a serious threat to local economic development and social stability. The Lancang-Mekong River Basin is an ecosystem on which the Lancang-Mekong countries rely for their survival and development. According to a report released by the Asian Development Bank (ADB),

Southeast Asia will become one of the regions that suffer the most losses from global warming. If no action is taken to make changes, the Gross Domestic Product (GDP) of the region may decrease by 11% by the end of this century. Therefore, addressing climate change and pursuing sustainable development are the top priorities for Lancang-Mekong region, which also conforms to the global development trend.

The Lancang-Mekong region's response to climate change is a crucial measure and the strongest driving force for achieving green recovery. Countries within the region have submitted NDCs, proposing the time frame for achieving net zero emissions, and are expected to intensify efforts for the next round of climate action plans in 2025. Global efforts to address climate change mainly involve promoting renewable energy development and green energy substitution, enhancing energy efficiency and recycling, fostering green transportation and smart urban/town, utilizing advanced technologies such as carbon-fixation technology and carbon-negative technology, and reinforcing international cooperation. Additionally, countries also prioritize investment and policy support in formulating low-carbon development strategies. The Lancang-Mekong region enjoys strong policy coordination between low-carbon development and inclusive growth of economy and industry. Lancang-Mekong region has great development potential and rich green resources, energy transition provides new opportunities for climate change response, environmental governance, and green development. Promoting low-carbon development can also ensure that the benefits of economic growth reach everyone, reduce social inequality and poverty, improve residents' quality of life.

Energy and electricity serve as one of the most crucial infrastructures in Lancang-Mekong region, drive forces for green growth. In 2022, the total final energy consumption (TFEC) of the Mekong countries (Laos, Myanmar, Thailand, Cambodia and Vietnam) reached 278 million tons of standard coal (AAGR is 1.5% for last decade), with a fossil energy share of 60.5%; the consumption of electric power was about 485 billion kWh (AAGR is 5.3% for last decade), accounting for about 21.4% of the share of TFEC, and the CO_2 emissions from the electric power industry are estimated to be more than 230 million tons. Industrial parks are important spatial carriers in economic development, and their contribution to the energy consumption and carbon emission level of each country cannot be ignored. Therefore, this report aims to promote green development in the Lancang-Mekong region, focuses on studying and practicing low/zero-carbon energy development pathways in industrial parks. The goal is to achieve a ripple effect, generating economic, environmental, and social benefits at a larger scale.

Chapter 2

Objectives and Methodology

2.1 Objectives

The economic development in Lancang-Mekong region is currently in the period of rapid growth. With the promotion of the "multi-country, multi-park" cooperative model, it will effectively optimize the layout of production capacity cooperation and promote the integrated development of industrial chains and value chains. Industrial clusters such as administration service, commerce, and manufacturing industry are gradually emerging. Energy is one of the fundamental driving forces behind the national economy and industrial development. Promoting the clean utilization of energy is the core means for the Lancang-Mekong countries to accelerate energy transition and fulfill their commitments to carbon neutrality. While ensuring the energy needs of various industries and improving energy utilization efficiency, it is crucial to accelerate the comprehensive energy transition process in the Lancang-Mekong countries from point to plane.

At present, Lancang-Mekong countries are actively promoting the planning and construction of low-carbon industrial parks. Given the fact that countries have varying levels of economic development and technological maturity, differences exist in the industrial layout, industrial processes, and clean energy resource potential of industrial parks. Low-carbon energy system construction overall level of this region is still at an initial stage. There is a

lack of comprehensive consideration of energy factors in the industrial parks and systematic planning for the long-term low-carbon development pathway of the industrial parks. In view of this, this study will propose differentiated construction pathways and solutions for low/zero-carbon development in the industrial parks. It is proposed to be applied in practice for a regional cooperation model.

2.2 Methodology

The report progresses gradually from macro-level frameworks to specific implementation, focusing on the research of low/zero-carbon energy. This report adopts a research framework of "policy recommendations—implementation pathways—application scenarios—capacity building", and is divided into four stages:

1.Policy recommendations;

2.The phased implementation pathway;

3. Pilot project construction;

4.Capacity building.

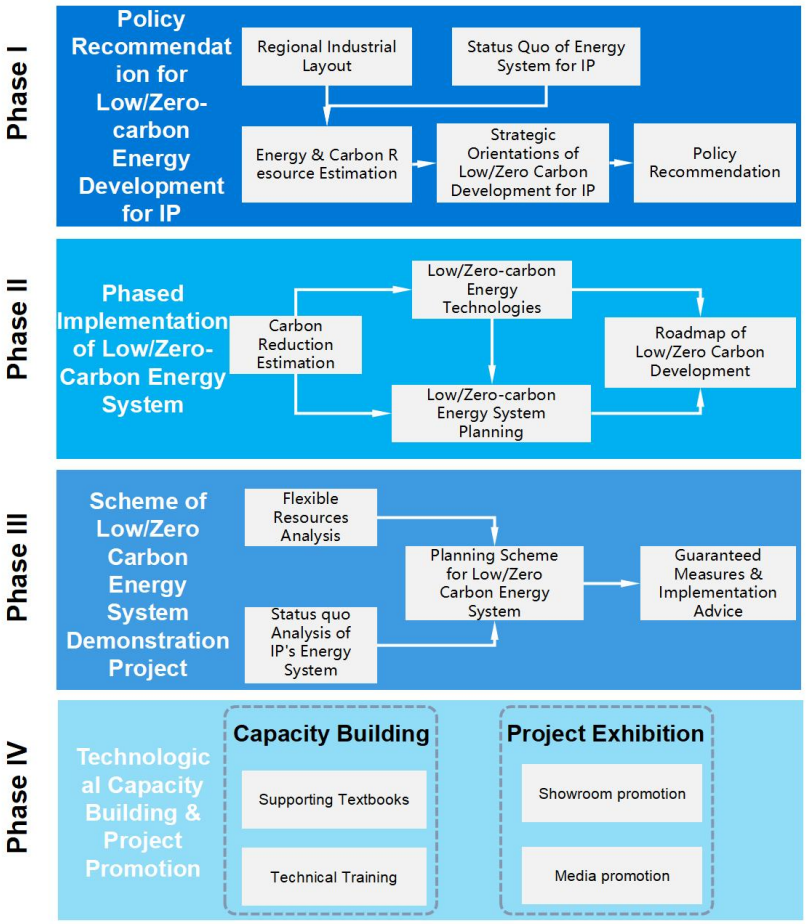
Research stages are as follows:

Phase Ⅰ： Based on research and analysis of the industrial structure and current state of energy systems in typical industrial parks of Lancang-Mekong countries, this study assesses the energy and carbon sink resources at the park level. From a top-level perspective, it proposes strategic development directions and policy recommendations for building low/zero-carbon energy systems in the industrial parks of the Lancang-Mekong countries.

Phase II： Based on the calculation of CO_2 emission in typical industrial parks, this study focuses on researching low/zero-carbon energy system technologies and planning methods. It aims to propose a phased implementation pathway for low/zero-carbon energy systems in industrial parks of the Lancang-Mekong countries.

Phase III： By selecting some typical industrial parks in the Lancang-Mekong region as the research projects, this study raises phased construction plans for low-carbon flexible microgrids and low/zero-carbon integrated energy systems that synergistically incorporate multiple energy sources, taking into consideration the industrial development characteristics of the parks. The aim is to create leading on-site application demonstrations for building park low/zero-carbon energy systems in Lancang-Mekong region.

Phase IV： Efforts will be made to provide training to technicians and senior professional personnel from relevant departments and institutes of the Lancang-Mekong countries. At the same time, through displaying of documentary videos, sand tables of low/zero-carbon park pilots, it proposes to create a platform for low/zero-carbon development communication and cooperation at industrial parks in Lancang-Mekong region.



Source: Compiled by the research team

Figure 2-1: Framework diagram of the research methodology in this study

This policy recommendation is based on research conducted during Phase I, which combined with a survey of the current status and energy resource of typical industrial parks in the Lancang-Mekong region, analyzes the challenges faced by low/zero-carbon energy systems in these parks. This Phase I report proposes targeted recommendations and measures for the low/zero-carbon transition of industrial parks energy systems, taking into account the future strategic development direction of the parks in the Lancang-Mekong countries.

Chapter 3

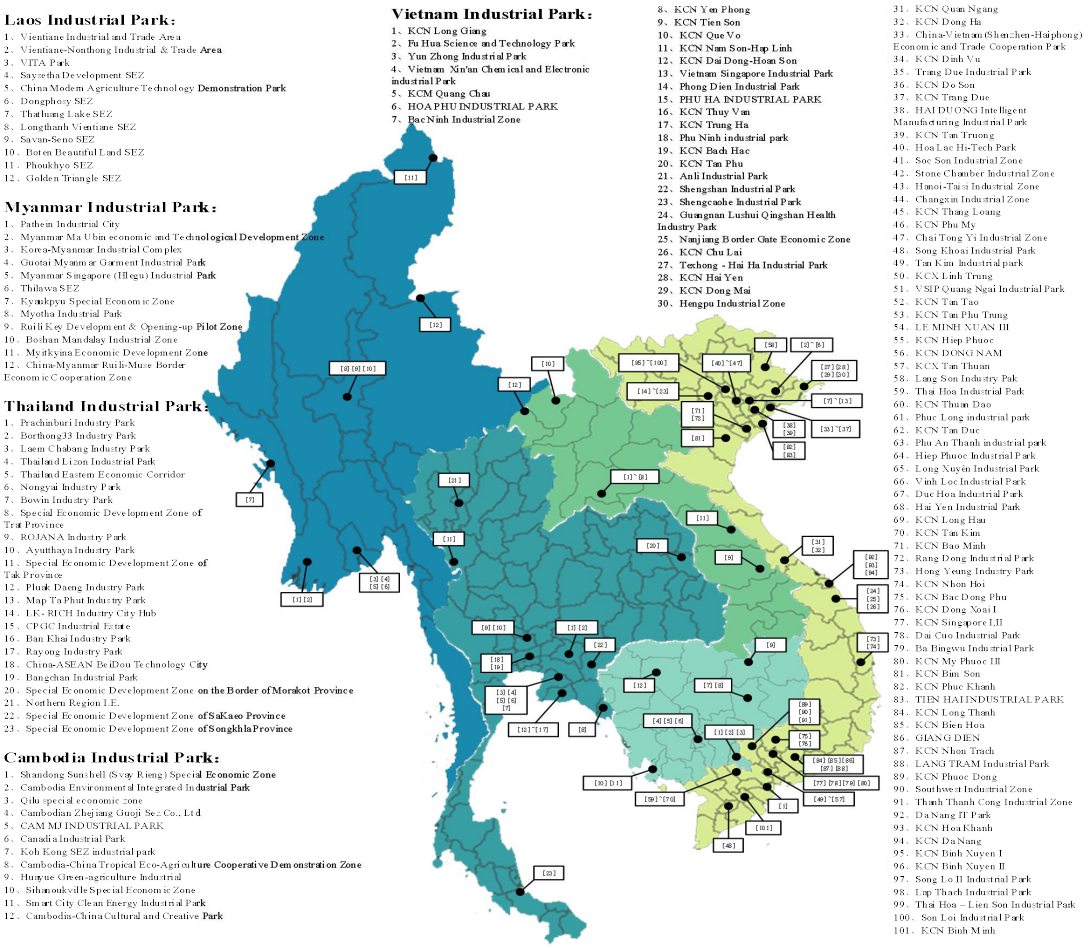
The Development Foundation of Industrial

3.1 The Development Foundation of Industrial Parks

In recent years, the Lancang-Mekong region has vigorously developed industrial parks that serves agriculture trade, industrial manufacturing, commercial administration, tourism, and cultural creativity industries. Relevant industrial clusters have gradually formed, effectively driving socio-economic development. Particularly, the implementation of the Regional Comprehensive Economic Partnership (RCEP) and the connectivity of infrastructure such as the China-Laos Railway, they have injected strong momentum into transforming the Lancang-Mekong region into an economic growth center.

The economic development potential in the Lancang-Mekong region is enormous. Under the evolving "multiple countries, multiple parks" cooperation model, numerous industrial parks have sprung up and developed diversely. It is a noticeable trend that industrial parks are formed in larger cities and their outskirts, as well as resource-rich areas and border areas to better serve the development of advantageous industries (mineral exploration, cross-border trade, and logistics, etc.). According to the survey and research, in Laos, industrial parks are mainly located in the capital, Vientiane, as well as in provinces bordering neighboring countries like Luang Mantha, Bokeo, Xaisomboun, and Champasak, which possess relatively

abundant mineral resources. In Myanmar, industrial parks are mainly located in Yangon and surrounding provinces, as well as in the areas bordering China such as Kachin State and Shan State. Thailand's industrial parks are primarily located in the capital city of Bangkok, coastal areas, Songkhla Province in the south, and eastern economic corridor. Cambodia's industrial parks are distributed in the capital, Phnom Penh, Siem Reap Province, Battambang Province, Preah Sihanouk Province on the coast, and other areas. Vietnam's industrial parks are mainly situated in the Red River Delta and Mekong Delta regions, forming a complementary spatial development pattern with urban centers centered around Hanoi and Ho Chi Minh City.

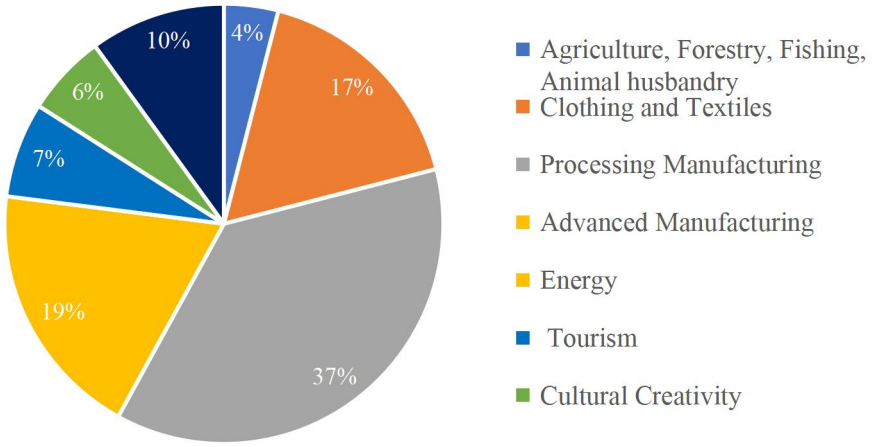


Source: Organized by the research team based on publicly available information

Figure 3-1 Schematic Map of Industrial Park Distribution in the Lancang-Mekong Region

(Disclaimer: The boundaries and names shown and the designations used on this figure do not imply official endorsement or acceptance by the United Nations.)

According to the research, the industrial types in the Lancang-Mekong region's industrial parks mainly include agriculture, forestry, fishing, animal husbandry, clothing and textiles, processing manufacturing, advanced manufacturing, energy, tourism, cultural creativity, and warehousing logistics. Among these, processing manufacturing industrial parks are the most numerous, followed by advanced manufacturing and clothing/textile industries. Processing manufacturing and clothing/textile industries are the most widespread across the five Mekong countries, while advanced manufacturing is primarily concentrated in Vietnam and Thailand.



Source: Organized by the research team based on publicly available information

Figure 3-2: Distribution of Industrial Park Industries in the Lancang-Mekong Region

The industrial parks in the Lancang-Mekong region hold significant potential and adaptability for future development.

- These industrial parks are gradually moving towards more rational specialization and higher value-added industries. For instance, Thailand has established a regional pattern of specialization, with the central region focusing on electronics and automotive components, the south on fisheries and rubber industries, and the eastern economic corridor on advanced manufacturing like electronics, smart manufacturing, and biomedicine.

- The planning of these industrial parks is shifting from mere industrial aggregation hubs to integrated urban functional areas, blending industry and city functions. For example, the Savan-Seno Special Economic Zone in Laos is becoming a sub-center of the capital Vientiane, integrating industrial parks and the new city. Thailand's Amata Industrial Park aims to be a "smart park," leveraging innovative technologies to improve industrial processes and efficiency.
- The region still holds immense economic growth potential with urbanization rates at around 40% in the Mekong countries in 2022, leaving significant room for industrialization and urbanization, leading to a substantial consumer market expansion.
- Leveraging trade advantages, especially with support from multilateral and bilateral economic agreements like RCEP, the region can attract more foreign technology and investment. This development pattern with initial industrial clustering facilitates a more conducive business environment for enterprises, ensuring sustained economic development for these parks.
- Abundant natural resources such as hydropower, agriculture, and mineral resources provide a favorable base for industrial parks development. Cost advantages in labor and energy also make the region an important destination for foreign investments.
- Under the Lancang-Mekong Cooperation (LMC) mechanism and Greater Mekong Subregion (GMS) mechanism, through strengthening trade, investment, and infrastructure cooperation to enhance the overall competitiveness of industrial parks.

In the future, these industrial parks will leverage each country's resource potential and geographical advantages to develop more distinctive industries. This involves not only developing domestic industries but also strengthening trade and economic cooperation with China-ASEAN, and other countries. Collaboration will enhance complement of each country's resource strengths, creating a more stable and efficient regional supply chain and value chain—from raw material sourcing, procurement, manufacturing, research and development to sales and market expansion. Additionally, these parks will expedite infrastructure development, ensuring reliable support like roads, energy supply, and hydropower facilities. Furthermore, to boost sustainability and industrial resilience, the region will further explore new ways to create green attributes and value of industries.

3.2 The Potential for Low/Zero-carbon Energy Transformation in Industrial Park Areas

The industrial parks development in the Lancang-Mekong region has sparked a robust momentum in energy demand, particularly driving significant potential growth. Most industrial parks in the region are currently in their initial phases. However, with the future improvement of park infrastructure and the influx of various industrial enterprises, the diversity in energy usage is expected to expand. It is anticipated that energy demands may grow by two to three times compared with the current stage, showcasing substantial room for growth.

Abundant clean energy resources within these industrial parks form a solid foundation for achieving a low/zero-carbon energy transition. Situated amid the Mekong, Nam Khan, Salween, and Yom rivers of the Indochinese Peninsula, the region enjoys ample hydroelectric resources owing to their

significant water volume and rapid flow. The potential for hydroelectric technology development is estimated at no less than 130 GW, with considerable untapped potential that can further optimize the power generation structure, facilitating the supply of abundant green energy to the industrial parks. Additionally, located in tropical low-latitude areas, these industrial parks benefit from long hours of sunlight, with solar energy utilization hours reaching up to 1300-1700 annually. This makes them conducive to large-scale deployment of solar panels on the roofs of numerous factory buildings. Moreover, areas in central Laos, eastern Thailand, and coastal Vietnam exhibit high wind energy density, offering favorable conditions for the future development of decentralized small-scale wind power tailored to the specific locations of the industrial parks.

The energy infrastructure within these industrial parks presents significant room for upgrades and adaptability to meet the demands of a low/zero-carbon energy transition. Most of the industrial parks in these countries are still in their initial stage, can promote clean energy substitution and electrical energy consumption by establishing energy consumption networks centered around electrical grids. This involves enhancing the electrical grid infrastructure to incorporate larger-scale clean power sources like wind and solar energy. Additionally, by forming an energy consumption system centered around electricity, these parks can expedite the transition from coal or oil to electricity in various industrial processes. Furthermore, integrating energy storage systems into the grid can facilitate renewable energy integration and strengthen grid resilience. Looking ahead, leveraging the capacity for green hydrogen production from renewable energy can contribute to establishing a flexible, reliable, green, and low-carbon energy consumption system within these industrial parks.

In these industrial parks, continual introduction of advanced energy manufacturing industries is instrumental in driving the symbiotic development of green industrial chains and low-carbon energy transition. Research indicates that industrial parks like the Savan-Seno Special Economic Zone in Laos and the Thailand-China Rayong Industrial Zone have successfully attracted solar power and electric vehicle companies. These parks are fostering the influx of more upstream and downstream green energy companies, they can establish a highly efficient and mutually complementary industrial chain gradually. At the same time, this endeavor seeks to achieve coordination between the economic benefits of enterprise production and the ecological benefits of energy transformation, facilitating their collaborative development.

Chapter 4

Challenges in the Low/Zero Development of Energy in Industrial Park

4.1 The Uneven Development of Industrial Economy Affects the Industrial Layout and Development of Industrial Parks.

The common vision of Lancang-Mekong Cooperation is to promote the economic and social development of six countries, enhance the well-being of their people, narrow the development gap among countries, support the construction of the ASEAN Community, and facilitate South-South cooperation in alignment with the United Nations' 2030 Sustainable Development Agenda. However, due to differences in geographical environment, historical and cultural backgrounds, political factors, economic systems, and educational levels, the uneven economic and industrial development among the Lancang-Mekong countries poses a challenge currently.

The Mekong countries are all characterized as outward-oriented economies. There exists an imbalance in the economic development among the Mekong countries, with differences in their economic growth and industrial structures. Thailand and Vietnam, in particular, contribute over 85% to the Gross Domestic Product (GDP) of the Mekong countries. In terms of industrial development, the tertiary sector dominates, playing a predominant role, while the primary sector (agriculture) also holds a significant position. As of the end of 2022, the industrial structure of the Mekong River countries is distributed as 11.8:36.7:51.5 across the three sectors.

The industrial structure, scale, and layout of industrial parks in the Lancang-Mekong region also exhibit differentiated development. Based on preliminary research results, although there is a convergence of industries in the processing and manufacturing, as well as the textile and apparel sectors, the processing encompasses a wide range of types, including electronics, machinery, medical equipment, rubber, and food. However, a well-established spatial division of labor or differentiated development has yet to take shape. In the field of advanced manufacturing, Vietnam and Thailand demonstrate advantages. Some parks are still predominantly engaged in low-end manual manufacturing, while others have initiated automation and intelligent upgrades.

The industrial development and coordination among parks in the region have not fully leveraged their respective strengths. As a result, regional resources are not optimally utilized, hindering economic cooperation, industrial chain layout, and competitiveness to a certain extent. Simultaneously, this diminishes the region's collective capacity to address issues such as climate change and environmental pollution.

4.2 The Power Infrastructure Within Industrial Parks Constrains the High-quality Development of the Industrial Economy

The power supply capacity in industrial parks may face challenges, and there is room for improvement in the reliability of power supply. In recent years, the Lancang-Mekong region has experienced a sharp increase in electricity demand for both industrial and urban residential purposes, posing challenges to power supply. The high temperatures this year have further intensified electricity demand.

However, existing power facilities encounter difficulties in coping with the rapidly growing electricity demand in industrial parks. This is evident in several aspects: the national power supply situation is tense, with lagging development in securing essential and flexible power sources, making it challenging to ensure non-residential or critical load power supply; insufficient transmission capacity in the power grid results in the industrial parks' power supply capacity falling behind the growing demand, leading to issues like power shortages and electricity deficits; aging and inadequately updated power grid facilities within the parks, along with significant transmission line losses, contribute to power outages and equipment failures, impacting the stability of the power supply system; remote areas with insufficient infrastructure development have rudimentary power supply facilities, potentially causing prolonged instability in power supply for industrial parks. These challenges and issues have disrupted industrial production and commercial activities in the parks. The adequacy and reliability of power supply directly influence investors' decisions, thereby affecting national industrial layout and development.

4.3 The Status of Low/Zero-carbon Construction in Industrial Parks is Mismatched with Sustainable Development

The utilization of distributed photovoltaics (PVs) and green energy in industrial parks has room for improvement to better achieve sustainable energy goals. Despite the abundant renewable energy resources such as hydropower, solar, and wind energy in the Lancang-Mekong region, some countries still rely on traditional coal-fired power generation and other non-renewable energy sources, leading to insufficient development and utilization of renewable energy. The transition from traditional to sustainable energy requires substantial investment and financial support. Currently, due to the

lack of relevant policy support and incentive measures in some countries in the region, including incentive policies for distributed PVs, tax incentives, and renewable energy quota systems, they face challenges in initiating and promoting sustainable energy projects, resulting in lower levels of distributed PVs integration in industrial parks. Furthermore, the energy market structure in the region is complex and greatly influenced by the dominant position of traditional energy. The relatively low prices of traditional energy make the competitiveness of distributed renewable source generation relatively weak, making it difficult to win in the energy market. However, given the increasing demand for energy and the pressure to reduce emissions, substantial development of distributed PVs will be a crucial lever for achieving the low/zero-carbon goals of industrial parks.

The insufficient power infrastructure in industrial parks has yet to establish a unified energy management model, leading to inadequate resource optimization and coordination. Currently, the parks mainly rely on grid power supply, and the low/zero development of energy in the parks is synchronized with the entire power system. The advantages of energy optimization and integration in the parks have not been fully played. Energy utilization in the parks is not centralized, resulting in energy losses. Companies within the parks operate independently, without shared energy resources, even if clean energy generation is present, it is mainly for individual enterprise use. The existing clean energy configuration within the parks and external power supply lack effective coordination, with green energy surplus not translating into economic benefits for the park and potential power shortages during insufficient clean energy generation. These factors hinder the competitiveness and development speed of sustainable energy in the Lancang-Mekong region.

The current energy technology in industrial parks is relatively traditional, facing challenges in technological upgrades and environmental aspects. In the Lancang-Mekong region, energy-intensive industries such as steel, cement, and petrochemicals have formed significant industrial clusters, accounting for over 40% of the total energy consumption in the region. These industries play a vital role in providing essential materials to meet the rapidly growing economic, population, and urbanization demands in the Lancang-Mekong region. However, these high-energy-consuming industries commonly use relatively traditional technologies in energy consumption, leading to issues of low efficiency and high carbon emissions. For instance, in industrial steam supply, most industrial parks in the Lancang-Mekong region currently use coal-fired or natural gas boilers, and some even use wood instead of coal for combustion, potentially resulting in higher carbon dioxide emissions. Additionally, the parks lack an integrated industrial steam network, with enterprises independently generating steam, which may lead to inefficiencies and higher costs.

4.4 External Factors are Driving Industrial Upgrading and Energy Transition

The pressure from international carbon border tax policies is driving industrial parks in the Lancang-Mekong region to accelerate their transition to low/zero-carbon energy. As the region primarily focuses on developing an outward-oriented economy, the comprehensive implementation of green trade barriers such as the European Union's Carbon Border Adjustment Mechanism (CBAM), the 100% renewable energy initiative, and carbon footprint certification may lead to significant additional tariffs for relevant manufacturing industries in the area. This could severely undermine the international competitiveness of exported goods. In industrial parks in the

Lancang-Mekong region, a significant proportion of energy demand comes from electricity supplied by the grid. Taking Thailand and Vietnam as examples, in 2022, fossil fuels accounted for approximately 80% and 50%, respectively, of the national electricity generation structure. To meet the continuously growing energy demand and address the pressure from international carbon border tax policies, there is an urgent need to seek the development of stable, reliable, and low-carbon green energy. This is crucial for reducing the carbon content in the production and manufacturing processes.

4.5 The Support and Guarantee System Still Need Further Improvement

There is insufficient awareness of low/zero-carbon development in industrial parks. Economic growth and employment opportunities are the primary concerns in the Lancang-Mekong region, and there is a lack of understanding of the environmental and sustainable development benefits brought about by clean energy. Due to limited channels for disseminating information and shortage of information disclosure about clean energy, the public in the region lacks profound understanding of concepts related to clean energy. The development of clean energy requires widespread societal participation, involving not only governments, businesses, and academic institutions but also the support and cooperation of the public. Insufficient societal engagement may result in a lack of rationality and feasibility in clean energy policies. Therefore, enhancing public awareness of clean energy in the region can contribute to its wider recognition and acceptance.

The insufficient capacity building and talent reserves hinder the low/zero-carbon development of industrial parks. Talent is the primary resource, and

the clustering characteristic of industrial parks is not only the gathering of enterprises but also the aggregation of talents. Industrial parks lack talent for low/zero-carbon development, and efforts to train and attract relevant talents are insufficient, creating a situation where there is a desire to implement initiatives but a lack of capability. Inadequate collaboration with educational institutions, research organizations for collaborative research and talent recruitment exacerbates the contradiction between the lack of talent and the willingness of enterprises to transform and upgrade. Simultaneously, the transformation of parks in the diverse development context of the region requires tailored approaches based on development foundations and stages, nurturing talents capable of leading the low/zero-carbon development of industrial parks and promoting the formulation of targeted, guiding, and practical low-carbon construction plans.

The institutional system supporting the low/zero-carbon development of industrial parks is not yet sound. Currently, the Lancang-Mekong region lacks synchronized planning for industrial park development and low/zero-carbon development in terms of relevant systems, plans, and policies. Green and low-carbon development in industrial parks involve numerous stakeholders, leading to significant coordination challenges, weak operability, and difficulties in implementation. Energy management, environmental statistics, and monitoring work are rarely existent, making it challenging to establish effective oversight of pollution emissions from various production and operating entities within the industrial parks. The management units of industrial parks may lack experience in developing the circular economy, and there is a lack of guidance and coordination for enterprises' low/zero-carbon development.

Chapter 5

Low/Zero Energy Strategic Direction and Suggestions for Industrial Park

5.1 Accelerate the Development and Utilization of Renewable Energy, Promote the Orderly Reduction of Fossil Energy

Develop distributed PVs in line with land planning, warehouse roof and other basic conditions. Fully integrate reservoirs and fishponds in the park and promote the development of "PV plus" models such as hydro-solar-integrated power plants and fishery-solar power plants. Conditional parks can develop and build decentralized wind power. Reasonable allocation of electrochemical energy storage and physical energy storage, explore the new mode of Power-to-X. On the premise of ensuring the security of energy supply in the parks, the orderly decline schedule of fossil energy in the park is formulated.

5.2 Exploit the Energy Saving Potential of the Productive Process, Promote the Substitution of Clean Energy in Final Energy Consumption

For key industries such as steel, petrochemical, nonferrous metals and building materials in the parks, priority should be given to equipment technologies with characteristics such as energy efficiency diagnosis, waste heat recovery and recycling, and improved production efficiency. In the heating, drying, steam supply and other industrial processes, promote electric furnace steel, electric boiler, electric kiln, electric heating, high temperature heat pump, high power electric energy storage boiler and other alternative process technology and equipment. We should actively promote

electric vehicles to replace fuel vehicles and develop hydrogen energy replacement for heavy-duty trucks in due course. Combined with the needs of electric vehicles and the layout of the road network, plan and construct centrally managed charging piles or solar-storage-integrated charging/swapping stations.

5.3 Promote the Application of low/zero-carbon Energy Technology, Create a Benchmark for Construction

Carry out technological innovation and demonstration applications around the green development, low-carbon utilization, pollution reduction and carbon reduction of fossil energy. Research and application of renewable energy generation technologies such as geothermal energy and biomass energy should be conducted. In combination with the upgrading of stock and incremental market of the park, the network construction of low/zero-carbon energy systems such as DC distribution/micro-grid, multi-energy complementary energy system, and large-scale hydrogen transmission of natural gas pipeline network will be integrally carried out. Promote forward-looking research on carbon negative emission technologies such as carbon dioxide capture and application, efficient conversion of carbon dioxide into fuel chemicals, and biochar soil improvement.

5.4 Strengthen the Construction of Energy Platform and Model Mechanism Innovation, Improve the Level of Synergic Optimization

According to the technology maturity and development level of the parks, promote the application of intelligent energy monitoring and control platform for integrated management of production, management and dispatch, and promote energy conservation and efficiency of the park with energy auditing and energy optimization dispatch mechanisms. Larger scale

parks can explore the development of load integrators, virtual power plants, vehicle network interaction, distributed power trade (e.g. electricity that cannot be consumed in the parks can be sold to the grid or other end-customers) and other low/zero-carbon energy new business models, explore new business models such as energy management services and energy sharing, and find more friendly business parks for enterprises. Research and develop the green certificate mechanism in line with international and regional development, attach "green label" to the park industry, and enhance the global competitiveness of the industry; At the same time, promote the development of the parks to zero carbon.

5.5 Deepen the Energy Cooperation, Promote the Integration of Low/Zero-carbon Industrial Consumption and Production

Relevant parties in the Lancang-Mekong region, such as government management departments, park managers and operators, settled energy and power-related enterprises, could strengthen discussions and exchanges on low/zero-carbon in industrial parks, encourage industrial parks to collaborate with universities, research and design institutions, energy and power construction units to effectively propose solutions for the low/zero-carbon development of industrial parks and implement them. Strengthen the construction and improvement of low/zero-carbon capacity in the parks of various countries in the region, share practical cases and experience, improve the comprehensive practical capacity of understanding, technology, plan and management of low/zero-carbon energy system construction in the parks. Constantly improve the level of clean energy use and clean output of the parks from learning to program research, technology application to overall deployment, to give new momentum to the sustainable development of the industry.

5.6 Give Full Play to the Leading Role of Economic Development and Low-carbon Transition of Parks, Promote Local Social Development and Industrial Transition

The governments of Lancang-Mekong countries could continue to provide policy support and guidance for industrial parks, help parks to attract foreign investment, drive industrial development and industrial transformation, promote economic development and also achieve the transformation from labor-intensive industries to technology-intensive industries, provide high value-added jobs for local residents. Through low-carbon energy allocation in the park, it provides a model and basis for urban energy transformation and drives the construction of urban power infrastructure.