Research on Current Development Status of Industrial Parks and Low Carbon Paths in Lancang-Mekong Countries

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Abstract. Under the background of global carbon neutrality, the imperative for the green development of industrial parks, vital hubs for national economic progress, cannot be overstated. This paper initially delves into the current state of industrial park development in the Lancang-Mekong countries (Laos, Myanmar, Thailand, Cambodia, Vietnam). Through an analysis of the layout, types, and developmental potential of these industrial parks, it unveils substantial opportunities for carbon emission reduction within these zones. Subsequently, aligning with the macro-level carbon neutrality objectives of the Lancang-Mekong countries, an assessment of carbon emissions from various industries and enterprises within these parks is conducted, proposing a low-carbon pathway for industrial parks. Lastly, focusing on a representative industrial park in Laos, calculations based on the aforementioned low-carbon pathway demonstrate the feasibility of achieving a reduction of over 70% in carbon emissions from industrial parks in the long term.

Keywords: Lancang-Mekong countries, Industry parks, Low carbon paths.

1 Introduction

According to the United Nations' "2022 State of the Global Climate," global greenhouse gas emissions continued to increase, highlighting an urgent need for energy transition. In recent years, the Lancang-Mekong countries have seen rapid economic growth, leading to a continual rise in energy demand across these nations. As industrial parks play a crucial role as spatial entities in economic development, their contribution to energy consumption and carbon emission levels cannot be overlooked.

Zhang's research focused on comparing the performance and measures of the United States, the United Kingdom, Japan, Germany, and France—five major world economies—in addressing climate change policies, energy structures, and carbon emissions [1]. Ding's study centered on the low-carbon transformations of Gulf countries such as the UAE, Saudi Arabia, Bahrain, and Oman [2]. Sheinbaum's findings from researching Argentina, Colombia, and Brazil revealed that increasing the share of clean energy

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sources like hydro and wind power can reduce energy consumption intensity in manufacturing, fostering low-carbon development in this sector [3]. Shi categorized enterprises into resource-based, industrial manufacturing, public service, and commercial consumption types, conducting simulation experiments to outline low-carbon pathways for these four types of businesses [4]. Wang conducted a comparative analysis of the low-carbon technology levels in six high-energy-consuming industries: electricity, steel, cement, aluminum smelting, petrochemicals, and coal chemicals. The results indicated that the low-carbon transformation in electricity and energy has become inevitable [5].

Through literature analysis, it was found that there is limited research on low-carbon pathways concerning the Lancang-Mekong countries. Additionally, existing studies primarily operate at a macro-level, lacking in-depth exploration of the micro-level aspects regarding low-carbon pathways within industrial parks. Hence, this paper aims to bridge the macro and micro perspectives, aligning with the macro-level carbon neutrality targets and presents tailored low-carbon pathways specific to these industrial zones.

2 Development Status of Industrial Parks

Industrial parks serve as crucial spatial entities for the economic development of nations, bearing significant responsibility in facilitating industrial low-carbon transformations and upgrades. In recent years, the Lancang-Mekong countries have vigorously developed industrial parks, and these industrial clusters have gradually formed, effectively driving socioeconomic development.

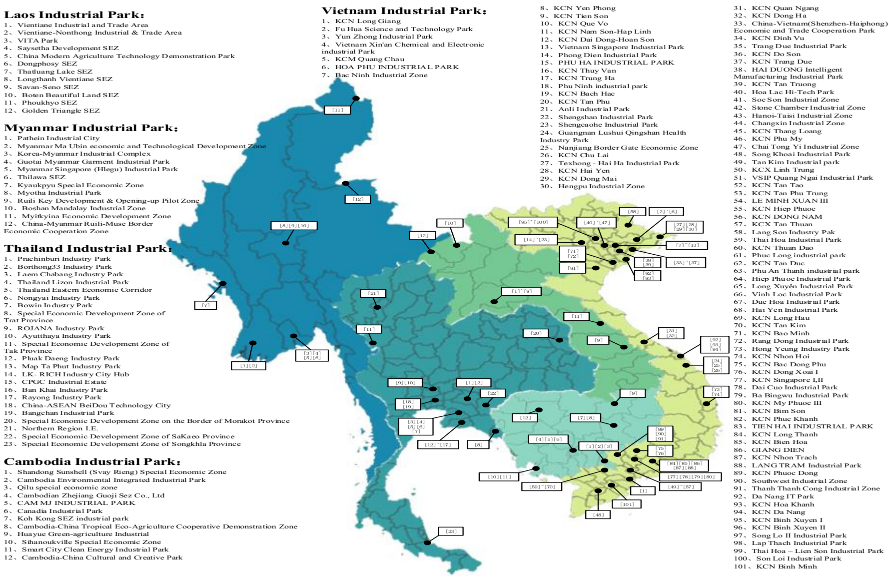

Fig. 1. Distribution Map of Industrial Parks in Lancang-Mekong Countries.

Industrial parks in the Lancang-Mekong region are strategically located in major cities and their outskirts, resource-rich areas, and border regions to facilitate activities related to service-oriented industries, resource extraction, cross-border trade, and logistics. As shown in Figure 1, industrial parks in Laos are primarily concentrated in Vientiane, along with provinces bordering neighboring countries. In Myanmar, industrial parks are mainly clustered in Yangon and surrounding provinces, as well as areas bordering China. Thailand's industrial parks are concentrated in Bangkok and its vicinity, the central coastal regions, areas bordering neighboring countries, and Songkhla Province in the south. Cambodia's industrial parks are mainly distributed in the capital city Phnom Penh and surrounding provinces, as well as coastal areas. In Vietnam, industrial parks are primarily located in the Red River Delta and the Mekong River Delta regions, centred around Hanoi and Ho Chi Minh City.

There are certain differences in the industrial structure and development levels among these countries' parks. As shown in Table 1, the types of industries mainly include Agriculture, Forestry, Fisheries, & Animal Husbandry, Clothing & Textiles, Processing & Manufacturing, Advanced Manufacturing, Energy Industries, Tourism & Cultural Creativity, and Warehousing & Logistics. Among these, industrial parks covering Processing & Manufacturing are the most prevalent, followed by Advanced Manufacturing and Clothing & Textile industries.

Table 1. Main industries in the industrial parks of the Mekong-Lancang countries.

Types of Industries	Countries					total
	Laos	Myanmar	Thailand	Cambodian	Vietnam	
Agriculture, Forestry, Fisheries & Animal Husbandry	4	1	5	2	3	15
Clothing & Textiles	4	8	2	6	40	60
Processing & Manufacturing	8	10	22	10	82	132
Advanced Manufacturing	0	0	4	0	63	67
Energy Industry	3	1	8	3	9	24
Tourism & Cultural Creatives	10	4	2	3	4	23
Warehousing & Logistics	6	7	12	4	8	37

3 Low-Carbon Pathways of Industrial Parks

3.1 Macro-level Carbon Neutrality Objectives of Countries

In active response to the Paris Agreement, the Mekong-Lancang countries have each proposed greenhouse gas reduction and net-zero emission targets tailored to their national contexts. As shown in Figure 2, Laos aims to achieve a 60% reduction in greenhouse gas emissions by 2030 and net-zero emissions by 2050.Myanmar pledges to reduce carbon dioxide emissions by 244 million tons by 2030 and attain net-zero emissions by 2050.Thailand targets a 25% reduction in greenhouse gas emissions by 2030 and aims for net-zero emissions by 2065.Cambodia aims to achieve a 42% reduction in greenhouse gas emissions by 2030 and carbon neutrality by 2050.Vietnam commits to a 9% reduction in greenhouse gas emissions by 2030 and aims for net-zero emissions by 2050.

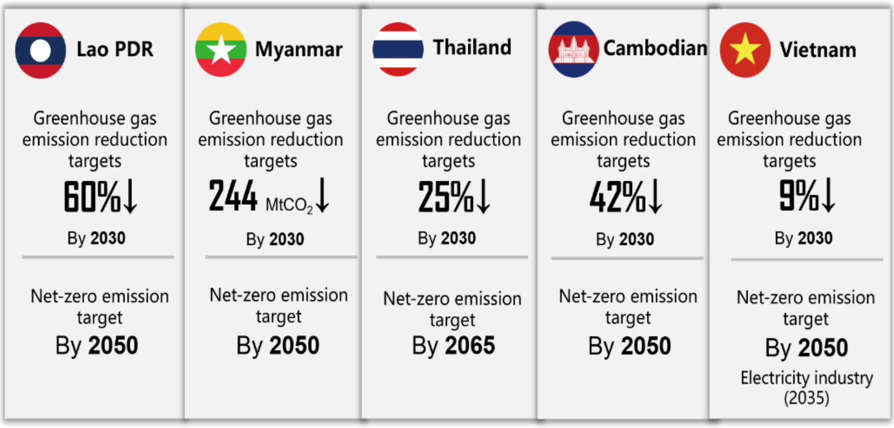

Fig. 2. Carbon Neutrality Targets for Lancang-Mekong Countries

3.2 Micro-level Low-Carbon Pathways of Industrial Parks

Industrial parks require significant energy consumption, directly impacting a nation's carbon emission levels. These parks should actively engage in and respond to macro-level carbon neutrality objectives. By considering their industrial characteristics and resource foundations, industrial parks should establish corresponding low-carbon pathways.

According to the National Determined Contributions (NDCs) of various countries and related documents, the proposed low-carbon development path for industrial parks is as follows:

(1) Near-term (2023-2030): Vigorously develop distributed photovoltaics in industrial parks to provide clean power supply; promote large-scale application of high-efficiency boilers and refrigeration technologies; implement waste heat recovery techniques to reduce the energy intensity of industries like steel and cement.

(2) Mid-term (2030-2040): Promote clean and low-carbon energy on the supply side, systematically reduce coal consumption in industrial parks; develop biomass power generation technologies to achieve fossil fuel substitution.

(3) Long-term (2040-Net Zero Target Year): Increase natural carbon sinks within industrial parks, promote biomass carbon capture and storage technologies; capable industrial parks can actively promote Power-to-X technology and develop seawater desalination techniques.

4 Typical industrial park examples

Based on the aforementioned low-carbon pathway, the Vientiane Seetha Development Zone [6] in Laos has been chosen as a typical case study for calculation. The development zone was established in 2010 as a nationally designated collaborative project between the governments of China and Laos. As shown in Figure 3, the development zone primarily focuses on industrial manufacturing and production. Presently, it spans an area of 4 km^2 in development, with a planned expansion area of 11.5 km^2.

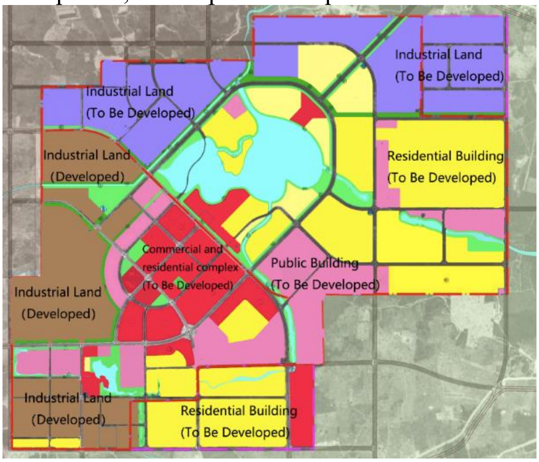

Fig. 3. Master Plan Illustration of Saysettha Comprehensive Development Zone.

An assessment will be conducted to analyze the zone's energy demand and potential for carbon emission reduction, to propose suitable pathways and measures for constructing a low-carbon energy system within the zone. The primary assumed conditions for this calculation are as follows:

(1) The energy consumption of the industrial park is uniformly converted into equivalent electrical energy. Steam energy consumption is converted at a rate of 0.72 MWh/t.

(2) Distributed photovoltaic configurations are calculated based on 60% of factory building area and 40% residential building area. The photovoltaic capacity is estimated at 180W/m^2, and the photovoltaic generation hours are calculated between 1700 to 2000 hours.

(3) Biomass cogeneration power plants consider an installed capacity of 30MW, an annual power generation of 234GWh, an average thermal load of 20t/h, and an annual steam production of 160,000 tons.

(4) The carbon sequestration capacity of green areas within the industrial park is calculated at 0.225kg/m^2 for forested areas and 0.09kg/m^2 for lakes.

4.1 Current Status and Trends of Energy Supply and Demand

According to the development plan of the development zone, as shown in Figure 4, the projected mid-term energy consumption demand is 1327 GWh, increasing to 2343

GWh in the long term. Industrial energy consumption is expected to stabilize, while the proportion of energy consumption for commercial and residential purposes will rise from the current 27% to an estimated 34-55%.

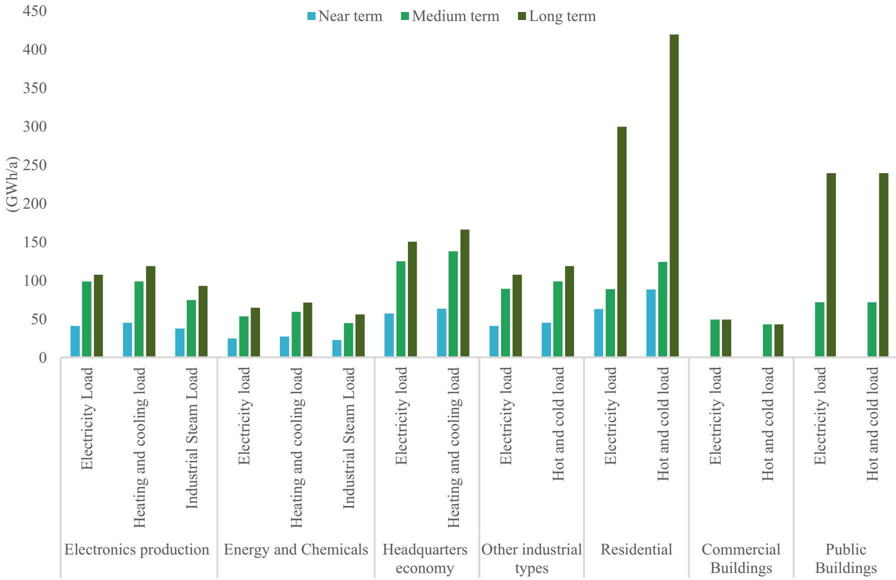

Fig. 4. Load profile of Saysettha Development Zone by phase

4.2 Low-Carbon Energy Plan and Carbon Emission Reduction Capacity

Combining the aforementioned low-carbon pathways, as shown in Table 2, the comprehensive promotion of clean energy production is spearheaded by new energy sources. Simultaneously, relying on natural carbon sinks and physical carbon removal methods to enhance carbon sequestration capabilities, and ultimately achieve the carbon neutrality goal for the park.

Table 2. Low-Carbon Configuration Plan for Saysettha Development Zone

Category	Configuration scale
Rooftop Photovoltaic	175 MW of rooftop PV with an annual capacity of 300 GWh.
Photovoltaic integrated Energy Storage	Configured capacity of 8.75 MW, with additional PV power consumption of 6.4 GWh per year.
Biomass Cogeneration Unit	Configuration capacity 40MW, annual power generation 312 GWh, and generate 213,000 tons of steam, fully meeting the long-term industrial steam load demand.
Air-Source Heat Pump Unit	Medium-term savings of 333 GWh, providing 133 GWh of cooling capacity; Long-term power saving of 592 GWh, providing cooling capacity of 237 GWh.
Lake and Green Space Carbon Sink	The green area covers approximately 2.54 km^2, while the lake area is about 0.74 square km^2, Providing carbon sinks of about 639 tons of equivalent carbon dioxide per year.
CCUS	Configuration of sequestration capacity of 72,100 tons DAC project.

As shown in Table 3, after the implementation of the plan, considering photovoltaics, energy storage, biomass combined heat and power, air-source heat pumps for energy supply, and the carbon sink effect of green areas, the park can achieve an annual reduction of approximately 163,500 tons of carbon dioxide emissions. In the long term, the park can achieve local carbon neutrality or even negative carbon emissions.

Table 3. Carbon Emission in different stages of Saysettha Development Zone

Type	Medium-term		Long-term	
	Baseline scheme	Emission reduction scheme	Baseline scheme	Emission reduction scheme
Electricity load(10,000 tons/year)	8.88	3.82	10.63	5.88
Cooling & heating load(10,000 tons/year)	5.18	0	6.47	0
Industrial steam load(10,000 tons/year)	5.64	1.63	6.46	1.39
Green carbon sink(10,000 tons/year)	0	-0.03	0	-0.06
CCUS(10,000tons/year)	0	0	0	-7.21
Total (10,000 tons/year)	19.7	5.42	23.56	0

5 Conclusions

By overseeing the macro carbon neutrality goals of the Lancang-Mekong countries and tailoring appropriate low-carbon pathways based on the actualities of industrial parks, phased development of distributed photovoltaic technology, biomass power generation technology, biomass carbon capture and storage technology, among others, can effectively assist the park in achieving a low to zero carbon transformation.

The industrial parks in the Lancang-Mekong countries hold significant potential and flexibility. In the future, industrial parks in these countries can develop unique industries tailored to each nation's resources and location. Besides developing their key industries, these parks can enhance trade and economic ties with China, ASEAN, and others, leveraging resource complementarity to create a stable and efficient regional supply and value chain. Moreover, these industrial parks should expedite the development of infrastructure such as roads, energy supply, and hydropower facilities to ensure stable and reliable infrastructure. To foster sustainable development and industrial resilience, enhancing the green attributes and value of industries is essential.

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