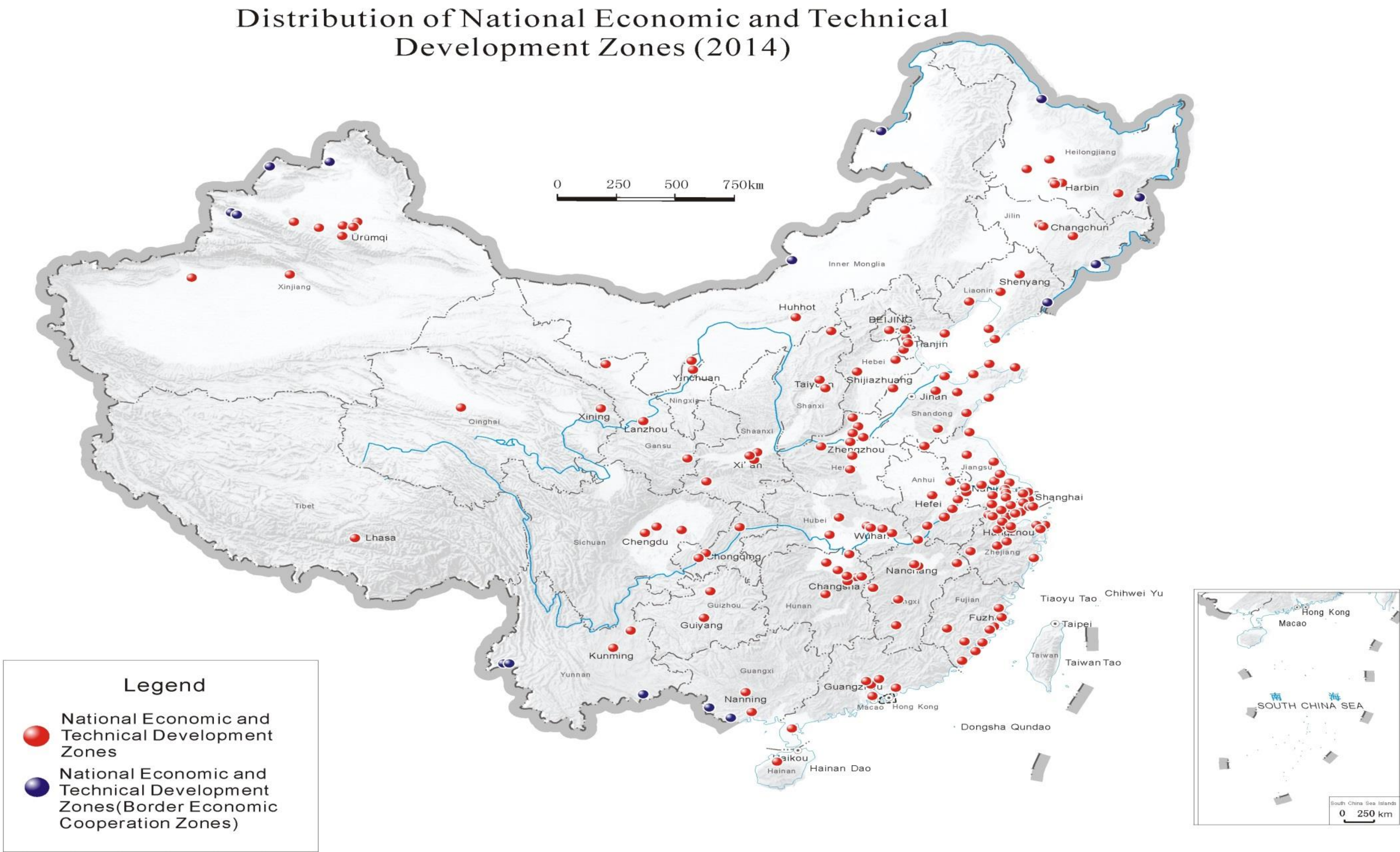
Barriers towards promoting eco-industrial parks in China: Perspectives from senior officials at national industrial parks

Yong Geng
Institute of Applied Ecology
Chinese Academy of Sciences

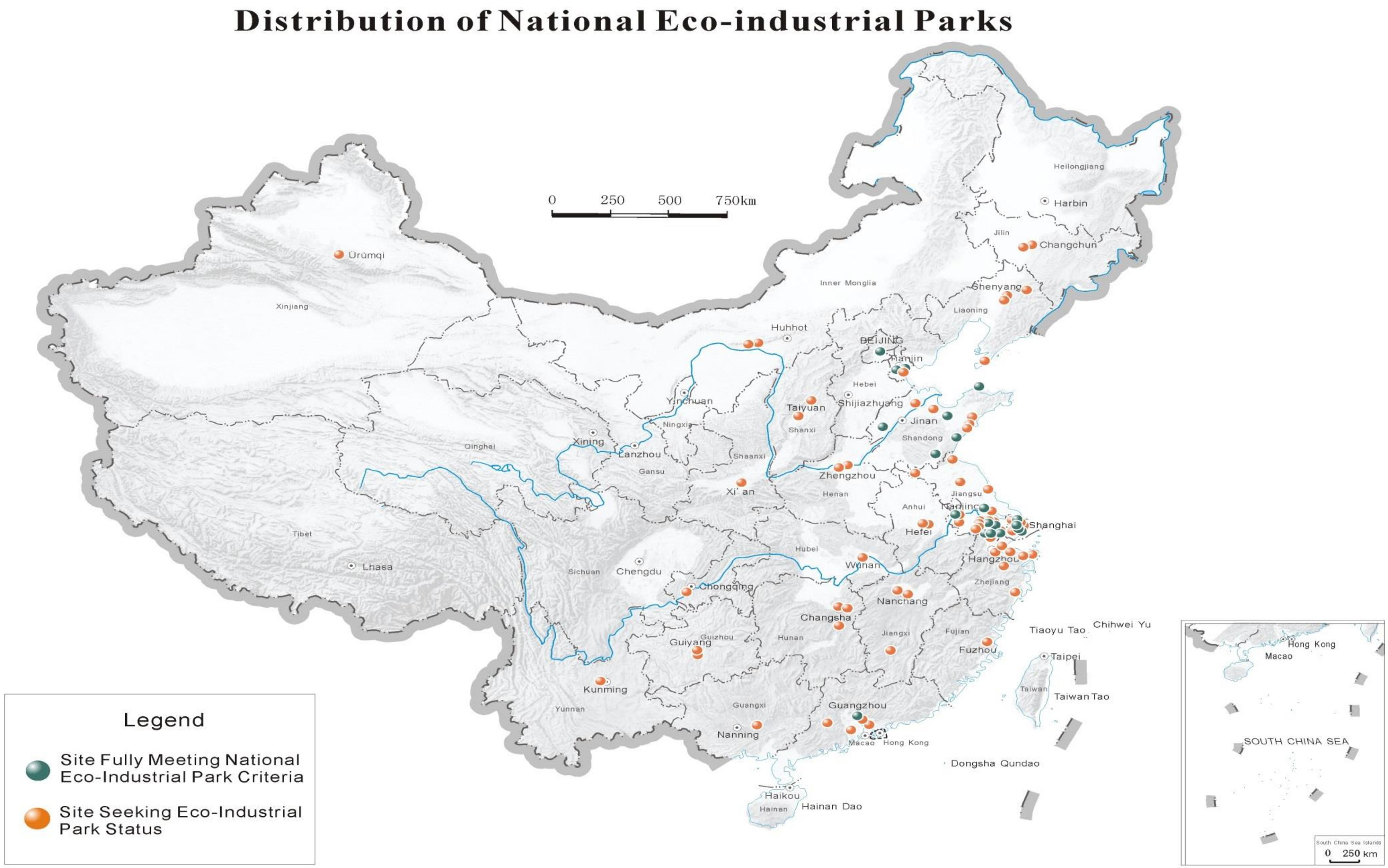
China’s industrial park development

Amount: Over 6600 industrial parks across the whole country;
Different levels, including national, provincial, municipal and county level;
Types: Economic development zones, High-tech zones, export processing zones, free trade zones;
Categories: Sector-integrated industrial parks, sector-specific industrial parks, venous industrial parks (recycling parks);
Involved agencies: Ministry of Commerce; Ministry of Environmental Protection; National Development and Reform Commission.

Location of national development zones



National Eco-Industrial Parks



National EIP Indicators

Table 1 Indicator standards for sector-integrated eco-industrial parks (EIPs) in China

Item	*No.*	*Indicator*	*Unit*	*Value*
Economic development	1	Added industrial value per capita	10,000 ¥/p	≥15
	2	Growth rate of added industrial value	%	≥25%
Material reduction and recycling	3	Energy consumption per added industrial value	SCE/10,000 ¥	≤0.5
	4	Fresh water consumption per added industrial value	m^3/10,000 ¥	≤9
	5	Industrial wastewater generation per added industrial value	t/10,000 ¥	≤8
	6	Solid waste generation per added industrial value	t/10,000 ¥	≤0.1
	7	Industrial water reuse ratio	%	≥75%
	8	Solid waste reuse ratio[a]	%	≥85%
	9	Middle water reuse ratio[b]	%	≥40%
Pollution control	10	COD loading per added industrial value	kg/10,000 ¥	≤1
	11	SO_2 emission per added industrial value	kg/10,000 ¥	≤1
	12	Disposal rate of dangerous solid waste	%	100%
	13	Centrally provided treatment rate of domestic wastewater	%	≥70%
	14	Safe treatment rate of domestic rubbish	%	100%
	15	Waste collection system	Yes/no	Available
	16	Centrally provided facilities for waste treatment and disposal	Yes/no	Available
	17	Environmental management systems	Yes/no	Established, certified according to ISO 14001
Administration and management	18	Extent of establishment of information platform	%	100%
	19	Environmental report release	Yes/no	1 issue/year
	20	Extent of public satisfaction with local environmental quality	%	≥90%
	21	Extent of public awareness degree with eco-industrial development	%	≥90%

Note: One cubic meter (m^3, SI) ≈ 1.31 cubic yards (yd^3). One metric ton (t) = 10^3 kilograms (kg, SI) ≈ 1.102 short tons. SCE = standard coal equivalent energy ¥ is the symbol of Chinese currency, RMB. As of 21 July 2008, US$1 equals 6.83 RMB, and one Euro equals 10.83 RMB. COD = chemical oxygen demand; SO_2 = sulfur dioxide.

[a]Reuse in this context means direct reuse of discarded products, such as printing on the reverse of once-printed paper and reuse of some solid wastes (with basic treatment), such as cleaning polyethylene terephthalate (PET) bottles and glass containers for refilling.

[b]Middle water is a Chinese term for the recyclable treated wastewater from wastewater treatment plants. This indicator does not need to be assessed if there is no water treatment plant in the industrial park.

National circular economy industrial parks Indicators

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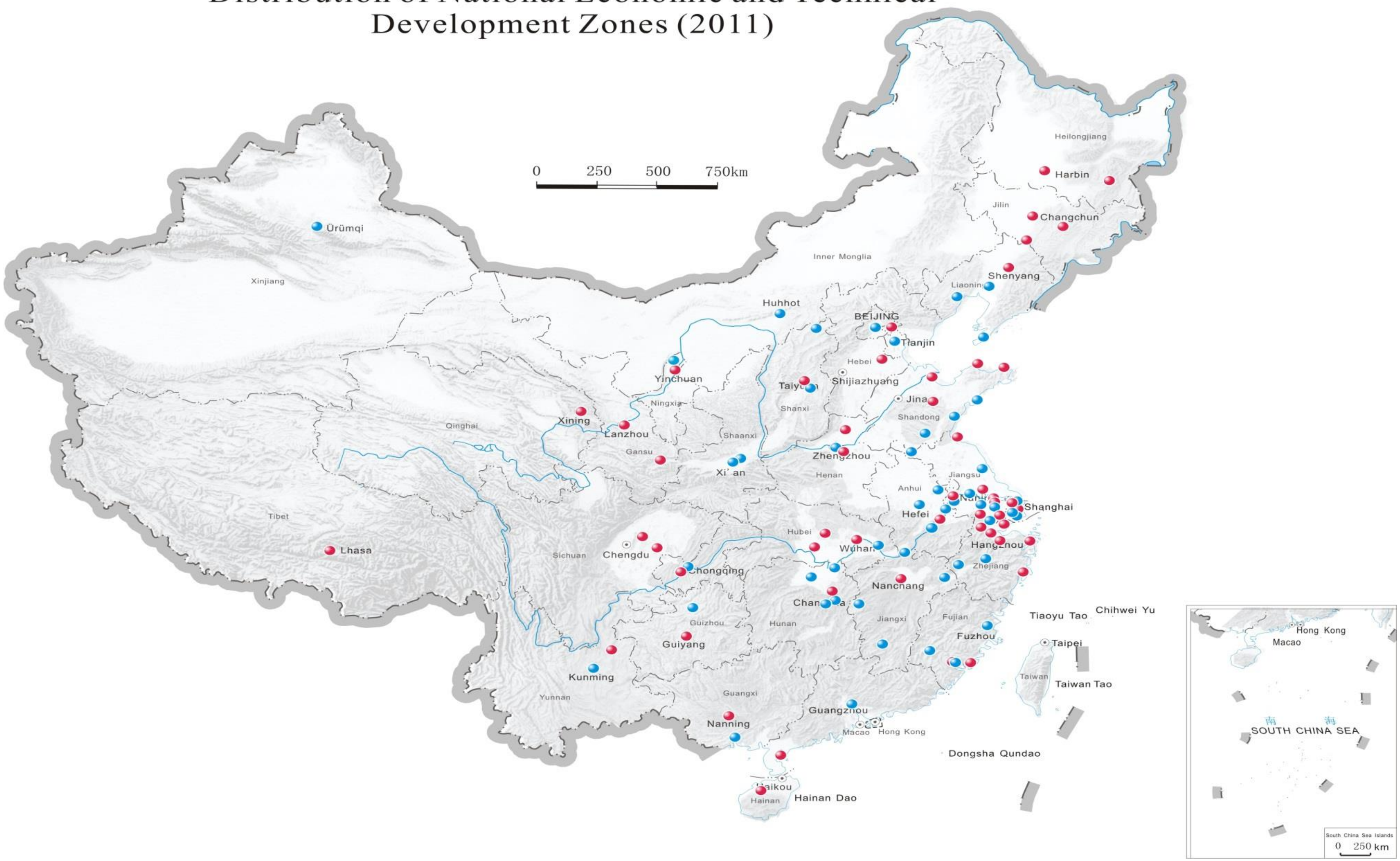
Table 4
Indicator calculation and explanation at industrial park level.

N.	Calculation formula	Explanation
1	Output of main mineral resource = Industrial production value/main mineral resource consumption *(unit: 10,000 ¥/ton)*	Mineral resource consumption = main mineral resource production + imported mineral resource − exported mineral resource
2	Output of energy = Industrial production/value Energy consumption *(unit: 10,000 ¥/ton sce)*	Ratio of energy consumption to GDP. The energy source here includes coal, oil, natural gas, nuclear power, wind power and hydro power.
3	Output of land = Industrial production value/total land area of industrial park *(unit: 10,000 ¥/ha)*	The higher value of this indicator means more efficient land use.
4	Output of water resource = Industrial production value/total amount of water withdrawal *(unit: 10,000 ¥/m^3)*	The higher value of this indicator means more efficient water use.
5	Energy consumption per unit industrial production value = Energy consumption/Industrial production value *(unit: ton sce/10,000 ¥)*	The lower value of this indicator means more efficient energy consumption.
6	Water withdrawal per unit industrial production value = Water withdrawal amount/industrial production value *(unit: 10,000 m^3/¥)*	The lower value of this indicator means more efficient water use. Water sources include surface water, groundwater, recycled wastewater, rainwater, desalinated seawater, but not includes directly used seawater.
7	Energy consumption of key product = energy consumption/weight of product production *(unit: Ton sce/ton)*	The lower value of this indicator means more efficient energy use. The key products include copper, aluminum, cement, fertilizer, paper etc.
8	Water consumption of key product = fresh water consumption/weight of product production *(unit: 10^8 m^3/ton)*	The lower value of this indicator means more efficient water use. The key product includes copper, aluminum, cement, fertilizer, paper etc.
9	Recycling rate of industrial solid waste = (recycled amount of industrial solid waste/total amount of industrial solid waste) × 100%	Ratio of amount of recycled industrial solid waste to total amount of industrial solid waste generated.
10	Industrial water reuse ratio = (amount of total reused wastewater for industrial purpose/total amount of industrial water consumption) × 100%	The reused industrial wastewater includes both treated domestic wastewater and industrial wastewater that is qualified with the national recycling water standard.
11	Industrial solid waste for final disposal (unit:ton)	Total amount of industrial solid waste for final disposal.
12	Industrial waste water discharge (unit: ton)	Total amount of discharged industrial wastewater.

¥ represents symbol of Chinese currency RMB;

National survey for industrial parks

Distribution of National Economic and Technical Development Zones (2011)



Investigation Process

- **The sample sites include 50 from the eastern China, 30 from central China and 20 from western China. This sample dispersion roughly matches the geographical distribution of the 140 national industrial parks, which include 73 parks in eastern China, 40 parks in the central China, and 27 parks in the western China.**
- **Respondents typically included the general director, the vice general director in charge of environmental protection and energy savings, and directors from three related bureaus including the environmental protection bureau, the planning bureau, and the financial bureau. These officials are critical for promoting EIPs due to their administrative authority.**
- **Investigation period: from April 9 to May 31, 2012.**
- **Collected questionnaires were from 51 industrial parks, including 217 senior officials.**

Questionnaire for external factors

Table 1 Rotated Component Matrix[a] on external barriers for promoting eco-industrial parks

Questionnaire items	Factors		
	1	2	3
National and regional energy saving and pollution reduction promotion policies are not enough	.139	.805	.293
National and regional regulations for energy saving and pollution reduction are imperfect	.305	.828	.255
National and regional enforcement level for energy saving and pollution reduction is not high enough	.398	.794	.119
Potential investment groups have no environmental preference	.804	.214	.172
Potential investment groups have no technologies or measures for energy saving and pollution reduction	.800	.272	.175
Market lacks preference for energy saving and pollution reduction products	.646	.157	.566
Preference for energy saving and pollution reduction products is unstable	.753	.131	.398
Enterprises can not get external production technologies for energy saving and pollution reduction	.744	.351	.248
Enterprises can not get external materials technologies for energy saving and pollution reduction	.742	.342	.229
Lack of information about international and domestic benchmarking eco-industrial parks	.319	.344	.810
Lack of ways to learn from benchmarking eco-industrial parks	.261	.250	.857

Questionnaire for internal factors

Table 2 Rotated Component Matrix[a] on internal barriers for eco-industrial parks

Questionnaire items	Component 1	Component 2	Component 3
Energy saving and pollution reduction has conflicts with GDP/tax growth	.772	.264	.243
High cost for energy saving and pollution reduction infrastructure	.822	.253	.180
High requirement for energy saving and pollution reduction affects investment attraction	.765	.262	.268
National and regional governments do not pay enough attention to evaluation on energy saving and pollution reduction (compared to economic indicators such as GDP)	.383	.134	.729
Zone lacks of data collection and management on materials and energy flow	.181	.211	.821
Difficulty to clearly allocate responsibilities on energy saving and pollution reduction to different bureaus in the zone	.171	.415	.683
Zone lacks of human resources for eco-industrial park management	.176	.735	.440
Zone lacks of fund to support energy saving and pollution reduction	.382	.798	.178
Enterprises lack of capabilities on energy saving and pollution reduction for technology development	.285	.756	.189

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Factor Analysis

An exploratory factor analysis (EFA) using maximum likelihood with a varimax rotation was used to extract the theoretical dimensions (factors) of external and internal barriers for promoting EIPs.

Both the scree test and initial eigenvalue test indicates three factors for external barriers explaining 77.9% of the inherent variation.

A further reliability test is conducted to examine if the items should be grouped into their respective factors.

If a reliability coefficient alpha value is over the benchmark value of 0.70, we can conclude that items grouped into respective factors are valid.

Results： General descriptive statistics

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Table 3 Descriptive statistics and ANOVA results of barriers for eco-industrial parks

		Means	S.D.	Means			F*
				Cluster 1 (N=172)	Cluster 2 (N=26)	Cluster 3 (N=9)	
External barriers	**Capital support barrier**	**3.23**	**.76**	**3.30**	**2.29**	**4.63**	**54.26**
	Potential investment groups have no environmental preference	3.13	.97	3.20	2.19	4.44	26.92
	Potential investment groups have no technologies or measures for energy saving and pollution reduction	3.25	.95	3.31	2.33	4.67	29.11
	Market lacks of preference for energy saving and pollution reduction products	3.16	.89	3.21	2.33	3.25	31.57
	Preference for energy saving and pollution reduction products is unstable	3.21	.88	3.27	2.41	4.44	25.41
	Enterprises can not get external production technologies for energy saving and pollution reduction	3.36	.91	3.44	2.30	4.78	42.06
	Enterprises can not get external materials technologies for energy saving and pollution reduction	3.26	.88	3.34	2.19	4.78	50.18
	Policy support barrier	**3.14**	**.87**	**3.26**	**1.85**	**4.63**	**76.05**
	National and regional energy saving and pollution reduction promotion policies for are not enough	3.22	.92	3.31	2.14	4.56	38.85
	National and regional regulations for energy saving and pollution reduction are imperfect	3.08	.99	3.22	1.63	4.67	68.93
	National and regional enforcement level for energy saving and pollution reduction is not high enough	3.13	1.02	3.26	1.78	4.67	52.16
	Informational support barrier	**3.20**	**.89**	**3.30**	**1.98**	**4.78**	**65.10**
	Lack of information about international and domestic benchmarking eco-industrial parks	3.18	.92	3.27	2.04	4.78	51.79
	Lack of ways to learn from benchmarking eco-industrial parks	3.21	.94	3.33	1.93	4.78	60.43

Results： General descriptive statistics

Internal barriers	**Tangible Resources**	**3.13**	**.84**	**3.21**	**2.05**	**4.81**	**67.80**
	Energy saving and pollution reduction has conflicts with GDP/tax growth	3.07	.96	3.15	2.00	4.89	48.92
	High cost for energy saving and pollution reduction infrastructure	3.35	.94	3.46	2.22	4.67	40.03
	High requirement for energy saving and pollution reduction affects investment attraction	2.98	1.01	3.04	1.93	4.89	43.60
	Intangible Resources	**2.97**	**.82**	**3.08**	**1.72**	**4.59**	**96.03**
	National and regional governments do not pay enough attention to evaluation on energy saving and pollution reduction (compared to economic indicators such as GDP)	2.96	1.03	3.10	1.52	4.87	64.44
	Zone lacks of data collection and management on materials and energy flow	3.03	.93	3.12	1.93	4.67	49.54
	Difficulty in clearly allocating responsibilities on energy saving and pollution reduction to different bureaus in the zone	2.92	1.01	3.03	1.70	4.44	42.37
	Capabilities	**3.21**	**.81**	**3.35**	**1.89**	**4.41**	**85.90**
	Zone lacks human resources for eco-industrial park management	3.14	.94	3.28	1.78	4.33	57.17
	Zone lacks funds to support energy saving and pollution reduction	3.15	1.00	3.30	1.74	4.44	54.53
	Enterprises lack capabilities on energy saving and pollution reduction for technology development	3.34	.89	3.46	2.15	4.44	46.48

* $p<0.001$

Main findings from General descriptive statistics

- Six factors have similar values between 2.97 and 3.23 approximately in the middle of the effect range scale. Such results show that all barrier factors have partly significant effects on EIP development.
- Capital support dependency barriers have the highest mean value of 3.23 from amongst the three external factors while capability has the highest mean value of 3.21 from the three internal factors.
- Three items within this factor are related to technology and achieve the highest mean values ranging from 3.25 to 3.36 while the other three items have similar mean values as the other two external factors.
- One internal item related to technology, enterprises lacking capabilities on energy saving and pollution reduction for technology development, achieves the highest mean value of 3.34 from among all external and internal items.

Cluster analysis results

- Hierarchical analysis is used to identify the cluster number. Using the agglomeration schedule for the coefficient changes of individual clusters, a three-cluster solution is deemed most appropriate. The sample Chinese officials are then assigned to the three clusters. After the hierarchical analysis, a K-mean cluster analysis (a non-hierarchical clustering technique) of the six factors was used to make this assignment of the industrial park management officials into clusters.
- To assess whether the mean values of all the factors and items were significantly different across the three clusters, one way ANOVA tests were performed.
- The results in Tables 3 show that all factors and items are significantly different among the three clusters at $p<0.001$.
- 172 of 210 appear in Cluster 1, and have mean values between 3.08 and 3.35 for the six factors, as well as values between 3.04 and 3.46 over all the items.
- Responses in both Cluster 1 and 2 have similar regional distributions to the sample of 51 industrial parks across eastern, central, and western. Seven of nine responses in Cluster 3 appear from respondents located in the less developed regions. Such results indicate that officials from less developed areas, though having a low percentage of the total sample, perceive greater barriers due to both lack of external support and internal resources/capabilities to promote EIP development.

Implications related to factorial and descriptive Results

- Internal industrial park capabilities for energy conservation and pollution reduction are limited. Thus, these capabilities and the need to develop them, is a significant barrier for developing EIPs in China.
- Technological development and diffusion is difficult to complete by a single entity, thus inter-firm networks and innovation within industrial parks are important for technology development.
- Promoting joint technology development among enterprises including those in different industrial parks should be strengthened. Innovative measures that can address internal capability concerns are needed for effective EIP transformation, including supporting technological cooperation among different industrial sectors, preparation of national guidelines on promoting industrial symbiosis in key sectors, and developing training and benchmarking capabilities through either centralized or decentralized knowledge sources.
- The capability internal barrier has the highest average values among the three internal factors. Besides technological concerns, most industrial parks also lack both human and financial resources to support EIP development.
- Specific clusters within the industrial parks experience lower barriers when seeking promote EIP development. The situations that cause these EIPS to effectively perceive fewer barriers (and the assumption of going forward with EIP development) should be investigated. The diffusion of practices that allow them to address and reduce these barriers is something that should be pursued. This situation will probably require a centralized authority with the reach, resources and power to help in this diffusion.
- One of the contextual issues that may aid or serve as a barrier to lowering barriers are regional differences in Chinese economic policy. It is important to establish a learning

Implications of cluster analysis

- Most officials in Cluster 1 have a standard perception of barriers while a few officials in Cluster 2 are less stressed in terms of EIP barriers perceived. Nine officials, most from less developed regions, are highly stressed with respect to EIP barriers perceived. Such facts indicate that regional disparity need to be addressed by the central government.
- The strict evaluation system prior to the application process and after the approval of the project makes most industrial park officials hesitant to apply for demonstration project funding.
- Eastern industrial zones can more easily address many of the barriers due to greater experience and knowledge. They have become more adept at getting external support and also effectively allocating internal resources for EIP development.
- With lessened EIP knowledge and experiences, zones in central and west China will find the barriers overwhelming, especially locating and attracting external support. Part of these issues may be the lack of developing networks and connections that may be necessary to traverse the government bureaucracy, develop support from communities, involve industrial partners, and locate and implement appropriate technology and processes. As a result, officials feel high external barriers.
- Simultaneously, many these industrial zones face pressures to economically perform, with environmental issues that do not contribute to direct and immediate economic benefits, taking a backseat. Overall, they also lack human resource and technological expertise, while allocating few resources to EIP development. Given these characteristics, officials in these zones also feel (perceive) high internal barriers.

Conclusions

- Senior officials in most national industrial parks in China have been familiarized with the EIP concept but have differing experiences in both external and internal barriers for successfully implementing EIPs.
- Most senior officials highlighted technology and capability capacity building barriers as key issues facing successful EIP implementation. Few senior officials from leading industrial parks overcome all barriers, but their experiences on how they overcome some of the barriers they do overcome can be valuable to other industrial parks.
- The mechanisms to acquire and build knowledge on the EIP implementation barriers faced and how they can be overcome are not well developed and disseminated to other industrial parks.
- Chinese governments have sought to provide financial support for technological innovation on energy saving and pollution reduction, however, how to encourage joint technology development or cooperation among enterprises and industrial parks still requires further investigation by government officials and policy researchers to determine the most effective approaches.
- EIP development is a comprehensive effort, and needs support from all stakeholders. Thus, capacity building programs should cover not only officials, and key managers from tenant companies, but also the public and investment organizations. A learning system with a common platform would be helpful for information sharing and communication among industrial parks.

Thank you for your patience.