Sino-EU Key Performance Indicators for Eco-Cities

Draft

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Europe-China Eco-City Link Project (EC-Link) and
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for
Ministry of Housing, Urban-Rural Development (MoHURD)

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1 Preface

In 2015, the General Assembly of the United Nations formally agreed to an ambitious set of 17 Sustainable Development Goals (SDGs) — a framework to coordinate global efforts for ending poverty and hunger, combating inequality and disease, slowing climate change and building peace. The SGDs emphasize the vital role cities have to play in the global effort. Several of the new Sustainable Development Goals — or SDGs as they are widely known — are specifically geared towards sustainable urban development; it demands governments to build cities that are "inclusive, safe, resilient and sustainable." All of the 16 other SDGs also touch the work of local authorities in one way or another. Goals such as ensuring climate action, clean water and sanitation for all can't be achieved without local-level leadership.[1] On the sidelines of the event at the United Nations, dozens of mayors and other local leaders committed to the cause. They signed a pledge saying they would "play a defining role in embracing, endorsing, implementing, and monitoring these goals." The commitments also included a list of actions around ensuring "the achievement of the SDGs in our cities and territories by 2030." [2]

Since 2006, the government of China has initiated the drive for the development of eco-cities. Initially this has been through a couple of pilot cities, like the Tianjin EcoCity and Caofeidian Eco-city, and later, many others have joined. Today over 100 cities are counted as eco-cities or eco-districts. The Ministry of Housing, Urban-Rural Development (MoHURD) issued a policy directive in 2007, which served to guide local planning authorities on key performance indicators for master plan preparation and monitoring.[3] These highlighted new resource management performance measures covering water resources and re-use, land resources, energy efficiency, emissions reduction and materials recycling.

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[1] Swope, C. 2016. Here's the list of Sustainable Development Goal targets that have a role for cities. *Citiscope.* 7 July 2016. http://citiscope.org/story/2016/heres-list-sustainable-development-goal-targets-have-role-cities?utm_source=Citiscope&utm_campaign=3eb263e944-Mailchimp_2016_07_08&utm_medium=email&utm_term=0_ce992dbfef-3eb263e944-118049425

[2] Biron, C. L. 2016. Cities turn to implementing the Sustainable Development Goals. *Citiscope.* 7 July 7, 2016. http://citiscope.org/story/2016/cities-turn-implementing-sustainable-development-goals

[3] Ministry of Housing and Urban-Rural Development (MOHURD). 2007. China Urban and Rural planning Law. 29 October 中华人民共和国城乡规划法 http://www.MoHURD.gov.cn/zcfg/fl/200710/t20071029_159509.htm

There are primarily two central government bodies engaged in the promotion, development and evaluation of eco-cities, namely, the Ministry of Housing, Urban-Rural Development (MoHURD) and the MEP. The regulatory and approval framework for the development and construction of government-sanctioned eco-cities appears to fall under the purview of the MoHURD.

On the other hand, the MEP accredits national level eco-cities and various other ecological demonstration sites such as Eco-Provinces, Eco-Counties, and National Environmental Protection Model Cities throughout the PRC. Both ministries are involved in the setting of eco-city performance standards in the PRC. The MEP recommends performance standards for eco-cities, eco-counties, and eco-provinces. These standards, which were first issued in 2003 and revised in 2007, cover social, economic, and environmental aspects, with the highest number of 36 indicators at the eco-county level, while there are 28 indicators at the eco-city level and 22 at eco-province levels.[4]

The MEP's eco-city standards per capita GDP, such as annual per capita income, energy and water consumption, and compliance rate for clean production are yet to be pronounced. Environmental indicators include proportion of forest cover, proportion of protected areas, air and water quality levels (per CNY10,000), municipal and industrial solid waste treatment rates, noise pollution, per capita urban green space, and level of investment in environmental protection. Social indicators include urbanization level, Gini ratio (at province level), public satisfaction with the environment. At least 80% of counties within the administrative control of the city should meet the eco-province standards and the primary city should have National Environmental Protection Model City status accorded by the MEP. Although local governments are expected to lead such projects, the performance evaluation and monitoring are carried out by the local MEP offices and reported back to the central MEP.

Since 2009 MoHURD and the Chinese Society for Urban Studies (CSUS) have embarked on a "Eco-city Assessment and Best Practices Program". The project is in its preliminary phase and a survey has been released to obtain feedback from various parties on their perspectives on key performance indicators for an eco-city in China. The Eco-City Index System to be developed is intended as a measurement tool to guide and measure the China´s eco-city planning and development, as well as existing eco-city practices. Individual cities, like Tianjin, Zhuhai or Guiyang, have attempted to develop their eco-city indicator systems. However, so far, these indicators are still being tested. The Tianjin key performance indicators, supported by MoHURD, seem to be by far the most concise of these indicator systems.[5]

The relevance of performance indicators is well recognized since the beginning of the eco-city movement. In 2009, the World Bank published a first review of key performance indicators (KPIs) of the Sino-Singapore Tianjin Eco-City (SSTEC). [6] This KPI system became the first major exercise of this nature in China. Since then, several others have followed, Caofeidian, Guiyang, and Zhuhai, to mention just a few.

This study takes stock of the status of eco-city indicators in China today, and proposes a list of workable indicators which shall be tested and utilized in the coming years. These indicators, here labelled as Sino-European Eco-City Key Performance Indicators have been compiled based on the toolbox work of the Europe-China Eco-City Link Project (EC-Link).

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[4] Ministry of Environmental Protection (MEP). 2008. *Revised Development Standards for Eco-County, Eco-City, Eco-Province.* 15 January 生态县、生态市、生态省建设指标(修订稿). Retrieved 20 July 2010 from http://sts.mep.gov.cn/stsfcj/ghyzb/200801/t20080115_116249.htm

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[6] World Bank. 2009. *Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China.* Technical Assistance Report. Beijing. www-wds.worldbank.org/.../PDF/590120WP0P114811REPORT0FINAL1EN1WEB.pdf

2 Objective of the Key Performance Indicators (KPIs)

Key Performance Indicators (KPIs) are developed as a part of a strategic management tool. They need to be easy to measure, and need reflect well the monitoring needs of MoHURD.

MoHURD as the urban oversight agency will need to monitor the evolution of eco-cities. Besides the issuance of implementation guidelines and technical handbooks, KPÏs will be an important strategic management tool.

KPIs shall reflect economic, social, environmental issues and reflect on resource efficiency. The proposed indicators are closely aligned with 9 sector of MoHURD concern which are also the sectors of the EC-Link project: Compact urban development, green buildings, green transport, clean energy, water management, solid waste management, urban renewal and revitalization, green industries, and municipal finance.

The objectives of this study is the compilation of relevant and tested indicators and the creation of a KPI system for these 9 sectors. These KPIs shall become MoHURD´s working tools during the current 13th Five-Year Plan period.

The proposed KPIs shall represent a summary of primary indicators. There can be many secondary more detailed sets of indicators which may be utilized if a more detailed sector assessment is to be made. In this study we will largely limit the focus on the primary indicators, and provide indications of secondary indicators where available (see Section 5 of this document).

3 Existing Indicator Systems

The present study makes full reference to existing indicator systems which were developed during the recent 10 years. The most prominent ones are listed below:

- Innovative Green Development Program (iGDP). 2015. *Low Carbon Cities in China: National Policies and City Action Factsheets.* http://www.efchina.org/Attachments/Report/report-cemp-20151020/1_CityPolicyFactsheet_EN.pdf
- Qiu Baoxing. 2012. Combine idealism and pragmatism – a primary exploration of setting up and implementing low carbon eco city indicator system in China [in Chinese], China Construction Industry Publisher. Beijing
- UN-Habitat and Tongji Urban Planning & Design Institute, Shanghai. 2014. Guiyang Green and Sustainable City Programme – Sustainable City Reviews. See also: Guiyang Municipality. 2015. Guiyang Eco-Civilization City Indicators System. Guiyang (unpublished report).
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- Tianjin Eco-City. 2012. 26 Key Performance Indicators of Tianjin Eco-City. www.tianjinecocity.gov.sg
- SWECO. No date. Caofeidian - Detailed ecological indicators system [unpublished document].
- CSUS. 2015. Zhuhai Eco-city Civilization Indicators. [unpublished report].
- MoHURD/Center of Science & Technology Cooperation (CSTC). 2015. *Appraisal standards for Green Eco-City/District Planning (draft)*. Beijing [Unofficial Translation].

In addition to the above there exist a number of technical documents which also provide important leads to indicators which we recommend to utilize in the proposed set of Sino-EU Key Performance Indicators. Such sources will be mentioned in Section 4 and Section 5 of this document.

Many indicator systems cover aspects of carbon emissions, climate action, natural environment, economic and social development, or even cultural development. Although such dimensions can be considered relevant, it is proposed for the purpose of these MoHURD eco-city indicators, not to include these wider aspects.

Key Performance Indicators NOT covered

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
	Carbon Emissions		
1	Peaking of total CO2 emissions [1]	40-45% (of 2005 levels)	By 2020 [Stockholm]
2	CO2 emissions per unit of GDP [1]	40-45% by 2020 60-65% by 2030 [compared to 2005 levels] [1]	
3	Total GHG emissions from building sector	-Total value -Value per m2	
4	Energy consumption per unit GDP [1]	≤150 ton-c/mil US$ GDP [1]	Immediate [1]
5	Non-CO2 GHG emissions reduction [1]		By 2020
6	atmospheric emissions of SO2, NOx, and small particles from: -residential energy use -transport	- -	

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
	-energy sector -industries -others	-___ -___ -___	
7	Climate change plans established		By 2020
8	GHG emissions inventories available		By 2020
9	GHG Reporting and Registry available		By 2020
10	Carbon market operational		By 2020
	Natural Environment		
11	Days with good air quality – SO2, NO2, PM10 indexes [2]	≥320 days/year No of days exceeding China's National Ambient Air Quality Grade II Standard ≥310 (85% of 365 days). No of days not exceeding limits Grade 1 standard ≥155 (85% of 310 days). Meet standards of GB 3095-1996 [4]	Immediate. Immediate. By 2013.
12	Days of PM2.5 standard reached [2]	≥292 days/year	
13	Areas with noise levels reach standard levels – for different functional zones [dB(A)] [2 / 4]	≥95%[2] 100% [4] indicator not clear -Regional level -Main arteries	Immediate
14	Preparedness for disasters [2]	- Institutions prepared through training: 100% - Basic infrastructure secured and back-up created: 100% - Emergency shelters ≥3 m2/person [2]	
15	Net loss of natural wetlands [4]	0 [4]	Immediate
16	Monitoring of air, water and soil pollution	Available monitoring stations ___	
	Economic and Social Development		
17	Income per capita	___ RMB / year [Relevance?]	
18	Employment ratio [2]	Proportion of green industry jobs in total jobs [3]; Registered unemployed [3] ≤4.20% [2]	
19	Local revenue [3]	Proportion of Added value for strategic new industries in GDP [3]	
20	Ecological civilization	Green education and green practice focused on youth area taken; Green Action Day activities are organized, various education mode and platforms are developed	
21	Carbon emission per unit GDP [2]	≤2.13 [2]	
22	Energy consumption per unit GDP (ton standard coal/10000 RMB) [2]	≤0.87 [2] ≤0.4 [7]	
23	R&D scientists and engineers per 10.000 labour force [4]	≥50 person-year [4]	By 2020 [4]

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
24	Proportion of social housing [4; 2]	≤20% [4; 2]	By 2013 [4]
25	Housing price – income ratio [2] [10]	≤20 times [2] ≤10 times [7]	
26	Employment-housing equilibrium index [4] Job-resident ratio in districts ≤10km2 [8] [18]	≥50 % (of residents in employment locally) [4] 0.8-1.2 [8] [18]	By 2013 [4]
27	Gini index [2] Inhabitants happiness index	0.33≤G≤0.4 [2] ≥85%	
28	People covered by social welfare system [2]	≥90% [2]	

Note: for sources, refer to table in **Section 4**.

4 Proposed Sino-EU Key Performance Indicators for Eco- Cities

The proposed indicators are cover the 9 MoHURD sectors. The number of indicators in this current draft version is 73.

Sino-EU Key Performance Indicators for Eco-Cities

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
	Compact Urban Development		
1	Average built-up area per capita (m2/pers) [2]	≤85 m2/pers [2] ≤100 m2/pers [14]	
2	Parks within a 500m radius [2] [11] Coverage of green areas [11]	≥80% [2] ≥100% [11] 20-40% [11]	
3	Public green space [2; 4] Proportion of green areas [8]	≥12 m2/pers [2] ≥35%	By 2013 [4]
4	Average land area for public facilities per capita [2] Proximity to amenities: schools, post offices, banks, retails, clinics, activity centres, restaurants, etc. [11]	≥5.5 m2/pers [2] ≤500m [11]	
5	Provision of free recreational and sport facilities within walking distance of 500 m [4]	100% [4] Walking distance to parks≤400m [3]	By 2013 [4]
6	Mixed land-use land [6]	20% [6]	
7	Residential density [11] Residential blocks [11]	10,000/km2 [11] ≤ 2 ha (= 20,000 m2) [11]	
8	Density : Floor Area Ratios (FAR) – 10-50 storeys [12]	2.7- 8 [12]	
9	Transit-oriented Development (TOD) around public transit systems [12] Floor area ratio (FAR) [12] Great accessibility (pleasant walking amenities to transit system within 500-meter radius) [12]	≤ 500-800 m to major transit stations (metro or bus rapid transit (BRT) [19] ≤ 500 m of nearest bus or transit stops (in case BRT or Metro is not available) For the city as a whole: ≤ 90% within 800m of public transit station. FAR 50% higher (big cities 70%) than the average FAR of the district. 90% ≤ 500 m radius [12] [18]	
10	Heat island effect density	<3.0℃ 70% of road, building roof areas with reflection coefficient ≤ 0.4	
11	Ambient noise meeting ambient noise standard GB 3096	≥80%	
12	Flood prevention as per national design standards GB50201 and GB50805 [8]	100% [8]	
	Green Buildings		
13	Percentage of green buildings [2]	existing buildings≥15% [2]	Immediate [4] By 2020 [12]

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
	Renewable energy percentage (R) [18]	newly-built = 100% [2] [7] $R_{hotwater}$ =30-80% [18] $R_{cooling/heating}$ =20-80% [18] $R_{electricity}$.=1- 4% [18]	
14	Public buildings with green standards [7]	100% [7]	
15	Passive house standard: Annual primary energy consumption for heating, cooling, lighting [16] Fresh air [16]	≤ 60 kWh/m^2.a (or 7.4 kgce/m^2.a) [16] ≥ 30 m^3/h.p [16]	
16	New buildings - Annual heating consumption: Severe Cold Climate Zone	≤ 18 kWh/m^2.a [16]	
17	New buildings - Annual heating consumption: Cold Climate Zone	≤ 15 kWh/m^2.a [16]	
18	New buildings - Annual heating consumption: Hot Summer And Cold Winter Climate Zone / Hot Summer And Warm Winter Climate Zone / Mild Climate Zone (National Standard GB 50189)	≤ 5 kWh/m^2.a [16] -heating in winter ≤ 20°C [8] - cooling in summer ≥ 26°C [8]	
19	Annual cooling demand kWh/m2.a	≤3.5+2*WDH20+2.2*DDH28 Where WDH20 $= \sum T_{hourly.\,outside\,wet-bulb\,temperature} - 20$ (when the hourly wet-bulb outside temperature higher than 20°C) DDH28 $= \sum T_{hourly.\,outside,Dry-bulb\,temperature} - 28$ (when the hourly wDry-bulb outside temperature higher than 28°C)	
20	Air tightness – Air change rate	≤ 0.6^{-1} at 50 Pa pressure difference	
21	Existing buildings – retrofit [7] Annual heat demand	≥10% of building stock [7] Existing buildings: ≤50 kWh/m2/year	
22	Elimination of harmful building materials [6] Use of prefabrication [13]	0 % of harmful materials [6] ≤30% of all buildings [13]	By 2025
23	Central heating coverage [10]	≥65% [10]	
24	Indoor air quality: radon density [6] More relevant for the building would be (meet national standard GB/T 18883-2002: – CO2 – ventilation rates – TVOC – HCHO – Formaldehyde	<50Bq/m3 [6] GB/T18883-2002: - Fresh air >30m^3/(h.p) - CO_2<0.1% (1000ppm) - TVOC<0.6mg/m^3 - HCHO<0.1mg/m^3 - Radon<400Bq/m^3	
	Green Transport		
25	Traffic related emissions reduced [13]	By 15%	By 2020 [13]

[7] Other indicators related to % of star-rated green buildings not considered relevant: 70% One-Star category; 20-40% Two-Star category; 15% Three-Star category [11].

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
26	Share of green traffic in total transport [2] % or green trips [5] Modern public transport systems in new residential areas	≤30% [4] ≥65% [2] [8] ≥70% [5] ≤40% of all new residential areas [13] -person-km, or -ton-km	By 2013 By 2020 [5] By 2020 [13]
27	Number of energy efficient cars per 10K vehicles [3]	__ /10K vehicles	
28	Ratio of clean energy buses [7]	≥80% [7]	
29	Average commuting time [2]	≤35 minutes/trip [2] ≤45 minutes/trip [3]	
30	Barrier free accessibility [4]	100% [4]	Immediate [4]
31	Non-motorized traffic: Dedicated-connected walking paths [11] Dedicated-connected biking paths [11] Bicycle lane width [8]	≤10Km in length/km2 [11] ≤10Km in length/km2 [11] ≤1.5m [8]	
32	Share of green transport Use of public transport Walking and cycling	90% [4] 60% [4] 30% [4]	By 2020 [4] By 2020 [4] By 2020 [4]
	Clean Energy		
33	Coal utilization rate of city [3]	__ % of total energy consumption	
34	Total residential energy input for heating and cooling within city boundaries. - Decentralised heat/cold generation (fossil energy sources, district heating and part electricity delivered to residential customers) - Delivery chain losses in district heating and electricity chain (distinguishing source of generation)	__ kWh/(m2a) __ kWh/(m2a) __ kWh/(m2a)	
35	Use of non-fossil energy [2] Renewable energy usage in buildings [4] Share of renewable-clean energy [8]	≥15% [2] ≥20% [4] ≥30% [1] ≥60% [6] ≥10% [8]	By 2020 [4] By 2030 [1]
36	Renewable energy generation: combined heat and power (CHP), waste to energy, and waste heat re-use [12]	5-15% local renewable energy generation for residential areas 2-5% for commercial areas [12]	By 2020 [12]
37	Emissions from district heating (based on renewable energy coefficient 0:8)	Reduced by 50% 105 kWh/(m2a) gross area	
38	Metered heating provision [13]	100% [13]	By 2020 [13]
	Water Management (Water Supply, Waste Water Treatment, Drainage and Storm Water Management)		
39	Quality of water bodies [4]	Grade IV surface water quality standard GB 3838-2003 [4]	By 2020
40	Water quality at centralized source reaches standard [2]	100% [2]	
41	Water quality at user level [2] Services network coverage [4]	100% [2] 100% [4]	` By 2013 [4]

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
42	Water from taps with drinking water quality [4] Drinking water Grade III standard [10]	100% 100% [10]	immediate
43	In buildings: adoption of cost-effective water saving appliances [11] Water leakages as per standard CJJ92 [8]	100% [11] ≤8 % [8]	By 2020 [11]
44	Rate of reuse of reclaimed water (%) [2]	In water-scarce areas ≥25%: in areas without water scarcity ≥15% [2] ≥60% [7] Water deficient cities: ≥20% [13]	
45	Domestic water consumption [4]	≤ 120 liters / day.pers.[4] Not higher than the average of lower & upper limits of GB/T50331 [8]	By 2013 [4]
46	Water supply from non-traditional sources [4] Water supply from recycled wastewater or rainwater [11]	≥50% [4] 20-30%[11] ≥85% [18] ≥10% [8]	By 2020 [4]
47	Water permeability of surface areas [9]	≥50% [9]	
48	Wetland conservation [8]	≥80% [8]	
49	Sanitation coverage, waste water treatment [13]	100% [13]	By 2020 [13]
50	Grey water treatment and reuse	50%	By 2020
51	Sponge city infrastructure contributes to water harvesting	30% of water supply	By 2020
52	Drainage and sponge city measures eliminate urban flood events	100%	
	Solid Waste Management		
53	Domestic waste generation [4]	≤ 0.8 kg / day / person [4]	By 2013 [4]
54	Garbage collation ratio [6] - Household waste - Businesses, institutions - Other activities	100% [6]	
55	Treatment to render hazardous and domestic solid waste non-toxic [4]	100% [4]	Immediate [4]
56	Rate of reuse of domestic waste [2]	Non-hazardous waste: 100% Recycling rate: ≥50% [2] reuse rate ≥50% [2] [11]	
57	Overall Solid waste recycling rate [4]	≥60% [4]	By 2013 [4]
58	Waste conversion to energy [7]	__ % of total waste __ KW of energy produced	
59	Recycling of building waste [7]	≥98% [7]	
	Urban Renewal and Revitalization		
60	Identify cultural heritage areas and buildings in all cities [13]	100% [13]	By 2020 [13]
61	Retrofitting of existing buildings	≥15% [2] ≥10% [7]	By 2020 [13]
62	Annual heat demand: Existing buildings	≤ 45 kWh/(m^2a) [15]	
63	Use of non-fossil energy [2] Renewable energy usage in buildings [4]	≥15% [2] ≥20% [4] ≥30% [1] ≥60% [6]	By 2020 [4] By 2030 [1]
64	Transformation, rehabilitation and integration of shanty towns [17]	100% [17]	By 2020

	Indicator Category	Indicators: indicative values	Current achievements / Time frame for accomplishment
	Green Industries		
65	Investment in Clean Industries	(¥ bn)	
66	Relevance of Clean Industries	Value of industrial production (¥ bn) Value of commerce (¥ bn)	
67	Share of green industry [8]	≥20% [8]	
68	Rate of reuse of industrial water [2][10]	≥90% [2] ≥80% [10]	
69	Use of non-fossil energy [2] Use of new energy [7]	≥15% [2] ≥3% [7]	
70	Rate of reuse of industrial solid waste [2] [10] [7] Hazardous waste treated [8]	≥90% [2] [10] ≥95% [7] __ % of hazardous waste treated	
71	Environmental impact of industries	__ (as per Env. Impact Assessment)	
	Municipal Finance		
72	Access to finance	National support __ (¥ bn) – as % of total investments. Own revenues __ (¥ bn) – as % of total investments.	
73	Green finance (special fund; green bonds) [8]	__ (¥ bn) – as % of total investments [8]	

Sources:

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The following section of the document will elaborate on these primary indicators, and provide some background and secondary indicators.

5 Main Parameters and Secondary Indicators

5.1 Compact Urban Development

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the 13th Five Year Plan objectives has stated three key objectives (i) Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly: (ii) city development shall be in accordance with the carrying capacity of resources and the cultural context. Green planning, design and construction standards shall be applied; and (iii) support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

The issue of density, and the right density-transport mode remains an unresolved issue: Transport planners have estimated, that the right mixture of high-density urban land use mixtures, avoidance of travel requirements, and good choices between public transport, non-motorized traffic and walking as an option, could reduce the energy requirements by 25%. “It is important that China continues to target inefficiencies and invest in energy conservation for example through stricter building codes.” [8]

The China Development Bank Capital (CDBC)’s policy document for Green Urban Development states several principles for compact urban development:

- **Urban Growth Boundary:** Every city should establish an enforced urban growth boundary (UGB). The UGB should be set based upon a rigorous analysis of ecological sensitivities, environmental capacity, and the efficiency and productivities of various land uses. The boundary can expand beyond the existing urban footprint only if there are no suitable infill locations as indicated by an intensity of urban land use of at least 10,000 residents per square kilometer.
- **Mixed Use:** All residential units should be close to at least six kinds of amenities within 500-meter radius of building entrance (amenities include schools, post offices, banks, retails, clinics, activity centres, restaurants, etc.). The job-resident ratio (the number of people employed divided by the number of residents) should be between 0.5 and 0.7 over every commuting district, which should have a spatial area that is no more than 15 km^2. Normally, these commuting districts are bounded by physical barriers for pedestrians.
- **Small blocks**. Blocks should be less than or equal to 2 hectares and 70% of the blocks should comply with this standard. Exceptions are made for industrial areas.
- **Public green space.** Publicly accessible and usable green space should comprise 20-40% of the construction areas (residential area should be at the higher end of this range). All residents should have accessible public space within 500 meters. [9]

Proposed urban density targets. The *Design Manual for Low Carbon Development*[10] as per the China Sustainable Cities Program has made the attempt to quantify floor areas rations (FAR), or floor space indexes (FSI), for diverse type of developments, ranging from mid-rise residential to highly compact commercial developments (Table 2). The range covers 10 storey to 50 storey developments, or FAR of 2.7 to 8.0. This range is substantially above the densities achieved by Eco-City pilots like the Sino-Singapore Tianjin Eco-City (SSTEC), or other current eco-cities in China.

[8] Creutzig, Felix; Baiocchi, Giovanni; Bierkandt, Robert; Pichler, Peter-Paul; Seto, Karen. 2015. A Global Typology of Urban Energy Use and Potentials for an Urbanization Mitigation Wedge, Proceedings of the National Academy of Sciences. http://www.mcc-berlin.net/~creutzig/CreutzigPNAS2015.pdf

[9] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

[10] The Energy Foundation - China Sustainable Cities Program (ed.). 2011. *Design Manual for Low Carbon Development.* p .46. http://www.chinastc.org/en/research/34

Development Standards Matrix as per the China Sustainable Cities Program.

	Mid-Rise Residential	High-Rise Residential	Tower Residential	Mid-Rise Commercial	High-Rise Commercial	Tower Commercial
Maximum building Height	10 storeys Max 46 m.	20 storeys Max 91 m	33 storeys Max 149 m	16 storeys Max 96 m	30 storeys Max 180 m	50 storeys Max 300 m
Total Maximum FAR	2.7	3.5	4.0	4.0	6.0	8.0
Minimum/maximum Sidewalk Commercial / FAR	0.12 / 0.4	0.12 / 0.4	0.12 / 0.4	0.3 / 0.65	0.5 / 1.3	0.5 / 2.0
Building Coverage Max.	40%	40%	40%	65%	65%	65%
Green Coverage Min.	30%	30%	30%	20%	20%	20%
Street Frontage	Min. 70% facing East/West streets Min 60% facing North/South streets			Min. 70% facing all streets		
Maximum and Minimum Street Front Setbacks	0-2 meters @sidewalk commercial 1-3 meters @office 3-5 meters @ residential 0-1 meters @ within 15 meters of intersection					
Solar Spacing – all ´small blocks´	North side- Building height limited to adjacent street right of way dimension plus building setback Block interior – maximum 45 degrees from building to the bottom of the first residential floor of the building to he north (e)			Building elements 7-16 stories must be placed to provide 45 degrees solar setback to any residential property lines to the north		
Tower elements – Maximum Floor Plate	NA	NA	400 m2 for tower element above 20 storeys	NA	1,200 m2 for tower element over 16 storeys	1,200 m2 for tower element over 16 storeys
Primary Pedestrian Entry	Primary entry must be located on and directly accessible to the most important public space or street. Multiple entries are encouraged.					
Parking Structure	Above grade structure must include sidewalk commercial use at ground floor where fronting street. Below grade preferred.					
Maximum Parking Ration	1 space per dwelling unit. Other uses as per existing code.					
Parking Entry	No entry off major streets 50 meters or greater. No entry within 20 meters of intersection.					

Source: The Energy Foundation - China Sustainable Cities Program (ed.). 2011. *Design Manual for Low Carbon Development.* p .46. http://www.chinastc.org/en/research/34

Urban design and configuration impacting density. One of the issues that needs to be resolved in China´s urbanization is the type of urban configuration and the type of density which will be applied. There is ample evidence that current new towns in China are not efficient in terms of space use and that they lack in density compared to European cities. A more rigorous exploitation of the transit oriented development (TOD) paradigm is recommended, as evidenced by the *Design Manual for Low Carbon Development*, developed by the Energy Foundation under its China Sustainable Cities Programme. The nine principles for sustainable urban development are highly important for eco-city development:

1. **Develop neighborhoods that promote walking** – by breaking down the block and street sizes, mixing users, and clustering density near transit, the neighborhood will be more functional, safe, and pleasurable for walking.
2. **Prioritize bicycle networks** – these facilities should be developed while maintaining traffic access.
3. **Create dense networks of streets and paths** – the smaller the block sizes allows for a more intensive and robust system of streets and paths,
4. **Support high-quality transit** – by clustering development near stations and by promoting job/ housing balance, promoting the health and efficiency of the metro system. Street designs include the possibility of transit-only lanes for fast and dependable services.
5. **Zone for mixed-use neighborhoods** – blocks and place types need to be mixed-use and allow many trips to be made locally at distances which promote walking and bicycle use.
6. **Match density to transit capacity** – recognize the high transit accessibility of public transport systems supporting the significant density of neighborhoods, including housing, employment, retail and civic uses.
7. **Create compact regions with short commutes** – by accommodating growth in appropriate locations, reducing pressure on developable land in more peripheral locations.
8. **Increase mobility by regulating parking and road use** – by reduction or elimination of minimum parking requirements. Parking can be sensibly included without impacting negatively the liveability.[11]

To achieve the proposed high-density neighborhoods, the *Design Manual for Low Carbon Development* proposes four approaches:

- Break up dominant arterial superblocks, and create a network of smaller blocks.
- Combine transit-oriented development (TOD) with the development of smaller blocks.
- Concentrate densities at transit stations, developing hierarchies of centers – commercial center, urban centers, and town centers.

Transform the superblock grid into an urban network of roads, consisting of arterial avenues, one-way streets, auto-free streets, and local neighbourhood streets.

5.2 Green Building

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the 13th Five Year Plan objectives has stated that green planning, design and construction standards shall be applied. The new policy will support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission. It will promote combined heat and power (CHP) in residential districts, green lighting, energy conservation; and improve heat production efficiency. Newly built residential buildings must be equipped with individual measurement of household heating consumption, while that shall be gradually provided for existing residential buildings.

The China Development Bank Capital (CDBC)'s policy document for Green Urban Development states several principles for the green building sector:

- **Green Building:** At least 70% of buildings should be MoHURD One-Star, 20-40% of buildings should be MoHURD Two-Star, and 5-15% of buildings should be MoHURD Three-Star within any development. [12]
- **Smart Technologies:** Smart lighting Systems, and smart grid technologies which support higher energy performance targets.

[11] Adopted from: The Energy Foundation (ed.). 2011. *Design Manual for Low Carbon Development*. Sustainable Cities Program. http://www.chinastc.org/en/resource/65/479

[12] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

In January 2015, China introduced its new ¨Green Building Evaluation Standard¨, replacing an earlier Green Building Evaluation Standard (GB 50378-2006) of 2006 (GBES). The current green building rating system uses a three star system which has some similarities with the LEED system of the US. [13]

MoHURD´s green building evaluation standard is China´s first attempt to create a local green building standard. So far, the Three Star System lacks hard criteria for assessment. This has stimulated other methodologies for the assessment of building physics buildings. The purpose is to create a voluntary rating system that will encourage green construction. The purpose of introducing this green building concept is to regulate evaluation of green buildings. The system introduced in 2006 is credit-based and allows developers to choose which credits they want to pursue. The evaluation system has two different standards one for residential buildings and one for public buildings (i.e. large commercial complexes. The rating system will particularly rate those buildings or building complexes which consume much energy and resources.

The evaluation standard rates buildings with a variety or prerequisites (¨control items¨) and credits (¨general items¨), covering six categories: (i) land savings and outdoor environment; (ii) energy savings; (iii) water savings (iv) materials savings, (v) indoor environmental quality; and (vi) operations and management. The seventh category, ¨preferred items¨ contains strategies that are both cutting edge and harder to implement, such as brownfield redevelopment, more than 10% on-site renewable power generation, etc. [14]

China´s 2006 Star Rating System for Green Buildings – Residential Buildings

Grade	General Items (Total: 40 Items)						Preference Items (Total: 9 Items)
	Land Saving & Outdoor Environment (Total: 8 items)	Energy Saving & Energy Utilization (Total: 6 items)	Water Saving & Water Resource Utilization (Total: 7 Items)	Material Saving & Material Resource Utilization (Total: 7 Items)	Indoor Environment Quality (Total: 6 Items)	Operating Management (Total: 7 Items)	
★	4	2	3	3	2	4	-
★★	5	3	4	4	3	5	3
★★★	6	4	5	5	4	6	5

Source: China´s green building evaluation standard and comparison to the LEED rating system, in: http://www.neec.no/uploads/Article,%20China%green%20building%20standard.pdf

China´s 2006 Star Rating System for Green Buildings – Public Buildings

Grade	General Items (Total: 43 Items)						Preference Items (Total: 14 Items)
	Land Saving & Outdoor Environment (Total: 8 items)	Energy Saving & Energy Utilization (Total: 10 items)	Water Saving & Water Resource Utilization (Total: 6 Items)	Material Saving & Material Resource Utilization (Total: 8 Items)	Indoor Environment Quality (Total: 6 Items)	Operating Management (Total: 7 Items)	
★	3	4	3	5	3	4	-
★★	4	6	4	6	4	5	6
★★★	5	8	5	7	5	6	10

[13] www.newwayswiki.org

[14] All of these seem still in their early stage as some of this conceptual work shows. Fu Qingpeng, Guo Li; Zhu Zhigang. 2011. Study on the evaluation of green building design based on the comprehensive fuzzy evaluation principles, in: *Electric Technology and Civil Engineering* (ICETCE), 2011 International Conference. Lushan. 22-24 April 2011.

Source: China´s green building evaluation standard and comparison to the LEED rating system, in: http://www.neec.no/uploads/Article,%20China%green%20building%20standard.pdf

In October 2015, MoHURD issued its Technical Guideline for Ultra-low Energy Consumption Green Building which – for the first time – include technical data which must be seen as performance indicators:

Technical Indicators[15]						
		Severe Cold Climate Zone	Cold Climate Zone	Hot Summer And Cold Winter Climate Zone	Hot Summer And Warm Winter Climate Zone	Mild Climate Zone
Energy consumption	Annual heating consumption (kWh/m².a)	≤ 18	≤ 15	≤ 5		
	Annual cooling consumption (kWh/m².a)	≤ 3.5 + 2.0xWDH20[16] + 2.2xDDH28[17]				
	Annual primary energy consumption for heating, cooling, lighting	≤ 60 kWh/m².a (or 7.4 kgce/m².a)				
Air tightness	Ventilation rate N_{50}	≤ 0.6				
Indoor Environment						
Indoor Environment		Winter		Summer		
Temperature (°C)		≥ 20		≤ 26		
Relative humidity (%)		≥ 30[18]		≤ 60		
Fresh air (m³/h.capita)		≥ 30				
Noise dB(A)		Daytime ≤ 40 ; night time ≤ 30				
Uncomfortable temperature		≤ 10%[19]		≤ 10%[20]		

SSTEC green building indicators. The case of the Sino-Singapore Tianjin Eco-City (SSTEC)´s green building standards may be taken here as an important example for real life standards. SSTEC´s key performance indicator for buildings is 100%. The 100%-target is ambitious considering that at the time of its establishment in Tianjin there were practically no experiences with green building. This target makes it higher than the national green building standard. However, the standards for energy efficiency in SSTEC still follow Tianjin´s existing building codes. Thus, a point of major concern in the case of SSTEC´s building standard will be the energy performance, in fields of heating, cooling and air conditioning. In Tianjin there are few resources of renewable energy other than solar energy which could be used for water heating and street lighting.[21]

[15] Abstract from MoHURD. Technical Guideline for Ultra-low Energy Consumption Green Building, October 2015. http://www.mohurd.gov.cn/wjfb/201511/t20151113_225589.html

[16] Wet-bulb degree hours 20

[17] Dry-bulb degree hours 28

[18] The relative humidity in winter doesn't count.

[19] The rate of accumulated hours per year when indoor temperature is under 20 °C while there is no heating.

[20] The rate of accumulated hours per year when indoor temperature is above 28 °C while there is no cooling.

[21] World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, p. 28.

All Buildings in SSTEC are to follow the Green Building Evaluation Standard (GBES), developed with guidance from MoHURD. According to GBES, the nominal energy use for heating of housing units is required to be at least 65% less (and at least 50% less for all public buildings), than those constructed in the 1980s. The GBES specifies that heating and cooling systems, and lighting as well as building appliances should use highly energy-efficient equipment. Renewable energy should make up 10% of energy consumption in residential buildings, and 15% in public buildings. Central heating, assuming with the utilization of renewable energy, is supposed to reach 100%, while in Tianjin, the target is 90% by 2015.

Green Buildings and Energy – Key Performance Indicators

KPI Area and Details	Indicative Value	Timeframe	Domestic standards	Domestic Benchmarks	International Benchmarks
Proportion of green buildings	100%	Immediate	• National standard for Green building GB50378-2006 • Technical Manual for Green Building Evaluation • Garden City standard: ≥ 50% energy-efficient buildings and green buildings	• China: less than 1% (current); 100% for Olympics buildings • Energy-efficient buildings: 16% of existing buildings in cities and towns (2008); 71% of newly built buildings (2007) • BJ: energy efficient buildings: 49.93% of existing buildings	• Singapore: building area exceeding 2,000 m^2 should be 100% green building
Services network coverage	100%	By 2013	• Eco-City standard: 65% Gas • Garden City Standard 80%	By 2013 Central Heating: • TJ: 83.2% (2005); TJ Plan≥85%(by 2010); ≥90% (by 2015) • BHNA: 75% (2005); ≥88% (by 2010)	
Renewable energy usage	≥ 20%	By 2020	• No national standard	• China 70% (current), Plan: 10%, 15% (by 2020) • BJ Plan: 4% (by 2010), Olympics venue: 26.9% (2008) • Caofeidian Eco-city Plan: 50% (by 2020)	• Finland: 25% • Sweden: 33.3% • Holland: 20% (by 2020) • EU: 20% (by 2020)

Source: World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, p. 29.

Green Building Evaluation Standard. Complementary to the new Green Building Evaluation Standard (GB/T 50378-2014), MoHURD has also compiled three detailed regulations, which are the "Technical Detailed Regulation of Green Building Evaluation Standard, Management Regulation of Green Building Classification", and "Implementation Regulation of Green Building Classification". At local level, provinces such as Jiangsu and Hunan issued Green Building Evaluation Standard in their autonomy. Besides, more than twenty standards and regulation at central and local level in various technical fields related to green building, such as energy saving design and assessment, is currently in use.[22]

A comparison of SSTEC´s green building evaluation standard, with those of the country in general, and neighboring Tianjin city, indicate that SSTEC aim higher for all indicators.

[22] Zhang Mingshun et al. 2014. Handbook Green Building Development. Chemical Industry Publisher. P. 6-12

Comparison of SSTEC GBES and National GBES for Residential Buildings

Category	SSTEC GBES	National GBES	Current Tianjin Requirements**
Land conservation and outdoor environment			
Per capita land occupation	Low rise: <43m^2, mid to high rise:<24m^2, high rise: <15m^2	NSR*	NSR
Green coverage	>=35%, >=2 m^2 per capita	>=30%, 1-2 m2 per capita	NSR
Roof green coverage	>=10%	NSR	NSR
Public transportation	Less than 500 m walking distance	General elective item	NSR
Other items such as flood and radiation protection, day lighting and natural ventilation, and noise limit.	Refer to national standards	Refer to national standards. Standard on noise is a general elective item.	National standards
Energy conservation and utilization of energy resources			
Building energy efficiency	Refer to Tianjin standard	Refer to national standard and local standards.	Tianjin standard: 65% heating energy savings
Sunlight hours	Two hours during the “Severe Cold Day”	same	same
Renewable energy	10% of the total building energy consumption	General elective item: 5% of the total building energy consumption; Preferred elective item: 10%.	NSR
Lighting	Refers to national standard	General elective item	National standard
Water conservation and utilization of water resources			
Utilization rate of non-conventional water resources	No lower than 20% by 2012.	General elective item: no lower than 10%.	NSR
Other items such as water system design, water conservation equipment, use of non-conventional water.	Refer to national and Tianjin standards and regulations	Qualitative descriptions and many are general elective items	National and Tianjin standards and regulations
Materials conservation and utilization of materials resources			
Wall materials	Use of clay cannot exceed 20%.	NSR	NSR
Limitation on toxic contents in building materials	Refers to national standards	Refers to national standards	National standards
Indoor environment quality			
Heat engineering	Refers to national standards	General elective item	National standards
Temperature control	Indoor temperature can be controlled when heating or air conditioning is used.	General elective item	Same as in SSTEC GBES
Other items such as day lighting, indoor air quality, and building accessibility.	Refer to national standards	Refer to national standards	National standards
Operation and management			

Building intellectual system	Includes security, telephone, cable TV, internet, and operation and management system. Refer to national standards	General elective item	National standards
*NSR: No specific requirement **Current requirements in Tianjin need to be checked with Tianjin			

Source: World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, p. 33.

The recommendation of the 2009 World Bank study concerning green building standard achievements, was that energy commissioning should be undertaken, to study the actual energy performance in SSTEC. Such energy commissioning is recommended at the design, or pre-construction phase as it can ensure more energy efficiency and lower operation and maintenance costs. It should be able to provide guidance on performance requirements over the lifespan of a project, and results in design specifications. Criteria need to be developed for at least 5 aspects: (i) lighting; (ii) air conditioning; (iii) water heating; (iv) appliances; and (v) controls. [23]

5.3 Green Transport

Policy Direction from the 13th Five Year Plan. Following the Central Urban Work Conference (20-21 December 2015) on 6 February 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development. Green transport is included under urban services: [24]

- **Complete urban public service**. The development of public transport enjoys priority. Until 2020, the share of super- and ultra-large public transport will reach 40%.[25]

The China Development Bank Capital (CDBC)´s policy document for Green Urban Development states several principles for the green transport sector:

- **Transit-oriented Development:** Cities should be built around their public transit systems. The area within 500-800 meters of major transit stations, such as the metro or bus rapid transit (BRT), or within 500 meters of nearest bus or transit stops (in case BRT or Metro is not available) should have FAR at least 50% higher than the average of the district. For big cities, at least 70% of residents should live in TOD areas characterized by convenient mass transit service. Great accessibility (pleasant walking amenities to transit system within 500-meter radius) must be offered).
- **Non-motorized Transit:** There should be dedicated and connected walking paths of at least 10Km in length per square kilometer, and dedicated and connected biking paths of at least 10 km in length per square kilometer in urban areas.
- **Public Transit:** All new developments must be within a 500-meter radius of a bus or rapid transit station. For the city as a whole, at least 90% of developments should be within 800-radius of a public transit station.
- **Car control:** Every city should have a strategy to cap car use. Where high-quality transit exists, there should be limits on parking.

Relationship between Smart and Green Guidelines

[23] World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, p. 34.
[24] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)
[25] See debate about this issue in China Daily http://www.chinadaily.com.cn/china/2016-02/22/content_23593906.htm).

Smart Guidelines	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Telecommuni-cations	All	An integrated operations center combined with a comprehensive data platform allows improved decision-making on all facets of the Green Guidelines. Cities can apply sensors in a number of ways to understand use of anything from resources to roads.	Wireless Sensors, Broadband Internet, Integrated Operations Center
Smart Mobility	Transit-oriented Developme nt	These smart technologies can use data to help people find the best route and integrate various modes of transportation to reach their final destination. Higher density areas are much easier to navigate when cities implement these technologies in conjunction with transit-oriented development.	Smart Bike-sharing Systems, Smart Traffic Management and Congestion Pricing, Smart Parking, Transit Data and Smart Payment
	Mixed-use	Mixed-use neighborhoods make travel distances much shorter and more walkable by having clear commuting districts. However, smart bike-sharing systems can offer a faster way to get to locations outside the neighborhood but within the commuting district.	Smart Bike-sharing Systems
	Non-motorized Transit	A great transit system integrates various transit options to allow users to optimize their routes—in other words, it is multi-modal. People are also more likely to combine walking with public transit, or biking with public transit, if transit systems offer accurate information and accessible payment systems. Smart bike-sharing systems can making biking more attractive and improve the bike-rail connection.	Smart Bike-sharing Systems, Transit Data and Smart Payment Systems
	Public Transit	Smart mobility technologies improve public transit services, increase ridership, and improve energy efficiency of public transit systems.	Transit Data and Smart Payment Systems
	Car Control	In addition to improving public transit or non-motorized transit systems to encourage people to drive less, smart parking can price parking more appropriately or shift more driving to off-peak hours through dynamic pricing.	All Smart Mobility technologies
	Small Blocks	Smaller blocks (hence more intersections) combined with smart traffic management system increases the flexibility in timing traffic signals to alleviate congestion and also adds more potential intervention points if the city chooses to use congestion pricing.	All Smart Mobility technologies

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

SSTEC green transport indicators. Achieving the Key Performance Indicators of the Sino-Singapore Tianjin Eco-City (SSTEC) for the green transport of 90% - with 60% using public transport, and 30% walking or cycling – may be attainable under today´s transport patterns, particularly given the high-share of non-motorized transport and the wide acceptance of public transport. [26] Notably, the SSTEC transport indicators do not (yet) have specific sub-indicators for leading-edge, low-emissions technologies in the bus fleet, private motor cars, and commercial vehicles. Such standards could promote ¨green¨ vehicles throughout the SSTEC community, and could provide

[26] World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing.

information on social and financial affordability, like the journey costs, transportation expenditures as percentage of income. For the measurement of financial sustainability of the public transport system, indicators such as the ration of operating costs (recurrent costs divided by operating revenues) could be used.

SSTEC Transport Sector Key Performance Indicators

KPI Area and Details	Indicative Value	Timeframe	Domestic Standards	Domestic Benchmarks	International Benchmarks
Proportion of green trips	≥ 30%	By 2013	• Garden city standard: proportion of public transportation ≥20% for big cities; ≥ 15% for medium cities.	• Tianjin (2000) : 91.5% • Tianjin plan: 75-80% (by 2020) • BHNA Plan: 65-75% (by 2020) • TEDA: 47.8% • Shanghai (2006): 56% • Beijing (2006): 64% Chongqing(2006): 88% • Hongkong SAR (2001) 83.8%	• Rio de janeiro 85% • Bogota 85% • Lima 84% • Moscow 73.7% • Curitiba 71% • Warsaw 71.4% • Budapest 66.9% • Sao Paulo 66.4% • Amsterdam 66.1% • Prague 64.4% • Vienna 64.0% • Berlin 60.8% • New York ≥60% • Tokyo ≥ 60%
	≥ 90%	By 2020			

World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, p. 50.

In 2003, Ministry of Housing, Urban and Rural Development (MoHURD) and Ministry of Transport (MoT) co-initiated the selection of demonstration city of green transport. For this initiative, the two ministries established a set of criteria for assessment of selecting demo cities. Though the selection criteria consist of less quantifiable indicators, they have been since then considered a relevant reference as a general standard of green transport. The criteria was constructed by five elements which are organization and management, planning and development, public transport, infrastructure, and transport environment. Each element has sub-indicators, which makes 66 indicators in total. [27]

5.4 Clean Energy

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated several key objectives for the energy sector:

- Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly.

- Pilot projects will be introduced to promote comprehensive use of combined heat and power, the wide-spread adoption of energy saving regulations in government agencies, and of municipal green lighting and other urban energy saving projects.

[27] MoHURD Website http://www.mohurd.gov.cn/zcfg/jsbwj_0/jsbwjcsjs/200611/t20061101_157091.html

- Technical specifications for the safety of heat supply will be introduced, as well as strengthened regulatory frameworks supporting urban energy savings, environmental protection and improved sanitation.

- Related service quality standards and evaluation methodologies will be optimized.

- Consumption-based billing for residential households will be promoted nationally, and all newly built residential buildings will need to be equipped with meters for heating, while existing buildings will be gradually retrofitted to reach 100% metered heat provision.

- Support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

New Urbanization Policy of 2016. This new policy aims to promote energy conservation: [28]

- Promote the district combined heat and power (CHP), green lighting, energy conservation in government departments; improve heat production efficiency; newly built residential buildings must be equipped with individual measurement of household heating consumption, while that shall be gradually provided for existing residential buildings.

The China Development Bank Capital (CDBC)´s policy document for Green Urban Development states several principles for the energy sector:

- **Renewable and District Energy:** Every project should analyze the potential for district energy, such as combined heat and power (CHP), waste to energy, and waste heat re-use. There should be 5-15% local renewable energy generation for residential areas and 2-5% for commercial areas.[29]
- **Smart Technologies:** Smart lighting Systems, and smart grid technologies which support higher energy performance targets:

Relationship between Smart and Green Guidelines

Smart Guidelines	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Energy Management	Renewable and Distributed Energy	Smart energy management technologies help to improve decision-making and even automates many decisions, which improves energy efficiency. Smart grid technologies help integrate a diverse mix of renewable and distributed energy sources to the grid and gives grid operators the flexibility to use the most efficient sources as conditions change throughout the day.	Smart Lighting Systems; Smart Grid Technologies
	Green Buildings	Even if a building is equipped with all the right energy efficient fixtures, building management systems can ensure that buildings actually capture these efficiencies. Otherwise, many green buildings end up operating at a much lower efficiency due to lack of robust management.	Building Management Systems

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

[28] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)

[29] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

MoHURD has set (national-level) indicators for eco-city development (and so has the MEP) but these indicators focus largely on buildings and green space, they are construction-oriented and they fall short of addressing broader parameters related to land use, clean energy supply, or GHG emissions monitoring. The specific set on clean energy - 20% Renewable Energy supply - is still vague. And it is unlikely that it will be reached: supply of heat and power is via CHP plants outside the eco-city, and all the Tianjin EC can generate in RE is street lighting via PV and some geothermal. For the urban energy sector, the key performance indicators of the Sino-Singapore Tianjin Eco-City (SSTEC) are interesting and need to be referred to:

- Carbon emissions per unit GDP: 150 tons per one million US$. [30]
- Proportion of green buildings: 100%. The percent of green buildings in new construction was practically zero in Tianjin in 2008.
- Usage of renewable energy: share of renewable energy in energy supply shall be at least 20%, compared to the national target of 15% by 2020.
- Central heating coverage: 100% as compared to Tianjin´s target of 90% by 2015.

Energy Sector: Key Performance Indicators for Tianjin Eco City

KPI Area and Details	Indicative Value	Timeframe	Domestic standards	Domestic Benchmarks	International Benchmarks
Renewable energy usage	≥ 20%	By 2020	• No national standard	• China 70% (current), Plan: 10%, 15% (by 2020) • BJ Plan: 4% (by 2010), Olympics venue: 26.9% (2008) • Caofeidian Eco-city Plan: 50% (by 2020)	• Finland: 25% • Sweden: 33.3% • Holland: 20% (by 2020) • EU: 20% (by 2020)

Sources: World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing, P29.

These broad KPIs are useful and strategic for the eco-city´s economic and energy planning. It will be imperative to pursue a service-oriented, knowledge-based and clean growth strategy, and to strictly enforce green building standards, make extra efforts to promote renewable energy, and to rely on modern district heating systems. However, there are some points of caution in the World Bank´s review of SSTEC´s performance targets. It is being queried whether the carbon emission per GDP indicator is adequate in small city, since such an indicator may represent many economic and energy characteristics of larger economic regions. And its assumed clean industry-orientation is supposed to result in lower carbon emissions than in other cities with high shares of heavy industries. Hence, it has been suggested that an additional indicator like carbon emission per capita may be added to capture the effects of population density.

The central heating coverage indicator may be misleading, since it is used to measure availability of modern district heating in northern China. However, in Tianjin there should be significant potential to develop clean or cleaner heating options, such a geothermal or gas-fired tri-generation. The target of 100% coverage of centralized heating does not yet indicate innovation in terms of heat supply. An alternative indicator could cover the performance of space heating provided by non-coal-fired technologies (although the electricity used by geothermal and heat pump systems may still be derived from coal-powered electricity plants). SSTEC has developed other important quantitative energy sector targets in heating/cooling efficiency, renewable energy usage, solar energy use, and natural gas usage which should be pursued if they make economic sense:

[30] However, it is being queried whether the carbon emission per GDP indicator is adequate in a small city, since such an indicator may represent many economic and energy characteristics of larger economic regions. And its assumed clean industry-orientation is supposed to result in lower carbon emissions than in other cities with high shares of heavy industries. Hence, it has been suggested that an additional indicator like carbon emission per capita may be added to capture the effects of population density.

Additional Quantitative Objectives of SSTEC´s Energy Sector Plan

Indicator	Indicative Value
Heating energy saving of residential buildings	≥ 70% (compared the current Tianjin standard of 65%
Heating/cooling energy saving of public buildings	≥ 55% (compared with the current Tianjin standard of 50%
Renewable energy usage in heating/cooling system	≥ 40% of building floor area
Solar energy usage in hot water system	≥ 80% of building floor area
Solar energy usage in road/landscape lighting system	≥ 90%
Natural gas usage in residential and public buildings	100% of buildings

Source: World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing. p.30.

5.5 Water Management

(Waste Water Treatment, Drainage and Storm Water Management)

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated among its key objectives: Effective control of water consumption.

New Urbanization Policy 2016. In 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development stresses that until 2020, in all cities above prefecture level, waste water shall be 100% collected and treated; for water deficient cities, the reclaimed water rate shall reach 20%.

The China Development Bank Capital (CDBC)´s policy document for Green Urban Development states several principles for water as part of the the green building sector:

- **Water Efficiency:** All buildings must have 100% adoption of cost-effective water saving appliances, and green spaces surrounding buildings must adopt low water-use plants. All water consumption should be metered and at least 20-30% of water supply must be recycled from either wastewater or rainwater. [31]
- **Smart Technologies can advance green development:** Save water through IoE technology and other water saving technology. Cities can improve water efficiency through smart storm and flood control equipment and water re-use. [32]

Relationship between Smart and Green Guidelines.

Smart Guidelines	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Governance	Water	Using data to manage water in an urban area can greatly improve efficiency by detecting leaks or identifying the most inefficient water users.	Smart Water Management

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

[31] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf

[32] Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

5.6 Solid Waste Management

Policy Direction from the 13th Five Year Plan. The Government´s pronouncement of the Five Year Plan objectives has stated three key objectives:

- Increased efficiency of energy resources development and utilization; effective control total aggregate of energy and water consumption, construction land, and carbon emissions. The total emissions of major pollutants shall be reduced significantly.

- City development shall be in accordance with the carrying capacity of resources and the cultural context. Green planning, design and construction standards shall be applied.

- Support reduced emission standards, and implement demonstration projects of ¨near-zero¨ carbon emission.

New Urbanization Policy 2016. The Government's new roadmap for city development which mentioned complete urban services. [33]

- **Build comfortable and livable environment.** Within 5 years, set up the system of collection and reutilization of kitchen and building waste.

The **China Development Bank Capital (CDBC)'**s policy document for Green Urban Development states several principles for the SWM sector:

- **Waste Management:** All buildings should have waste classification facilities. All household waste must be sorted and collection of hazardous waste must be prioritized. .At least 30-50% of waste should be composted and 35-50% recycled or reused.[34]
- **Smart waste management.** Smart Technologies can advance green city management: smart technologies can improve waste flows and contribute to the implementation of integrated waste management practices. [35]

Relationship between Smart and Green Guidelines

Smart Guidelines	Relevant Green Guidelines	Relationship	Relevant Smart Technologies
Smart Governance	Waste	Optimizing waste routes or understanding when to empty public waste bins can save on fuel and labor costs associated with waste management.	Smart Waste Collection

Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf

SSTEC solid waste management indicators. Three KPIs have been put forward by the 2009 World Bank study[36] of the SSTEC experience:

[33] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)
[34] China Development Bank Capital (CBDC). 2015. *12 Green Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/12/12-Green-Guidelines.pdf
[35] Source: China Development Bank Capital (CBDC). 2015. *6 Smart Guidelines. CDBC´s Green and Smart Urban Development Guidelines*. Beijing (draft). http://energyinnovation.org/wp-content/uploads/2015/11/Six-Smart-Guidelines.pdf
[36] Source: World Bank. 2009. Sino-Singapore Tianjin Eco-City: A Case Study of an Emerging Eco-City in China. Technical Assistance Report. Beijing.

- KPI 5: Carbon emissions per unit GDP: ≤150 tons C per one million US$ GDP;
- KPI 11: per capita domestic waste generation: ≤0.8 kg per day (by 2013);
- KPI 13: Overall solid waste recycling rate: ≥60% (by 2013);

Re. KPI 5: Carbon emissions per unit GDP: ≤150 tons C per one million US$ GDP. This KPI is related to solid waste management (SWM), but not limited to SWM. Less fuel per collected amount of waste will contribute positively to the index. Production of heat and electricity using waste incineration may displace the consumption oil, gas, and coal. Recycling may also have a positive impact since it is minimising the need of new raw materials. However, it is not an easy KPI to measure and a number of sub-KPI have to be elaborated in order to be able to measure.

Re. KPI 11: per capita domestic waste generation: ≤0.8 kg per day. This KPI is problematic. It is not possible to measure waste generation. It is only possible to measure collected amount of waste, which is performed by the formal sector. The activities of the informal sector – Scavengers – cannot be measured. The correct KPI should be amount of waste and recyclable materials collected.

The KPI raises more question that it can answer:
a) Is the ambition to have less than 0,8 kg per person per day?
b) What will happen if there is more?
c) When studying the household waste figures in Europe it is clear that:
    - Higher GDP per capita gives a higher waste amounts;
    - Economic growth generates more waste; and
    - Improved waste collection system gives higher waste amounts.

Several studies have tried to disconnect economic wealth and waste amounts but it has, so far, failed. It is better to measure: collected waste amount per capita, waste landfilled per capita, waste recycled per capita, and waste incinerated per capita, in order to make the KPI operational. (This, could, for instance be the number of citizens being serviced by waste collection. But it should rather not be the number of citizens paying for the service.

Re. KPI 13: Overall solid waste recycling rate: ≥60%. Depending on what is defined as " recycling" the ambition of 60% is high. It is not clear whether composting or bio-gasification of organic waste is considered as recycling? This KPI has to be divided into several sub-KPI's: for instance, one for glass, one for newspaper, one for office paper, one for plastic in order to be measurable.

By elaborating sub-KPI's, changes in consumer habits will also be taken into consideration. In Europe in 1990s it was easy to get a high recycling percentage just by collecting glass bottles and newspapers. Today we have replaced all the glass bottles are with PET and the newspapers are read on the internet. The recycling percent would have dropped if not other materials and processes where included as recycling.

These KPI's have to be divided into sub-KPI's in order to be operational and measurable. In general, this may be about wording: A key performance indicator (KPI) is a business metric used to evaluate factors that are crucial to the success of an organization, and what are presented here are political ambitions that are not simple to measure.

In Europe, KPIs for SWM may classify waste, and according to these classifications, secondary indicators are established under municipal waste management plans which form part of performance-based local waste management contracts.

The waste management plan may divide the activities into three major elements:

- Household;
- Businesses and institutions;
- Activities across.

Household wastes are again divided into 10 activities:

- Waste collection (kitchen waste and others)
- Garden waste,
- Bulky waste
- Recycling: Paper, cardboard
- Recycling: Glass
- Recycling: Bottles
- Recycling Iron and Metal
- Construction and Demolition waste
- Waste of Electrical and Electronic Equipment (WEEE)
- Hazardous Waste

5.7 Urban Renewal and Revitalization

12th Five Year Plan. In the 12th FYP. In the Plan, ten tasks have been put forward to highlight the potentials, which include energy saving buildings, **retrofitting of the existing buildings, retrofitting of heating system,** up-scaling the utilization of new energy in building sector, energy management in public buildings, research and development of new building technologies, promotion of the green building material, industrialization of building, management of demolishment processes, and recycling of construction waste.[37]

New Urbanization Policy 2016. For the 13th Five-Year Plan, this new policy directive has stated that within about 5 years, identify historic cultural blocks & historic building in all cities.

MoHURD Strategic Objectives, Pronounced at the 2015 Central Urban Work Conference. In December 2015, the following directives were issued in regard to urban renewal and rehabilitation:

- Complete the ongoing renovation of urban substandard housing, underdeveloped areas in cities, and dilapidated housing by 2020;
- Enhance urban management to build smart cities;
- Adapt the historical heritage into urban strategies. Overall city planning shall consider reforms, technology and culture in order to improve urban sustainability… Cities shall consider the promotion of stable employment and life of the resident population as the primary task... Cities shall protect the traditional Chinese culture, and rehabilitate the city's historical context, as well as protect the cultural heritage. To combine their historical heritage, regional culture, cities shall promote their own profile.
- Accelerate the reconstruction of urban shantytowns and the transformation of the old districts. Urban development shall take into account nature and ecological restoration. This implies control of the intensity of urban development, promotion of the formation of green low-carbon production. Urban transport, energy, heating, waste water management shall act according to the concept of low-carbon green development.
- Encourage private enterprises and citizens to participate in development and management of their cities.[38]

[37] Green Building Action Plan
[38] MoHURD. Meeting notes. 20-21 December 2015.

Basic Concepts. The following challenges of revitalization of old and historic centres appear to be the most relevant interest. There are a number of specific objectives which any urban renewal program may be requested to achieve – and these differ from project to project:

Historic towns in disaster-risk areas. Some of the historic old town centers in China, particularly in its long coastal belt are at risk to climate change-related risks of flooding and extreme weather. Through disaster risk mapping it need to be assessed which old towns are most at risks.

Smart green technologies. As green technologies will be applied, this will open opportunities for the use of smart technologies to more efficiently use environmental resources: for instance this can cover better control of renewable energy (for room heating and cooling, water heating, and electricity generation), or ¨Passivhaus¨ technology (remote control of shading or day light), water management (supply management). As smart technologies are being introduced to the general public through the Internet of things, this can also extend to more energy-efficient usage of household light and electrical equipment.

Community participation. In modern China, the issue of community participation has emerged like in the rest of the world. Techno-savvy China has developed its own approach to this topic through the use of the internet as a platform to solicit the views of community members and to request constructive inputs for planning and development of public interest schemes. As shown below in the case of the urban renewal programme in Guangzhou, the local planning authorities have encouraged public participation for the drafting of a comprehensive renewal plan. However, as experiences of other URR has shown, there can be property owners who would not relent and would not like, for instance, to sell their property. This shows the limitation of the internet-based community participation, and indicates that there is ultimately no substitute for direct communication, particularly in cases of conflict management. The development of mobile applications (apps) may also offer additional opportunities for citizens to participate and be regularly consulted and involved.

Urban renewal and revitalization standards. For URR, China´s construction standards for new construction seem to prevail. There seem not to exist any specific standards for the retrofitting and conservation of older buildings [verify]. In the European cases simplified energy-efficiency standards used to exist for building retrofits. However, as the case of Germany illustrates, these standards are currently undergoing an upward revision, and adjustment towards standards at par with new buildings [verify]. In case that China engages on a larger scale in urban renewal and revitalization, of course there may be scope for the formulation of specific standards.

However, there are cases where cities have developed a so-called negative list of interventions which are not permissible: Negative lists require specifying the investments amount as well as a development schedule, and setting punishment mechanisms, in a bid to prevent certain giant developers from developing real estate under the pretext of conserving ancient towns¨. [39] The city of Kunming used a negative list to introduce 20 bans on urban planning in 2009, including one that the height of newly constructed buildings should not exceed 35 meters. While the intentions may be positive and based on the desire to preserve heritage, there is also criticism, that rigid rules may leave little room for development, and that inflexible rules have ¨suffocated the diversity of architecture¨. [40]

Green building and green energy indicators. The prevailing indicators for green buildings, for green energy, water, waste water treatment and waste management will need to apply if URR projects are to be considered as compliant with national standards. In case that China engages on

[39] ´Preserving ancient villages' charm - ´Negative List´ a new tool for ´protecting goose that lays golden eggs, in: Global Times, 17 June 2015. http://www.globaltimes.cn/content/927404.shtml
[40] ´Preserving ancient villages' charm - ´Negative List´ a new tool for ´protecting goose that lays golden eggs, in: Global Times, 17 June 2015. http://www.globaltimes.cn/content/927404.shtml

a larger scale in urban renewal, of course there may be scope for the formulation of specific standards and indicators, as available in some European cases.

Note: Indicators for Urban Renewal and Revitalization may be repeating indicators of other sectors since URR is multi-sectoral.

5.8 Green Industries

New Urbanization Policy 2016. In February 2016, the Communist Party of China Central Committee and the State Council issued a roadmap for city development, including energy conservation in cities, covering also industrial development: [41] This wants to promote the district combined heat and power (CHP), green lighting, energy conservation…; and improved heat production efficiency.

Industrial policy framework. Green industries form part of the general industrial policy framework, but have strong linkages to energy, housing, transport, land-use and resource policies as well. This paper looks at green industries from the perspective of urbanisation and how to promote sustainable urban development. The intention is thus not to cover all aspects of industrial policy, but to present the elements that are most relevant to city representatives, urban planners and developers in shaping an ecological and low-carbon urban development.

Green industries are not a sector as such, but are a terminology used to characterise efforts in industrial policy to optimising:

a) the way the individual industries design their processes and deal with energy consumption, materials and waste;
b) the way they interact with other industries and sectors for overall sustainable development, and finally
c) the way the products are produced in relation to energy and materials consumption.

Indicators and certification. There are several areas of indicators and certification. In the following the focus is on industrial parks, but other indicator regimes exists for policy monitoring of specific areas such as air pollution, renewable energy, water usage etc. These other areas are dealt with in other toolboxes (water, energy, transport, waste, etc.) and reference is therefore made to these.

Industry is not required to participate in the national certification programs for industrial parks in China. However, the official certification granted by these programs, financial subsidies and increased ability to attract investment, motivate participation. Each program is characterised by a unique governance structure, certification procedures and associated requirements.

Under the Eco-Industrial Park (EIP) Demonstration Program the industrial zones must prepare a development plan. Once approved, the zones are entitled *National Trial EIPs*. The leading authorities organize performance evaluations every three years resulting in a grading of the zones as excellent, good, qualified, satisfactory or unsatisfactory. When the implementation has sufficiently progressed and performance metrics are achieved, the zones can be granted the title of *National Demonstration EIP*. For the current National Demonstration EIPs, it has taken an average of three to four years to become certified after approval of the development plans. The EIP Demonstration Program comprises three standards corresponding to the three types of EIPs[42]

- The sector specific EIP (HJ/T273-2006)
- The sector-integrated EIP (HJ/T274-2009), and

[41] Extracted and translated from: http://www.gov.cn/zhengce/2016-02/21/content_5044367.htm)
[42] International Institute for Sustainable Development (IISD), Thieriot, Hubert and Sawyer, Dave, *Development of Eco-Efficient Industrial Parks in China: A review* (March 2015)

- The venous-industry EIP (HJ/T275-2006)

These standards are key documents guiding the EIPs in their certification process comprising 24 indicators across four categories. These are further described in section 3.4 below.

Guidelines for eco-industrial parks. The MEP (jointly with MOFCOM and MOST) issued in 2006 EIP standards for:

- Sector-specific eco-industrial parks
- Sector-integrated eco-industrial parks
- Venous industry based eco-industrial parks

The EIP Demonstration Program contains three standards comprising 24 indicators across four categories, including economic development, resource conservation and recycling, pollution control, and environmental management. Many of the indicators are similar among the three standards, however, while threshold values are explicitly defined in the standard for sector-integrated zones, the sector-specific standards refer to international advanced performance levels.

In the table below the indicators of the sector-integrated EIP standard are shown as amended in 2012.

Indicators for sector-integrated EIPs

CATEGORY	METRICS		UNIT	VALUE
Economic development	1.1	IAV per capita	10^4 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/10^4 RMB	≤ 0.5
	2.3	Coefficient of elasticity on energy consumption	--	< 0.6
	2.4	Fresh water consumption per IAV	m3/10^4 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 (SO2) emission per IAV	kg/10^4 yuan	≤ 1
	3.4	Coefficient of elasticity on SO2 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

Source: International Institute for Sustainable Development (IISD). 2015. Thieriot, Hubert and Sawyer, Dave, *Development of Eco-Efficient Industrial Parks in China: A review.* March.

Additional requirements for the zones to obtain certification under the EIP Demonstration Program comprise reaching a higher GDP growth level than the average provincial and municipal zones, setting up an environment management system in accordance with the ISO 14001 norm, and establishing a local environmental agency. Further, all national and local environmental regulations must be enforced within the park and no pollution accidents should have occurred within the past three years[43].

The indicators for the CTIP comprises no benchmarks with threshold values. Instead, participating zones submit their own values in their work plans which serves as basis for the performance reviews. The indicators developed for the industrial park level is presented in the table below.

Indicators for the CTIP program at 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/m^3
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	m^3/RMB
	2.4	Water consumption per unit of production in the key industrial sector	m^3/RMB
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	SO2 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	%

Source: International Institute for Sustainable Development (IISD). 2015. Thieriot, Hubert and Sawyer, Dave, *Development of Eco-Efficient Industrial Parks in China: A review.* March.

To date, no standard for target indicators under the Low-Carbon Industrial Park Program has been published, however, a first version is being drafted by the NDRC and the MIIT.

The National Development and Reform Commission (NDRC), working with the State Environmental Protection Administration and National Bureau of Statistics, has published an index system for appraising four aspects of the circular economy: resource productivity or material intensity, waste discharge, the comprehensive utilisation of resources and waste treatment.

[43] Source: International Institute for Sustainable Development (IISD). 2015. Thieriot, Hubert and Sawyer, Dave, *Development of Eco-Efficient Industrial Parks in China: A review.* March.

The resource productivity or material intensity index refers mainly to GDP produced by per unit of resource; the discharge of waste index reflects waste generation per capita; the comprehensive utilisation of resources index concerns reclamation and utilisation of solid waste, wastewater, urban household garbage; and the waste treatment index mainly describes the treatment rate of solid waste, wastewater and could reflect the finally reduced discharge (disposal) quantity of waste. In future years, these indicators will be studied, improved and linked more closely with circular economy targets to measure more effectively the degree of decoupling economic growth from resource consumption and pollutant discharge and raising the ecological efficiency of economic growth.

5.9 Municipal Finance

Policy Direction from the 13th Five-Year Plan. The Government´s pronouncement of the Five Year Plan objectives has not stated any targets for municipal or green financing. While no specific mention was made about municipal financing, it is assumed that green municipal financing will become a requirement if the above targets are to be achieved. Other pronouncements have pointed at the need for a national green development fund and green bonds.

Green Development Fund needed. A 2016 report from the China Council for International Cooperation on Environment and Development recommends that China launch a national green development fund, develop long-term sources of finance by promoting green bonds and support the development of a green finance risk guarantee mechanism, including environmental liability insurance. [44]

Objective of green municipal finance. The overarching objective of green municipal finance (GMF) is to support the development of cities to provide necessary infrastructure in a socially and environmentally sustained and long-term manner. GMF is instrumental to the higher objectives of livable green cities in an overall country context. It is embedded in the larger picture of national policies, the regulatory environment and the institutional framework under which it works. These cornerstones enable local decision makers to pull the right strings when it comes to prioritizing municipalities green expenditures as well as design proper green revenue sources.

[44] Bapna, M. 2016. Golden opportunity to embrace green growth. China Daily. 17 March 2016. http://www.chinadaily.com.cn/opinion/2016-03/16/content_23887655.htm

6 Conclusions

The proposed set of Sino-Europe Key Performance Indicators (KPIs) pretends to be simple and operational. Most indicators proposed are based on established Chinese sources. A few others are based on common sense assessment of the sector.

This proposed set of 71 indicators is, however, a larger and expanded set of indicators when compared with the 2009 SSTEC indicators which numbered only 22. Nevertheless, it is considerably smaller than the Caofeidian indicators with 135 indicators.

The presentation of sectoral work done on indicators, shows that besides the recommended primary indicators (Section 4) there are a number of secondary indicators (Section 5).

7 Recommendations

Five recommendations are suggested:

1. **Workshop.** It is recommended to discuss these draft indicators at a dedicated workshop to obtain feedback from sector specialists.

2. **Field testing.** The next step should be field testing in a number of selected eco-cities, to demonstrate that proposed data for the indicators can be collected.

3. **Revision.** After revision, an improved version of these indicators can be compiled.

4. **Upscaling during 13th Five-Year Plan.** It, it is recommended that MoHURD and its local HURD use these during the current 13th Five-Year Plan.

5. **Converting indicators into MoHURD regulation.** If the system turns out operational and of value, it is recommended to institutionalize its use.