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China's Low-Carbon Competitiveness and National Technical and Economic Zones

Development of Eco-Efficient Industrial Parks in China: A review

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March 2015

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China's Low-Carbon Competitiveness and National-Level Economic and Technological Development Zones
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Written by Hubert Thieriot and Dave Sawyer

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Acronyms and Abbreviations

CEPZ	Circular Economy Pilot Zone
CO_2	carbon dioxide
COD	Chemical Oxygen Demand
CTIP	Circular Transformation of Industrial Parks
EIP	eco-industrial park
ETDZ	Economic and Technological Development Zone
FYP	Five-Year Plan
GHG	greenhouse gas
IAV	Industrial Added Value
ISC	Institute for Sustainable Communities
MEP	Ministry of Environmental Protection
MIIT	Ministry of Industry and Information Technology
MoF	Ministry of Finance
MofCOM	Ministry of Commerce
NDRC	National Development and Reform Commission
SO_2	sulphur dioxide
TEDA	Tianjin Economic Development Area
USEPA	United States Environmental Protection Agency

1.0 Introduction

China is designing and implementing a wide range of energy and greenhouse gas (GHG) policy measures that include a mix of incentives, regulations and information programs. The proliferation of policy measures has increased significantly in the 12th Five-Year Plan (FYP) period; the Top-10,000 Energy-Consuming Enterprises Program and the seven carbon emission trading pilots are notable examples of policy action. While these flagship programs are important, and are likely affecting a wide range of industry behaviours, they do not represent the full breadth of policy measures being implemented nationally and cascading down locally to China's almost 1,600 industrial zones.

This paper looks at the important emerging trend of eco-efficient industrial parks and low-carbon certification. Currently, there are three national programs underway that cover about 15 per cent of all industrial zones in China. Typically, these certification programs are voluntary, but given the number of participating zones, clearly industry sees significant advantages to participation. Motivations vary for why firms participate and allocate scarce managerial and financial resources for compliance with the certification scheme; they can include demonstrating leadership in alignment with government priorities, accessing capital to help with energy and emission projects, and demonstrating to the market a commitment to improved environmental performance.

Also important are the capacity-building opportunities these certification schemes bring. As industrial zones and enterprises transition from a growth-oriented agenda to one of more balanced environmental performance, there are real gaps in expertise and capacity. By participating in the emerging certification schemes, firms are systematically looking at their operations and better understanding opportunities to manage energy and emissions while seeking to improve economic performance through efficiency gains.

In this briefing note, we shed light on the concerted Chinese effort to develop low-carbon-certified industrial zones. Section 2 gives the industry context for the paper, and Section 3 introduces the three leading Chinese certification programs, their respective governance structures, the associated procedures and their associated indicator systems. Section 4 further analyzes the commonalities among these schemes, their potential impacts for low-carbon transition, and the zones' motivations and impediments to participating in these initiatives.

2.0 Context

In China, the industrial sector is responsible for around 70 per cent of the country's energy consumption and 72 per cent of its carbon emissions (Lu & Price, 2012; National Bureau of Statistics, 2013). The industrial sector is therefore of central importance if China is to achieve its carbon emission intensity targets as identified in a 2009 State Council declaration (a 40–45 per cent reduction in carbon intensity by 2020 based on 2005 levels) and, more recently, in the 12th FYP (a 17 per cent reduction between 2011 and 2015). However, carbon emissions are not the only constraints that Chinese industry is facing. Indeed, the growing scarcity of natural resources necessitates increased resource efficiency, including improving its reuse and recycling rates. These improvements belong to the development of a so-called *circular economy*, which has been strongly promoted within the 12th FYP.

To address these related concerns (carbon emissions, natural resource scarcity and pollution), Chinese authorities set up three pilot programs for industrial parks: the Eco-Industrial Park Demonstration Program led by the Ministry of Environmental Protection (MEP); the Circular Transformation of Industrial Parks led by the National Development and Reform Committee (NDRC) and the Ministry of Finance (MoF); and the Low-Carbon Industrial Park Program led by the Ministry of Industry and Information Technology (MIIT). While not identical, these programs share the overall ambition both to reduce the environmental impact of Chinese industry and to increase its competitiveness. The zones promoted in these programs fall into the generic category of eco-industrial parks (EIPs). The United States Environmental Protection Agency (USEPA) defines an EIP as: *a community of manufacturing and service businesses seeking enhanced environmental and economic performance by collaborating in the management of environmental and reuse issues. By working together, the community of businesses seeks a collective benefit that is greater than the sum of the individual benefits each company would realize if it optimized its individual performance only* (Martin et al., 1996). This collaboration is often referred to as industrial symbiosis, in which there is a physical exchange of materials and by-products, as well as shared management of infrastructure for water, energy and waste.

The development of EIPs is not a new phenomenon. The industrial park of Kalundborg in Sweden is often mentioned as the earliest development of an EIP, commencing operations in the early 1970s. In Europe, the development of EIPs has often been initiated by industry themselves. Industrial associations or dedicated organizations such as the National Industrial Symbiosis Programme[1] in the United Kingdom have been active for several years. In other countries, such as the United States, Australia and Japan, the movement towards EIPs has notably been supported by local governments and state agencies such as the USEPA. Compared to international experience, the Chinese programs described in this paper present some unique features not seen elsewhere globally, such as a strong top-down approach, the adoption of unified standards and procedures, and an unprecedented scale.

[1] http://www.nispnetwork.com/

3.0 Chinese Programs and Certifications

There are three main programs focused on developing low-carbon industrial zones and EIPs in China:

1. The EIP Demonstration Program
2. The Circular Transformation of Industrial Parks
3. The Low-Carbon Industrial Park Program

These programs are all are designed to motivate and help industrial parks to improve their environmental and economic performance. While zones are not required to engage in these programs, the official certification granted by these programs, as well as some financial subsidies, motivate industrial parks to participate. The sections below explore each program's governance structure, certification procedures and associated requirements.

3.1 EIP Demonstration Program

3.1.1 Description and Governance

The EIP Demonstration Program was initiated at the end of the 1990s by the MEP and has been accelerated in recent years (see Figure 1). The aim of an EIP is to minimize waste generation and improve the overall eco-efficiency of the park by applying principles such as those of industrial symbiosis, clean production, green supply chain management and centralized pollution abatement. While legislation does not exclude the possibility of building a whole new EIP, the policies are now focusing on the improvement and certification of existing industrial parks (Shi, Tian, & Chen, 2012b).

There are three categories of national demonstration EIPs in China: the sector-specific EIP (with a predominant sector), the sector-integrated EIP (with mixed industries) and the venous industry EIP (focused on recovery of solid industrial waste). As of today, most of the zones belong to the second category. Industrial zones are not legally bound to apply for the EIP designation and need not respect EIP standards. Instead, this is a voluntary program. National authorities do not grant certified industrial zones with specific subsidies or preferential tax treatment.

While this program was initiated by the MEP, two other ministries are now involved: the Ministry of Science and Technology (MoST), responsible for High-Tech Industrial Development Zones, and the Ministry of Commerce (MofCOM), which leads the Economic and Technological Development Zones. A leading group composed of members of these three ministries has now been established to efficiently manage the EIP Demonstration Program.

Construction of 50 National Demonstration EIPs was planned in the 12th FYP period (2011–2015). At present, 94 zones have seen their development plans approved, making them *National Trial EIPs*. As indicated in Figure 1, the pace of certification has sharply increased since 2010, corresponding to, albeit slightly preceding, the 12th FYP emphasis on the transition toward a circular economy. Among the conditionally approved zones, 31 have achieved sufficient milestones to be fully accredited as *National Demonstration EIPs* (MEP, 2014a, 2014b, 2014c).

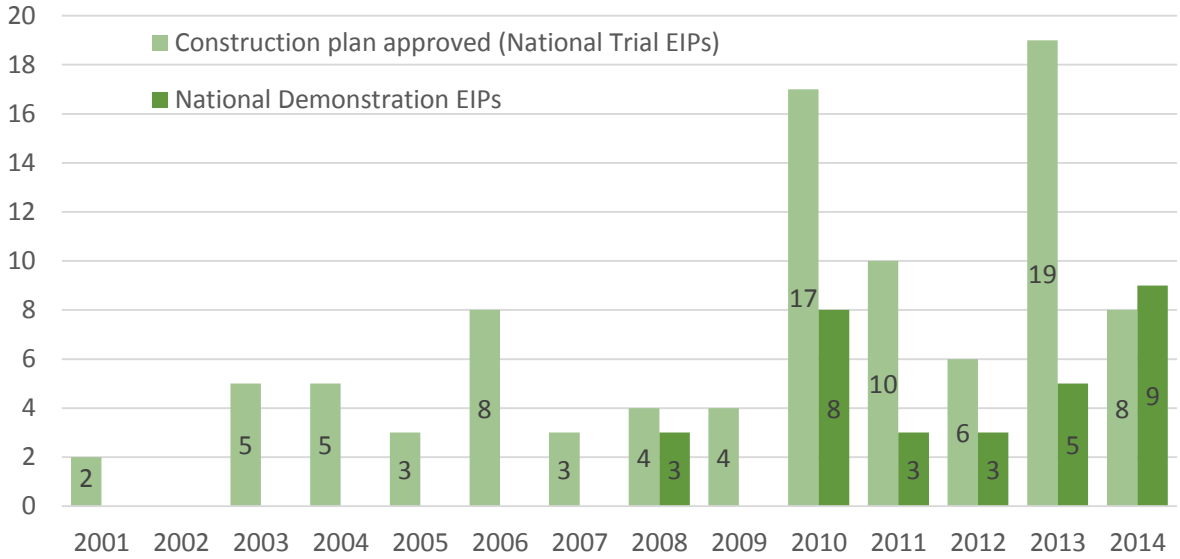

FIGURE 1: ANNUAL APPROVALS FOR INDUSTRIAL ZONES AS OF APRIL 2014 (MEP, 2007, 2014A)

3.1.2 Procedures

For zones to apply for an EIP approval and be considered as a National Trial EIP, three main steps must be satisfied (MEP, MofCOM, & MoST, 2007; Zhang, Yuan, Bi, Zhang, & Liu, 2010):

1. The industrial park first submits an application to the leading group; the leading group then verifies that the performance conditions are met (see Section 3.1.3).
2. The industrial park drafts an EIP construction plan and a technical report for EIP construction planning. The former document describes the local favourable conditions (social, economic and environmental), the overall objectives and specific targets, the development plan of eco-industries, the plan for controlling pollutants, the key projects and their cost-benefit analysis, and a supporting plan. This plan includes management and governance, supporting policies and environmental management tools. The technical report provides more specific details on the plan and associated projects.
3. The leading group appoints experts to verify and provide comments concerning the submitted documents before approving or rejecting the application.

Once the zone's implementation plan has been certified, the leading authorities organize performance evaluations every three years. Depending on its progress, performance and ability to fulfill requirements, the zone will be graded as *excellent, good, qualified, satisfactory or unsatisfactory*. In the last case, the zone loses its approval. Once the planned implementation has sufficiently progressed and performance metrics are achieved, the zone may be granted the title of National Demonstration EIP. For the current National Demonstration EIPs, it took an average of three to four years to be certified after their development plan was approved. However, 15 zones whose development plans were approved more than six years ago have not yet been certified.

3.1.3 Indicators and Requirements

There are three standards corresponding to the three types of EIPs:

1. The *sector-specific EIP* (HJ/T273-2006)
2. The *sector-integrated EIP* (HJ274-2009)
3. The *venous-industry EIP* (HJ/T275-2006)

These standards are key documents to guide EIPs in their certification process, comprising 24 indicators across four categories, including: economic development, resource conservation and recycling, pollution control, and environmental management. Along with these standards, authorities provide detailed methodologies, including guidelines for collecting data and computing indicators. Many indicators are similar among these standards, particularly between sector-integrated and sector-specific ones. Of note, while threshold values are explicitly defined in the standard for sector-integrated zones, the sector-specific standards are less specific, referencing instead international advanced performance levels. Table 1 lists the indicators of the sector-integrated EIP standard as well as the required performances. In 2012 the MEP amended this last standard and, notably, removed the criteria imposing an annual growth of Industrial Added Value (IAV) above 15 per cent (MEP, 2012).

There are additional requirements for industrial zones to receive certification: zones should reach a higher GDP growth level than the average provincial and municipal zones; they should set up an environment management system according to the ISO 14001 norm; and they should establish a local environmental agency. Apart from these stipulations, all national and local environmental regulations must be enforced effectively within the park, and no pollution accidents should have occurred within the last three years.

TABLE 1: METRICS IN THE STANDARD FOR SECTOR-INTEGRATED ECO-INDUSTRIAL PARKS (HJ 274-2009) AS AMENDED IN 2012

CATEGORY	METRICS		UNIT	VALUE
Economic development	1.1	IAV per capita	104 RMB/P	≥ 15
Material reduction and recycling	2.1	IAV per industrial land occupancy	100 million/km^2	≥ 9
	2.2	Energy consumption per IAV	tce/104 RMB	≤ 0.5
	2.3	Coefficient of elasticity on energy consumption	--	< 0.6
	2.4	Fresh water consumption per IAV	m^3/10^4 RMB	≤ 9
	2.5	Coefficient of elasticity on fresh water consumption	--	< 0.55
	2.6	Industrial wastewater generation per IAV	ton/10^4 RMB	≤ 8
	2.7	Solid waste generation per IAV	ton/10^4 RMB	≤ 0.1
	2.8	Industrial water reuse ratio	%	≥ 75
	2.9	Solid waste reuse ratio	%	≥ 85
Pollution control	3.1	Chemical Oxygen Demand (COD) emission per IAV	kg/10^4 yuan	≤ 1
	3.2	Coefficient of elasticity on COD emission	--	< 0.3
	3.3	Sulphur dioxide (SO_2) emission per IAV	kg/10^4 yuan	≤ 1
	3.4	Coefficient of elasticity on SO_2 emission	--	< 0.2
	3.5	Disposal rate of hazard solid waste	%	100
	3.6	Centrally provided treatment rate of domestic wastewater	%	≥ 85
	3.7	Safe treatment rate of domestic rubbish	%	100
	3.8	Waste collection and disposal system	--	available
Administration and management	4.0	Extent of establishment of information platform	--	established
	4.1	Extent of establishment of eco-industrial information platform	%	100
	4.2	Environmental report release per year	issue/year	1
	4.3	Implementation of cleaner production audit in heavy pollution enterprises	%	100
	4.4	Extent of public satisfaction with local environmental quality	%	≥ 90
	4.5	Extent of public awareness degree with eco-industrial development	%	≥ 90

3.2 Circular Transformation of Industrial Parks

3.2.1 Description and Governance

The national demonstration program for Circular Economy Pilot Zones (CEPZ) was initiated in 2001 by the MEP alongside the EIP demonstration program. In 2005 the NDRC assumed management of the CEPZ program and reinforced cooperation with the following agencies: the MEP, the Ministry of Science and Technology, the Ministry of Industry and Information Technology, the MoF, the MofCOM and the National Bureau of Statistics. This program is run

at three different levels: firm, industrial park and regional. This section focuses on the industrial park level only, where the ultimate goal is to develop participating zones through a more circular economy pattern. In 2008 the financial crisis is thought to have played a role in the temporary slowdown of this program (see Figure 2). In 2012, as the 12th FYP began, the NDRC and the MoF initiated a new demonstration program named the Circular Transformation of Industrial Parks (CTIP) (NDRC & MoF, 2012). While the name differs from the CEPZ, it is considered its successor. Indeed, the procedures and indicators are almost identical. However, only the NDRC and the MoF now serve as leading agencies.

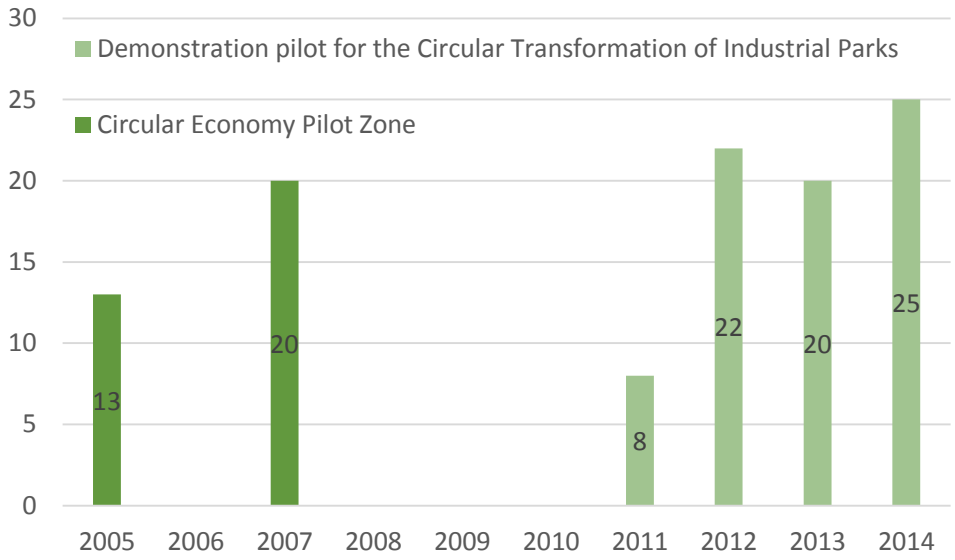

FIGURE 2: TWO BATCHES OF ACCREDITED ZONES (NDRC, 2005, 2007)

Figure 2 represents the number of zones accredited since the program was initiated. The years 2005 and 2007 correspond to the CEPZ program, while the later ones represent the CTIP program. Six zones were certified in both programs, in Dalian, Tianjin, Fujian, Wuhan, Yichang and Guangzhou.

The NDRC recently commenced an evaluation of the first two pilot batches from 2005 and 2007 (NDRC, 2013). Zones are required to perform their own evaluation first and to submit their report to the relevant authorities (either the provincial government or national authorities). Further investigation is then carried out by NDRC officials. Apart from verifying that zones have respected their commitments, this process will be used to learn from experiences and to identify the different development patterns and challenges faced by industrial zones.

Unlike the EIP program, the CTIP program is a direct source of national financing for the parks. Within their development plans, industrial zones define a list of priority projects and associated investments. The NDRC and the MoF then decide which projects will be subsidized as well as an individual subsidy amount. In 2012 alone, a total of RMB745 million was provided to the 22 industrial zones as a first financing tranche. Based on a sample of the industrial zones, we estimate that the average subsidy per zone is RMB182 million, which is significant: it corresponds to approximately 8.5 per cent of the project's investment (see Table A1 in the Appendix).

3.2.2 Procedures

The latest notice issued by the NDRC and the MoF defines the following procedures (NDRC & MoF, 2014):

1. *Submission of a work plan.* Industrial zones submit a work plan according to dedicated guidelines (NDRC, 2012). This work plan includes intended measures, projects, planned investments and quantitative targets to be achieved.
2. *First review by local authorities and experts.* Provincial departments with circular economy and finance accountabilities jointly organize a group of experts to review the work plan. The results of the review are then attached to the work plan, which is then submitted to national authorities.
3. *National evaluation and approval.* The NDRC and the MoF organize an evaluation by experts. Based on evaluation comments, they modify, approve or reject the work plan.
4. *Agreement signature.* If the work plan is approved, an agreement is signed between the national and regional authorities, indicating targets, tasks, important projects, measures and incentive policies. The zone is then designated a Circular Transition Pilot Industrial Zone.
5. *Appropriate national funding.* After reviewing the planned investments by the zone, the NDRC and the MoF will decide a subsidy amount, transferring the first half of the approved subsidy; the remaining sum is disbursed based on performance (discussed below).
6. *Implementation of the transformation plan.* Zones are responsible for implementing the work plan and sending annual progress reports to the NDRC and the MoF. Local authorities monitor, supervise and assist in the implementation of the work plan with the apportioning of the dedicated fund.
7. *Review and evaluation.* During the implementation period, examinations are carried out by local and national authorities to verify that zones are meeting work plan milestones. Once zones satisfy at least 90 per cent of the anticipated targets, they are allocated the remaining half of the subsidy. If no substantial progress has been made in the first three years, zones are responsible for refunding any part of the subsidies they have already received.

3.2.3 Indicators and Requirements

Table 2 lists the most recent version of the indicators. The index system in the second phase has remained nearly identical since the CEPZ demonstration program.

TABLE 2: INDICATORS FOR THE CEPZ/CTIP PROGRAM AT THE INDUSTRIAL PARK LEVEL

DIMENSIONS	NO.	INDICATORS	UNIT
Resource output indicators	1.1	Output rate of main mineral resources	
	1.2	Output rate of land	RMB/km^2
	1.3	Output rate of energy	RMB/tce
	1.4	Output rate of water	RMB/m3
Resource consumption indicators	2.1	Energy consumption per unit of production value	tce/RMB
	2.2	Energy consumption per unit of production in the key industrial sector	tce/RMB
	2.3	Water consumption per unit of production value	m3/RMB
	2.4	Water consumption per unit of production in the key industrial sector	m3/RMB

DIMENSIONS	NO.	INDICATORS	UNIT
Integrated resource utilization	3.1	Utilization rate of industrial solid waste	%
	3.2	Recycling rate of industrial wastewater	%
	3.3*	Disposed natural resources	Ton
Waste generation indicators	4.1	Industrial solid-waste disposed	Ton
	4.2*	Industrial solid-waste handled	Ton
	4.3	Industrial wastewater discharge	Ton
	4.4	SO_2 emissions	Ton
	4.5	COD emissions	Ton
	4.6*	Ammonia emissions	Ton
	4.7*	Ammonia compounds	Ton
	4.8*	Carbon dioxide emissions per unit of GDP	ton/RMB
Others	5.1*	Association degree of the industrial zone	%
	5.2*	Share of non-fossil fuels in primary energy-consumption	%
	5.3*	Share of renewable energy	%

**introduced in the last version*

Source: NRDC (2012)

There are no benchmarks with threshold values provided by the program; instead zones submit their own values in their work plan, which then serve as a basis for the performance review by the national and provincial authorities. The values could differ widely among zones (for examples, see the cases of Tianjin and Rizhao in Table A2 in the Appendix).

Recently, the China National Institute of Standardization (CNIS) initiated a consultation campaign to improve a draft version of the *General Principles of a Standardized System for the Circular Economy of Industrial Enterprises and Parks* (CNIS, 2014). Answers were required by June 2014. As of today, no definitive version of these guidelines has been issued.

3.3 Low-Carbon Industrial Park Program

3.3.1 Description and Governance

The Low-Carbon Industrial Park Program was officially launched in September 2013 as a joint project of the MIIT and the NDRC (MIIT, 2013). The ambition is to accelerate China's movement toward low-carbon industries and increase its industrial competitiveness by supporting innovation, upgraded technology and enhanced carbon management. A pilot experiment will be run from 2014 to 2016 with 55 zones selected from a two-round process: they were first recommended by the provincial branches of the MIIT and the NDRC, and then verified and approved by the national-level authorities (MIIT & NDRC, 2013). The official objective is to reach 80 pioneering zones by 2015; a second batch this year is expected. The experience gained during this pilot phase will later be used to help all industries under MIIT's scope to improve their low-carbon practices and performances.

According to the Institute for Sustainable Communities (ISC), "the biggest distinguishing feature of a low-carbon zone when compared to other types of industrial zones, such as circular economy zones or ecological industrial zones, is that it is managed by its GHG emissions data—both intensity and total carbon emissions" (2012a, p. 5). As such, this program is not explicitly focusing on industrial symbiosis and circular economy. Nevertheless, decreasing carbon emissions and improving resource recovery may go hand-in-hand. Typical examples include infrastructure sharing (leading to more efficient power or steam generation) and the recovery of waste steam for other industries with lower pressure requirements.

3.3.2 Procedures

The zones selected for the pilot were expected to submit their work plan to the MIIT and the NDRC by September 15, 2014. The proposed work plans include a description of the zone and its performance over the last three years, the performance targets and associated indicators, the main tasks and projects, a social and economic cost-benefit analysis, and planned safeguard measures. Naturally, the targets are required to be more ambitious than those already in place or being contemplated (e.g., the carbon intensity target associated with the 12th FYP).

Local branches of the MIIT and the NDRC are responsible for ensuring that their respective industrial zones are functioning in accordance with their work plans before reporting to the national-level authority.

3.3.3 Indicators and Requirements

In the initial documents published in 2013, the MIIT announced that a standard for target indicators would soon be released. To date, no official document has been published; a first version is currently being drafted by the MIIT and the NDRC and should be first communicated to the industrial zones only. It is expected to be publicly available next year. In the *Guidelines for Drafting a Work Plan for Low-Carbon Industrial Park Pilots*, the MIIT and the NDRC (2014) simply recommend defining measurable indicators in relation to more general objectives. The quantifiable indicators include carbon emission per industrial added value, energy consumption for main products, the proportion of enterprises having initiated audits for cleaner production and the proportion of buildings with a green certification.

In 2012 the ISC and the Administration Center of China Agenda 21 concluded a research project about the low-carbon transformation of Chinese industrial zones (ISC, 2012a). This project aimed to help industrial zones to build the required capacity to reduce carbon emissions. Within this work, ISC published an indicator system including 23 indicators across four categories: planning layout, energy utilization and GHG management, circular economy and environmental protection, and industrial park management and safeguard mechanisms (ISC, 2012b). In addition, the Chinese Academy of Sciences, Chongqing Chinese Academy of Social Sciences and Cambridge University published a report entitled *Low-Carbon Transformation of Western Area: The Example of Chongqing* (Chongqing Daily, 2013; Wang, 2013). This report includes a low-carbon industrial park evaluation system composed of 21 indicators across four categories: economy, energy, emissions and management.

4.0 Discussion

4.1 Evolution of the participation

As illustrated in Figure 3, the movement towards eco-efficient industries is accelerating, as more and more industrial zones are joining one of these eco-efficient programs each year. However, the abrupt rise in 2014 is partly explained by the introduction of the new Low-Carbon Industrial Park Program.

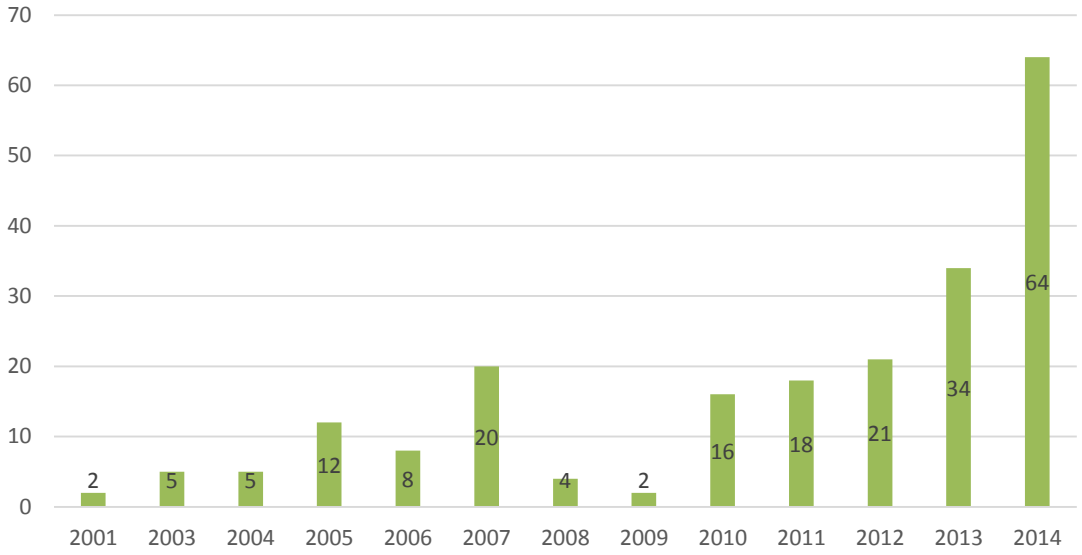

FIGURE 3: ANNUAL NUMBER OF ACCREDITATIONS (ONLY THE FIRST ACCREDITATION OF A ZONE IS CONSIDERED, REGARDLESS OF THE PROGRAM)

Source: Author's calculations based on NDRC (2005, 2007); MEP (2007, 2014a); MIIT & NDRC, 2013); and Zones' official documentation.

4.2 Comparison of the Indicators

The different indicators used to assess the environmental and economic performance of industrial zones can be sorted into five main categories: (i) land and population, (ii) material consumption, (iii) energy and emissions, (iv) pollution, and (v) administration and management. In Table 3, the indicators from the official programs mentioned above as well as the ISC low-carbon evaluation system are used to map out each program's indicators. It appears that the EIP metric system is the most complete, with indicators within all the categories. The Circular Economy zone indicators logically focus on waste/water reuse and recycling, as well as energy consumption, but lack information on pollution and management practices. The ISC evaluation system also excludes these pollutants from its index system.

Programs differ also in the way performance levels are decided: in the EIP program, threshold values are defined in the standard itself (see Table 1). Those values are set equal for all integrated-sector industrial parks, regardless of their history or of their respective composition of industries. In contrast, the CEPZ/CTIP certification process offers greater flexibility, in which different values are submitted by each industrial zone and then approved by the responsible authority. For instance, the energy intensity target is more than three times higher for Rizhao's industrial zone than for Tianjin Economic Development Area (see Table A2 in the Appendix).

TABLE 3: COMPARISON OF INDICATOR SYSTEMS

CATEGORY	EIP METRIC	CEPZ/CTIP	ISC
Land and population	IAV per industrial land occupancy IAV per capita	Output rate of land	Floor Area Ratio Land type diversity Green Area Ratio
Material, water, waste reduction and recycling	Fresh water consumption per IAV Industrial wastewater generation per IAV Solid waste generation per IAV Industrial water reuse ratio Solid waste reuse ratio	Output rate of main mineral resources Output rate of water Water consumption per production value Utilization rate of industrial solid waste Recycling rate of industrial wastewater Disposed natural resources Industrial solid-waste disposed Industrial solid-waste handled Industrial wastewater discharge Association degree of the industrial zone	Comprehensive utilization ratio of industrial solid wastes Living garbage sorting and collection ratio Repeated utilization ratio of industrial water uses Fresh water consumption per unit of IAV
Energy / emissions	Energy consumption per IAV Coefficient of elasticity on energy consumption	Output rate of energy Energy consumption per unit of production Carbon dioxide emission per unit of GDP Share of non-fossil fuels in primary energy-consumption Share of renewable energy	Electricity consumption per unit area of public buildings Ratio of certified green buildings Energy consumption per unit of IAV Energy consumption per unit of product Comprehensive industrial energy consumption elasticity coefficient Decrease rate of energy consumption per unit of operating truck transport volume Ratio of people taking green commuting means Proportion of green electricity in total electricity consumption Industrial waste heat recovery and utilization rate Carbon dioxide emissions per unit of IAV Carbon dioxide emission intensity decrease ratio

TABLE 4: COMPARISON OF INDICATOR SYSTEMS (2/2)

CATEGORY	EIP METRIC	CEPZ/CTIP	ISC
EIP metric	COD emission per IAV Coefficient of elasticity on COD emission Sulfur dioxide emission per IAV Coefficient of elasticity on sulphur dioxide emission Disposal rate of hazard solid waste Centrally provided treatment rate of domestic wastewater Safe treatment rate of domestic rubbish Waste collection and disposal system	Sulphur dioxide emissions COD emissions Ammonia emissions Ammonia compounds	
Material, water, waste reduction and recycling	Extent of establishment of information platform Extent of establishment of eco-industrial information platform Environmental report release Implementation of cleaner production audit in heavy pollution enterprises Extent of public satisfaction with local environmental quality Extent of public awareness degree with eco-industrial development		Proportion of enterprises having completed GHG inventory verification in the industrial park Proportion of enterprises having put an energy management system in place Proportion of enterprises having set up an energy management system Establishment of leading and operating bodies of the low-carbon industrial park Establishment of special fund for low-carbon development

4.3 Overlapping of Pilot Programs

The three reviewed programs pursue similar objectives: addressing the growing resource scarcity, reducing air and water pollutants and curbing carbon emissions. This similarity is visible in their indicator systems, as described in Section 4.2. Duplication of the programs does not seem significant based on our analysis. In 2014, there were 1,568 industrial zones at the provincial and national levels in China (Bao, 2013), including 215 National Economic and Technological Development Zones (MofCOM, 2014) and 114 National High-Tech Industrial Development Zones (MoST, 2014). Of these 1,568 zones, about 13 per cent belong to at least one of the pilot programs; 33 zones belong to two or three of the described programs (211).

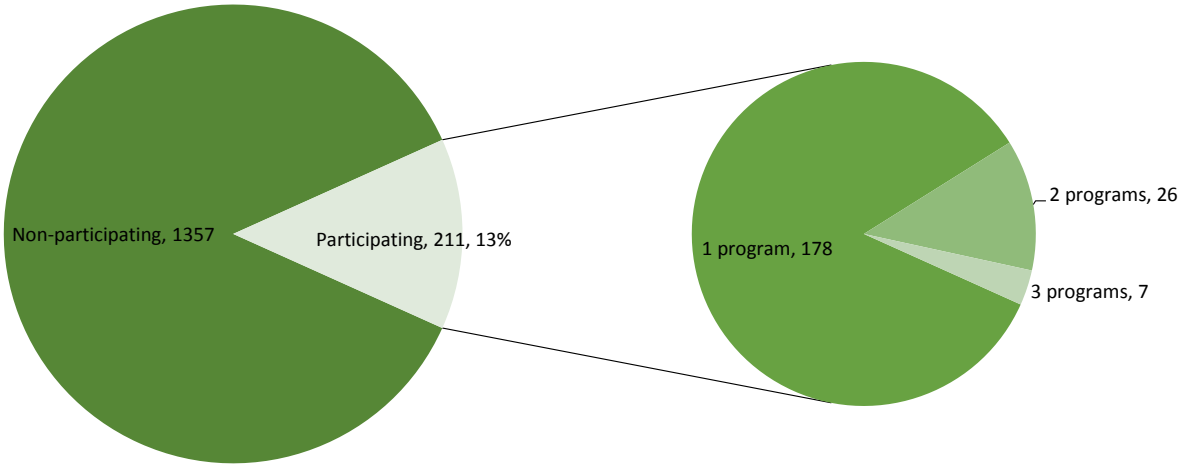

FIGURE 4: OVERLAPPING: ZONES PARTICIPATING TO ONE, TWO, OR THREE PROGRAMS

Source: Author's calculations based on NDRC (2005, 2007); MEP (2007, 2014a); MILT & NDRC, 2013); and Zones' official documentation.

4.4 Contribution to a Low-Carbon Transition

Among these three programs, only the Low-Carbon Industrial Park Program is explicitly designed to reduce GHG emissions. However, the EIP and CPEZ/CTIP programs also directly and indirectly promote low-carbon development.

Among the requirements and assessment indicators that determine a zone's certification, several have potential impacts on carbon emissions:

1. The energy intensity, present in both official indicator systems, is strongly correlated to its carbon intensity since most of the carbon emissions are energy related.
2. The energy mix, which determines the carbon content of electricity, is partly considered in the CPEZ/CTIP indicators through the share of renewable energy.
3. The diminution and recycling of the generated waste reduces the need to extract and process natural resources, as well as the need to treat these waste streams. These elements, incidentally, reduce the associated carbon emissions.

However, these effects do not encompass all GHG emissions associated with an industrial park. For instance, these certifications do not consider full life-cycle impacts that include product usage, recycling and disposal. Performance requirements, including life-cycle-assessment, labelling or extended producer responsibility, could reinforce the attention paid by manufacturing industries to the whole life cycle of their products. Overall, the existing standards do not offer a comprehensive evaluation system for low-carbon performance. However, the recently announced requirement for large firms to report their carbon emissions will probably contribute to accelerating the adoption of carbon emission indicators in zones' performance evaluations (NDRC, 2014).

Strengthened cooperation among manufacturing enterprises is a crucial element to achieve carbon emission reduction targets. Indeed, it has been demonstrated that a single firm's practice (e.g., technology innovation within processing plants) can only achieve a minor part of the national reduction targets (Zhang & Wang, 2014). By promoting the adoption of industrial symbiosis principles, these programs can help fill the gap. Industrial symbiosis usually brings

about carbon emission reductions through effective use of resources and energy; for instance, through by-product exchange and infrastructure sharing (e.g., combined cooling heating and power, steam production and waste treatment plants) (Hashimoto, Fujita, Geng, & Nagasawa, 2010; Liu, Zhang, Bi, Wei, & He, 2012; Liu, Tian, & Chen, 2014; Yu, Han, & Cui, 2014). In 2009 the MEP acknowledged the importance of EIPs for carbon emission reductions and required that "the planning, constructing and assessment of national EIPs should implement the concepts of circular economy, low-carbon economy as well as industrial symbiosis, so as to reduce energy consumption, environmental pollution and GHG emission within EIPs" (MEP, 2009).

Another potential impact is the mitigation of air pollution associated with these zones—although the relationship is not necessarily positively correlated. For instance, reducing sulphur dioxide emissions may entail the installation of a flue gas desulfurization unit or switching fuels from coal to synthetic natural gas converted from coal. Both actions are associated with increased carbon emissions. Depending on the local context, the objectives of reducing carbon emissions and air pollution may, therefore, not be mutually reinforcing (Maddocks, Wen, Luo, & Shiao, 2013). Holistic approaches are required to precisely assess the effects of political and technological decisions.

Other elements of EIP and Circular Transformation programs indirectly contribute to a less carbon-intensive industry, like the establishment of energy management systems, the development of clean production audits, the technological developments associated with those programs, and improving communication and raising awareness about environmental issues.

4.5 Motivations and Opportunities for Industrial Parks

An important motivation for industrial zones to participate in these programs is to attract investment, whether foreign or domestic, within fierce competition among zones. For multinational corporations and investors, zone certification can mean convincing arguments in favour of investment, including reduced risks of pollution incidents, greater transparency and higher environmental performance. For the enterprises in the zone, the shared infrastructure and recuperation of waste streams might prove economically beneficial. However, examples exist in which industrial symbiosis is not associated with positive economic incentives (Shi et al., 2012b). To overcome these barriers and foster the development of a circular economy, as highlighted in national programmatic plans, local governments often subsidize the development of shared infrastructure and industrial symbiosis initiatives. In some cases, top-down pressures from local governments (which are given their own environment- and efficiency-related targets) as well as national rankings established by the State Council can also motivate zones to participate in these programs.

The development of eco-efficient programs has now a long history in China. In the first decade of development, technical expertise and capacity have mainly been sought abroad. Many partnerships were initiated with foreign or international organizations like World Resources Institute, World Wide Fund for Nature, Institute for Sustainable Communities, United Nations Environment Programme and foreign universities. Accordingly, indigenous knowledge has progressively increased in Chinese research institutes, universities and industrial zones (Shi, Tian, & Chen, 2012a). For instance, the Tianjin Economic and Technological Development Area Eco-Center and the Suzhou Circular Economy Extension Center have grown an advanced and renowned technical capacity in this domain. However, despite the recent efforts to draft guidelines and standards, a recent study concluded that industrial zones still lack clear guidance and definitions (Zhang, 2012). Limited awareness and motivation on the part of many companies also impede such eco-efficient and low-carbon development. A recent survey of 210 senior officials at 51 national industrial parks concluded that the lack of capacity building and the limited technological development are preponderant barriers mentioned by industrial zones (Zhu, Geng, Sarkis, & Lai, 2014).

4.5.1 Training and Guidelines

It is clear that industrial zones still lack the technical capacity to undertake low-carbon and more environmentally friendly transformation. To address some of the aforementioned barriers and increase the capacity of industrial zones to lead a low-carbon transition, several guidelines have been issued by various sources. These guidelines are indicated in Table 5.

TABLE 5: EXISTING GUIDELINES FOR INDUSTRIAL ZONES

TITLE	AUTHOR, YEAR
General Guideline of Circular Economy Management for Industrial Parks (Draft)	CNIS, 2012
Guide for Low-Carbon Industrial Development Zones	ISC, 2012a
Guidelines for Drafting Recycling Transformation Zones Work Plans (NDRC, 2012)	NDRC, 2012
Guideline for EIP Construction Planning	MEP, 2007b

Table 6 lists some examples of capacity-training sessions designed to help in developing or managing an EIP or a circular economy zone. These training sessions may be designed for three different levels: local government, zone management and enterprises.

TABLE 6: EXAMPLES OF AVAILABLE TRAINING FOR LOCAL GOVERNMENTS, INDUSTRIAL ZONES AND ENTERPRISES

ORGANIZERS	AUDIENCE	CONTENT
MEP, MofCOM, MoST (MEP, MofCOM, & MoST, 2012)	Zone management	EIP standards Management processes for EIP Legal analysis about EIP
Industrial park (Wujin People's Government, 2014a, 2014b, 2014c)	Enterprises	Energy management system (ISO 14001) Environmental Impact Assessment Clean production audit
Industrial park (Beijing Economic and Technological Development Area, 2010)	Enterprises	Energy saving and emission reduction
Industrial park (EcoTEDA, 2014)	Enterprises	Energy management system (national standards and ISO 14001) Advanced energy saving management GHG monitoring (ISO 14064)
Association (China Association for Science and Technology Industrial Parks, 2010)	Local government Zone management Enterprises	EIP procedures, requirements, management and verification methods EIP targets, indicators, framework, projects, and safeguard mechanisms EIP and CEPZ zones case studies
Association (All-China Environment Federation, 2010)	Local government officials Zone management Enterprises	EIP theory, regulations, methods, standards and verification EIP and CEPZ zones case studies Clean production regulations, standards, and audits
Association (Guangdong Clean Production Association, n.d.)	Enterprises	Clean production audit
University (Renmin University, 2013)	Local government Zone management Enterprises	EIP and CEPZ methods, requirements, procedures EIP and CEPZ planning method and case studies Clean production audit

5.0 Conclusion

In this briefing note, we assessed three national certification programs that have been initiated by different ministries in China to push industries to become more energy efficient and reduce their emissions. These programs have increased in momentum since 2010 with the proliferation of participating industrial zones to include about 211 zones in the three programs by the end of 2014.

For each of the three programs, we assessed the standards and shared indicators that have developed and identified some similarities and differences across the programs. Older programs have been more focused on the concept of EIPs, with a range of indicators that reveal the performance of water, material and energy use across enterprises, as well as waste and emissions generated. More recently, there is a push to focus on low-carbon-zone certification, mirroring a national priority to improve air quality, improve energy efficiency and achieve national-level GHG emission targets.

While the certification programs are voluntary, firms clearly see the benefit of participating. These benefits could be less tangible, such as demonstrating alignment with government priorities or differentiating products in the consumer's mind. The benefits could be also be more tangible, including by accessing financing through participation in the certification schemes and gaining access to technical expertise to help with improving energy and emission performance.

Another important benefit is that the certification schemes provide a framework for enterprises to evaluate their own facilities, with certification requiring a systematic review of multiple facets of the enterprise. Building internal capacity is particularly important, as industrial zones and their enterprises are increasingly asked to not only achieve economic growth but also to minimize their environmental impact. Switching from a growth-oriented business plan to one of a more balanced path requires new skills to be learned and capacity to be developed.

To the extent enterprise capacity is improved through the certification process, China's push to implement three complementary, but at times overlapping, eco-industrial and low-carbon certification schemes is a good thing. Providing firms with frameworks to systematically assess their own operations will only aid enterprises to identify operational priorities that improve economic performance through resource efficiency. Improved capacity will then make enterprises all the better prepared to understand how China's emerging energy and emission policies will affect their business and to make cost-effective decisions that will help maintain competitiveness.

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Appendix

Corresponding Chinese terms

Circular Economy Pilot Zone (CEPZ)	循环经济试点园区
Circular Transformation of Industrial Park (CTIP)	工业园区循环化改造
Eco-industrial parks	生态工业园区
Low-carbon industrial park	低碳工业园区
Sector-integrated eco-industrial park	综合类生态工业园区
Sector-specific eco-industrial park	行业类生态工业园区
Venous (circular) eco-industrial park	静脉产业类生态工业园区

Zones belonging to the three programs

Suzhou Industrial Park

Tianjin ETDZ

Rizhao ETDZ

Shanghai Chemical Industry Park

Ningbo ETDZ

Dalian ETDZ

Nanchang High-Tech Industrial Development Zone

TABLE A1: SUBSIDIES ATTRIBUTED TO CIRCULAR TRANSFORMATION ZONES BY NDRC AND MOF (SOURCE: ONLINE PROVINCIAL OFFICIAL MEDIA, AVAILABLE ON DEMAND)

ZONE	SUBSIDY (MILLION RMB)	INVESTMENT (MILLION RMB)	SHARE
Wanzhou ETDZ	150	n/c	
Dongying ETDZ	113.5	2091	5.4%
Ningbo ETDZ	275	n/c	
Anhui Huoqiu Economic Development Zone	300	n/c	
Guangzhou ETDZ	100	4290	2.3%
Caofeidian Industrial Park	146.5	1384	10.6%
Wuhan Qingshan Industrial Park	139	n/c	
Jiangxi Yingtan Hi-Tech Industrial Zone	94	n/c	
Zhejiang Taizhou Chemical Raw Material Industrial Zone	297	n/c	
Hailin ETDZ	146	1500	9.7%
Hubei Yichang Economic Development Zone	267	n/c	
Puyang Economic Development Zone	137	n/c	

ZONE	SUBSIDY (MILLION RMB)	INVESTMENT (MILLION RMB)	SHARE
Quzhou Hi-tech Industrial Zone	210	1451	14.5%
Ganzhou ETDZ	89	856	10.4%
Jinchang ETDZ	254	n/c	
Zhenjiang ETDZ	158	n/c	
Qingdao ETDZ	210	3335	6.3%
Average	181.5		8.5%

TABLE A2: TARGETS IN CTIP WORKING PLAN OF TIANJIN AND RIZHAO ETDZS

DIMENSIONS	INDICATORS	TIANJIN TARGETS FOR 2010 (/2005)	RIZHAO TARGETS FOR 2015 (/2010)
Resource output indicators	Output rate of main mineral resources		
	Output rate of land [RMB/km^2]	10bn	
	Output rate of energy [RMB/tce]	50k (+25%)	
	Output rate of water [RMB/m3]	1316 (+12%)	
Resource consumption indicators	Energy consumption per unit of production value [tce/RMB]	2.0 E-5 (-20%)	7.5 E-5 (-17%)
	Energy consumption per unit of production in the key industrial sector		
	Water consumption per unit of production value [m^3/RMB]	7.6 E-4 (-10%)	n/c (-30%)
	Water consumption per unit of production in the key industrial sector		
Integrated resource utilization	Utilization rate of industrial solid waste	90% (+12pt)	99%
	Recycling rate of industrial wastewater	88% (+4pt)	90%
Waste generation indicators	Industrial solid-waste disposal rate	10% (-12pt)	
	Industrial wastewater disposal rate		
	SO_2 emissions	n/c (-10%)	
	COD emissions	n/c (-10%)	70-100mg/l for pulp-and-paper industry

Source: (Rizhao Economic and Informatization Committee, 2012; Tianjin Economic-Technological Development Area, 2006)

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