

Towards sustainable cities in China? Two industrial parks in the Yangzi delta

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China has experienced three decades of double digit economic growth. This is not a specific phenomenon in economic history if we consider the rhythm of growth, as previously Japan and other “Asian Tigers” have undergone a dramatic take off (Pairault, 2008). It is unique, however, in terms of numbers as never before has a country of more than 1 billion people been engaged in such a transformation for such a long time. The country has dramatically changed, for the better (improvement of standard of living) and for the worse (growing inequalities, destruction of the environment). This is visible in the large metropolises of the east coast (Logan, 2002; Sanjuan, 2009; Lorrain, 2011) as well as in central provinces. It is clear, since the early 2000s, that the environment is becoming a growing and quite sensitive issue that is an increasing concern for civil society (Economy, 2004; Ho and Vermeer, 2006; Obringer, 2007; Wu Fengshi, 2009)². This dark side of economic success is now a central theme of public policies and a global collective preoccupation with a growing use of epithets added to the words "economy" or "cities": sustainable, green, low carbon, smart, sober, safer. Is this change in public policy rhetoric a sign of a real transformation? If so, what is changing? Or is this simply a clever repositioning to adapt to the latest concerns of international institutions?

Among the signs of transformation in public policy, the joint report issued in 2006 by the State Environment Protection Agency and the National Bureau of Statistics is certainly a landmark. It is an official report carried out by two legitimate agencies and the first calculation of an environmentally-adjusted GDP in China³ that demonstrates recognition of the problem by the highest authorities. The result shows that economic loss caused by environmental pollution reached 511.8 billion yuan in 2004, or the equivalent of 3.04% of national GDP⁴. The calculation also establishes that a one-off direct investment of 1,080 billion yuan, the equivalent of 7% of GDP, would be required "*if all the discharged*

¹ We thank Jonathan Rutherford (Latts - Ecole des Ponts ParisTech) for his revision of the first English version of this article.

² During fieldwork in 2010, several managers of water utilities from the Yangzi basin told us that the controls of drinking water quality were more stringent, and this was becoming their major concern in terms of risk management. In case of a serious breach their career could be negatively impacted. See also a recent dispute between Chinese officials and the US embassy in Beijing. A senior Chinese official asked the embassy to "stop publishing its (air) pollution readings". As the official standards do not require the measurement of smaller particles there can sometimes be a large discrepancy, with official data indicating "moderate pollution" in contrast with the US data showing "hazardous levels" (Financial Times, June 6, 2012, p. 4).

³ SEPA-NBS, "China Green National Accounting Study Report", State Council Information Office, Beijing, 2006. See also "L'environnement en Chine, le rapport SEPA-NBS", In *Entreprises et Histoire*, n° 50, avril 2008, pp. 150-151. This Green National Accounting (Green GDP for short) refers to a "system deducting natural resource depletion costs and environmental degradation costs", p. 151. Previously, another report had been published. SEPA, "Environmental Protection in China (1996-2005)", State Council Information Office, Beijing, 2005.

⁴ Water represents 286 GY, air and solid waste 220 GY.

pollutants from point source were treated or disposed (in 2004)"⁵. The cost of pollution could reach 13 per cent of GDP by 2020 if the country continues on its current track. According to the World Bank, pollution costs China the equivalent of 8 per cent of its GDP. These figures give a general indication of the scale of the problem.

In fact, since the early 1990s several national agencies have promoted environmental policies with greater or lesser success: building a legal framework, fighting pollution and changing practices. The first set of reforms was aimed at designing a new legal framework, since many essential regulations were missing, and at adopting technical standards⁶. In addition China has imported a great deal of technical equipment, frequently with the support of cheap loans granted by foreign institutions and western countries (World Bank, 1992; World Bank, 1994; Commission Européenne, 1994; Baye and Lorrain, 1997; HEC Eurasia, 1997; Brown and Halweil, 1998). A second set of reforms aimed to fight pollution where it was the most severe. In the industry sector, following the communist period when companies were considered as "total" organisations in charge of producing goods and services, as well as providing various services (such as housing) to their employees (Pairault, 2008: 20; Ayrault, 1999), this led to a first policy to make industry responsible for the primary treatment of effluents before their discharge to municipal sewers. This policy has been quite slow to bring results. Many factors converged to prevent the environment becoming a priority. All performance indicators for the chief executives as well as the local elected officials were based on their economic results (Edin, 2004: 278 *suiv.*). Second, environmental remediation was not the core business of the companies, as they lacked knowledge and direct interest given that this policy was viewed as a cost. Third, at that time the controls were not strict enough: the Environment Protection Bureaus in charge of monitoring and control were ineffective under the dual responsibility of EPA (in Beijing) and the municipal governments, as they lacked equipment and staff. For example the Shanghai EPB in 1996 was responsible for controlling more than 3,000 companies but it actually carried out controls of only 100 of them (Baye and Lorrain, 1997: 51). Basically the choice for many companies was to invest in their socio-business networks (their *guanxi*) rather than to pay the cost of environmental remediation (Chan and al., 1993).

For all these reasons, in order to fight pollution the Chinese authorities promoted new policies. Regarding industry they decided to concentrate the most polluting companies in industrial parks. A central issue was air pollution in the cities, so factories were removed and relocated in industrial parks outside of the cities. This first generation of parks was inspired by the Special Economic Zones created a decade earlier, and were thus organised as enclaves providing a good level of infrastructure and fiscal incentives. In some cases additional services were offered in order to simplify the administrative procedures (permits, imports/exports). The purpose was to improve the quality of the environment as

⁵ *Entreprises et Histoire*, op. cité, p. 152

well as to attract foreign investment. In addition more stringent standards were imposed for wastewater discharge and air pollution. This policy has been a success, in so far as industrial zones have flourished all over the country, from second tier cities to rural districts. The results are not so clear, however, concerning environmental protection, as regulations were breached more and more as the number of parks increased. Local managers and elected officials were still focusing on economic growth. Priorities only changed a decade later in the 2000s when attention to the environment increased with industrial parks occupying a central role in policy. The Chinese central government officially outlined in the 11th Five Year Plan (2006-2010) the objective to build a new, more balanced and environmentally conscious model of development, and with this in mind began to transform the overall legal and administrative architecture. This new model was crystallized in the formulation and massive promotion of the concept of a "circular economy" (see Annex A). The level of standards has been increased, and the control of EPBs reinforced. Organisation of the wastewater sector has been modified in some cases. The idea is to treat all the pollutants from industries in a single wastewater plant with a single operator and one discharge point. Several arguments are used to support this policy. The performance in term of environmental remediation is better as the process is undertaken by a company specialized in this activity. It is more advantageous as well in terms of capex/opex. It is easier furthermore to control the discharge. This solution suits industries that do not want to manage their waste as they prefer to concentrate their activity on their core business and to delegate environmental remediation to a specialist company. Many foreign companies are concerned about their reputations. China now has several of these "new" parks. Some have national status such as SIP (Suzhou) or TEDA (Tianjin), while others are municipal such as SCIP (Shanghai) or Chongqing.

In the current process of transformation of the Chinese economy these industrial parks are strategic and specific, and can be considered as pilot projects as they concentrate the most stringent problems and offer part of the solution. First, the industrial parks are organized as closed systems where the number and the heterogeneity of actors is reduced compared to the complexity of a city, such that this facilitates decision-making. Second, all these actors share the law of the market: they understand notions of costs and profit, and cash flows are available to be invested in environmental protection. For example, the investment in fixed assets in Shanghai Chemical Industrial Park is around 16-17 G\$ and the total annual turnover of the companies in the park is around 17 G\$⁷, so investment and turnover are roughly equivalent, which is a low ratio compared to utilities. The total invested for the ethylene's cracker (the central fixed asset of the petrochemical park) is around 18 GY, while the profits from this activity represent around 10% of the sales (between 2 GY and 2.5 GY each year), so this means that the investors get a return on investment after 6 to 9 years⁸. Third, these parks are places where some experiments of

⁶ For a comprehensive view of this legal framework in different sectors see SEPA, "Environmental Protection in China (1996-2005), Beijing, 2005".

⁷ Interview: manager of a company in the park, April 2012.

⁸ Interview of a representative of the development company of the park, April 2012

symbiosis with short loops of exchange (outputs/inputs) can be observed. Sometimes these industrial "enclaves" can be related to urban development. Industrial parks are thus at the heart of the fundamental equation that China needs to address today: that of how to articulate accelerated industrial production and economic development, massive integration of new urban populations, and increasing demand for environmental protection. These parks are simultaneously key objects in both building and solving this equation: to enable and support the industrial and economic activity (the "machine to produce"), to provide satisfactory living conditions for employees, to preserve the natural environment and ensure the sustainability of resources. In short, they aim to conciliate over the long term the creation of value and quality of life. Studying Chinese eco-industrial parks means analysing how environmental principles are introduced into the development patterns and practices in the country. We can then study the extent to which industrial parks represent the first step of a more sustainable urban region, and interrogate whether they represent the invention of a radically new development model, or just a green readjustment of the traditional established one. In other words, by focusing on the industrial park, it is possible to reach a central issue for China, that of how to invent a new regime of accumulation.

Behind the focus on the transformation of industrial parks lie two main research questions. The first one concerns the implications of a circular economy on the structure of cities and the organization of technical networks. Many experts agree that a greener economy presupposes a reduction in the consumption of natural resources, so they recommend setting up local circular exchanges in order to minimize transportation costs and energy consumption. This vision is the opposite of the way cities have traditionally been organized where urban planning and zoning have contributed to separate functions rather than to facilitate exchanges. Technical networks were organized along a centralized and vertical structure and many good arguments converged to support this model: efficiency and economies of scale, social justice with universal service, safety with a single operator (Coutard and Rutherford, 2009; Coutard, 2010). This implies that changing the existing model requires clear evidence of the superiority of the circular architecture. The second broad question concerns the process of change and its opposite, path dependency. How can a country change a regime of accumulation? There must surely be a combination of factors between a top down strategy (the role of government), pressure amounting from serious problems, and some degree of freedom for the actors present. In the 1980s China undertook the challenge to move from a communist society to a socialist market economy. Is it possible to change again? At first glance the challenge seems to be more difficult. For the previous shift there was a model to copy (the western market economy), and technologies and cheap loans were available from developed countries. If the challenge is now to invent a new green-sober-circular economy there are no references, no model, and nothing which is ready made on the market. The question thus concerns the real factors of innovation. What can the role of pilot projects be? Is it possible to replicate the incremental approach that characterizes the Chinese way, in opposition to rupture (Lorrain, 2011)?

The case studies and research protocol

Shanghai and its mega urban region (the Yangzi Delta) has become one of the most industrialized and advanced regions in China. This region simultaneously concentrates and crystallizes all the problems facing China today (Weiping Wu, 1999; Ged, 2000; Wu Fulong, 2000; Baye, 2001). It is certainly advanced in the process of change, as it combines the pressure of problems, the momentum of transformation of the industrial base (from heavy industry to a more service oriented base) and an international upgrade (with notably the support of the World Bank and the massive attraction of FDI). In this vast region we decided to concentrate our investigation on what seems to be a salient point of these transformations, namely two industrial parks: the Shanghai Chemical Industrial Park (SCIP) and the Suzhou Industrial Park (SIP). First, previous investigations we have carried out since the mid 1990s testify that they are strategic and at the cutting edge of economic/ecological transformation. This global view is reinforced as both appear in the academic literature⁹ as the most advanced (eco-)industrial parks regarding environmental management, a point confirmed by our own interviews. They are exemplars in all spheres in China (political-administrative, private, academic: they are seen as the "best pupils in the class"). For example, a CEO of a utilities company which has several Joint Venture contracts in Chinese industrial parks told us¹⁰ : *"You should be aware that SCIP and SIP are certainly the two best industrial parks in China, and far ahead (...). SCIP and SIP have a very sophisticated management, compared to majority of Chinese parks. (...) They are the head of China"*. Second, the choice of SCIP and SIP enables us to study the topic of environmental protection and the changing regime of accumulation hypothesis in two very different types of context: SCIP is a strictly industrial park of heavy and highly polluting (petrochemical) industries, whereas SIP is a wider city - industrial park comprising both light manufacturing and an important urban entity. The first case allows us to analyze the implementation of industrial symbiosis or eco-industrial chains, while the second offers an interesting and meaningful case for studying how it is possible to move from policies dedicated to reduce pollution to more ambitious urban symbiosis. This means that the policies implemented in these two parks have an important potential for dissemination and generalization all over the country. Our investigation relies on two methods: i) a review of the literature (scientific publications, reports and official documents, press articles ...) on the environment (diagnosis, policies, evaluation), utilities (water, waste water, energy, waste management), circular economy / industrial and territorial ecology / eco-industrial parks, and urban planning in China; ii) fieldwork carried out in April 2012 in Shanghai and Suzhou (see box).

⁹ Regarding this literature see articles that concentrate on the technical dimension (Zhang H. and al., 2009; Zhang B. and al., 2009; Yuan and al., 2010); and articles that are concerned with the mechanisms of governance (Wang and al., 1999; Wong and Goldblum, 2000; Thomas, 2001; Pereira, 2002; Pereira, 2004 and 2004b; Inkpen and Wang Pien, 2006).

¹⁰ Interview, CEO of a foreign utilities company, April 2012

The protocol.

We conducted twenty semi-structured interviews (of between one and two hours) over two weeks with three types of actors:

- Managers of the parks' administrative authorities (Development Office, Office of Planning, Environmental Protection Bureau);
- Managers of private firms operating in the parks;
- Professors and researchers specializing in environmental protection, utilities management and urban planning.

In addition to these interviews, we have carried out field observations of both SIP and SCIP sites through visits by bus, subway, taxi and on foot, photographs, and spontaneous discussions with local people...

Our research and our paper is a symbiosis process in itself, combining the research process of Dominique Lorrain, who has conducted fieldwork on the urban environment of Shanghai in 1996, 2004 and 2010, and that of Rémi Curien, who started a Ph.D. thesis in urban planning in 2011 on the emergence of alternative utility systems to conventional networks in the Yangzi Delta region.

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Shanghai Chemical Industrial Park (SCIP)

In the early 1990s, when Shanghai began its great transformation, the municipal government decided to relocate some polluting industries. Under the direct administration model that prevailed at that time, the Chemical Industrial Bureau was the owner and the manager of many small and large chemical companies scattered in different parts of the city. It thus made sense to relocate these factories far away from Puxi (the dense core) and to restructure the chemical industry as well. The big names that have emerged from this restructuring and concentration process are Sinopec, GCC and Hua Yi, that are now large private companies. The decision was taken to create a petrochemical platform with the aim to be among the world's top ten. Shanghai Chemical Industrial Park (SCIP) (*Shanghai Huaxue Gongye Qu* in Chinese) was established in October 1999 by the Economic Commission of Shanghai Municipality, after having obtained authorization from the Chinese central government. This park is an object/project created and controlled directly by the Municipality of Shanghai (and not by central authorities or by the Jinshan District), which established an administrative organ dedicated to the development and management of the park: SCIP. It is thus a "municipal level" park, but one which is quite unique: it was the subject of huge investments, and it is a flagship industrial park not only for Shanghai but also for the whole of China. The core of the project was structured around an ethylene cracker with a production capacity of 900,000 t/y¹¹, financed by a joint venture (Secco) between Sinopec and British Petroleum. From the outset this project was promoting "5 forms of integration": in production, logistics, utilities, environmental protection, and government management. Regarding production, the key point was to co-locate firms that integrate the supply chain along the chemistry of naphtha, from upstream (ethylene) through mid stream (Metyl –MDI- and toluene –TDI) to downstream and the final products.

¹¹ In 2010 the production capacity was expanded to 1,090,000 t/yr.

Timeline

1996: the principle and the location are approved

10-1999: official approval by SMG and central government

08-2001: feasibility study report approved by the State Council

11-2001: Secco established as a JV between BP 50%, Sinopec 30%, Shanghai Petrochemical Co (SPC) 20%

12-2004: mechanical completion

06-2005: operational status

Place and planning (see Plan Annex B). SCIP is located 70 kilometres from downtown Shanghai, at the southern extremity of the municipality of Shanghai, along the coast, in the Jinshan district which has now a population of 800,000 inhabitants. It covers a well planned area of 29.4 square kilometers, including several km² which have been reclaimed from the sea. The area is divided in three parts: i) a rectangle of 9.9 km² for the chemical industries (this is the heart of the complex); ii) a western extension of 6 km² for an upstream integration with a refinery¹² and a second cracker (this part has also been expanded on land reclaimed from the sea and a dike was erected in 2003); iii) a northern part for logistics (see map). This park is quite large and has a rectangular shape. A large road ‘checkerboards’ the space by subdividing it into different lots, in which each company has its production units. Another feature of SCIP’s landscape (after the roads and the factories) consists of the pipe racks that support the flows of physical matter in the park. They are built outdoors and run along roads all over the park: at SCIP all the technical networks are visible. This set of material infrastructure forms an amazing sight: a visitor has the feeling of being faced with a huge “city of factories.” At the entrance of the park are several buildings, including the headquarters and offices of SCIP, a hotel, an exhibition hall which presents and promotes the park, and a golf course! When visitors “set foot” in SCIP, they can immediately see that the park is an important place, and an international industrial showcase for China. Today the park has attracted both several big name Chinese companies and their subcontractors, and many multinational companies, notably BP, BASF, Bayer, Degussa, Huntsman, Mitsui, Mitsubishi, Suez Environment, Vopak, Air Liquide and Praxair, who have set up production units or operate utilities in the park. According to Zhang H. and al. (2009), the proportion of foreign investment in SCIP has reached 82%. Seven years after being in operation the park is a success although many lots remain unoccupied. In fact the long term project of the municipal government is to develop this park towards the west and the nearby industrial park of Shanghai Petrochemical Co (SPC), to form a huge industrial area over 60 km² along the waterfront¹³.

Utilities organization. The quality of infrastructures and utilities (transport, electricity, gas, heat, steam, drinking water, sanitation, waste management) is a strong point of SCIP, compared to those of “ordinary” Chinese industrial parks. Utilities play a fundamental role in the development and success of

¹² There is a plant (naphtha) in Pudong near the Whampoa, the transport is done by pipe, it could be moved.

¹³ Interview with Jinshan district's chief planner (and other members of the bureau), April 24, 2012

SCIP. Providing and ensuring a high level of service is indeed a central element in the strategy of SCIP-DC officials to attract the top global chemical companies. Regarding utilities the principle was to establish a “*utility island, as foreign investors did prefer professional services*¹⁴”. The park calls upon specialists of each fluid to manage the resources and pollutants of all the park’s industries in a pooled, centralized and optimized way. By outsourcing these functions to specialists, the industries can thus focus on their core business. The objective of the park is to provide a turnkey service to industrialists from a single porthole. The introduction of "specialists" (in fact foreign companies) to operate infrastructure posed two problems. As infrastructure had to be built before the arrival of any industry it was not so easy to find utilities ready to invest in advance. There was then the classical power monopoly problem. Once the infrastructure was built, there was a single company in charge which thus had a strong power over the industries. If their prices were too high this could discourage industries from investing in the park. The solution has been for the park's administration (the developer) to invest in advance, then to establish joint ventures with foreign companies specialised in different infrastructure and to sell around one half of the asset value (plus the value of the intangible assets). Nevertheless, the system works largely according to market mechanisms. The utility companies negotiate the tariff directly with private industries who understand profit and cost structure. The system is therefore governed by a double mechanism: first, the joint venture structure which provides permanent information to the administration of the park, with it being part of the tariff setting; second, market mechanisms with direct negotiation between the utilities and industries.

Environmental protection The environmental concern is a key element in the development and management of SCIP. Yet as industries located in the park are heavy polluters, the question is how to control and reduce pollution. The first step begins with the Environment Impact Assessment (EIA) when a company applies for a permit to invest in the park¹⁵. If an applicant intends to generate too much pollution or pollution which is too toxic to be treated, it is not allowed to invest in the park. Under this procedure the park's administration has the capacity to select the investors. There is an EIA for each project of each firm. The Shanghai EPB delivers (or not) the permit to invest. Before operation begins, the EPB then comes to the site to check if the equipment matches the standards. Once operation begins the "bureau" monitors the pollution. The development of the park has required reinforcing the structure of the EPB on the park. Originally the small structure located in the park to carry out the daily monitoring was under the authority of Shanghai's EPB. In order to reinforce its power, the service has been established in May 2012 as the local “branch of Shanghai EPB”. It has thus received more power and now employs 8-10 people and has the right to impose penalties. The control procedure combines on-site visits and remote monitoring (through digital sensors).

¹⁴ Interview, Vice-Manager, SCIP, Engineering Administration Dept. April 2012

¹⁵ Interview SCIP, Planning and Construction Dept. April 23, 2012

Concerning the wastewater treatment, the choice has been to concentrate all the flows emitted by the industries in a single plant operated by a joint venture between SCIP and Sino French¹⁶. Two different sets of standards are monitored: the "Shanghai discharge standard" focused on toxic waste (heavy metals ..), and a standard jointly defined by Sino French and SPIC. These standards are used at two stages of the process. First, there is a control of the discharge of each company at the end of its production process. If the discharge is too toxic and doesn't meet the standard, Sino French can use an "emergency tank". Second, there are the standards before the final discharge from the output of the wastewater treatment plant. Globally there are few cases above the limit. The final discharge is controlled by a remote monitoring on the outlet, directly linked to EPB. In addition there is a random monthly control (EPB's team do not inform companies in advance of the day of the visit). In this framework the JV operating the plant must comply to environmental law and standards. There are penalties (in case of non-compliance), and reputation is a strong incentive as this company is supposed to solve the problem of the pollution from industrial companies. In addition to these policies, there are procedures to monitor the water quality of the ocean. Two regional EIAs cover a surface of 30 km². Twice a year there is a monitoring of the sea where discharges occur from the wastewater treatment plant, at a long distance from the coast, and if there are remaining pollutants they are diluted (diffusion). According to the officials "*there are no big changes*".

For the solid waste which is another large pollutant in such a park, Shanghai has standards that define the nature of waste and of "qualified companies". Normal waste is collected by "qualified companies", Qco). The treatment is done in other urban districts. Any industrial company can send its waste to any Qco, and this market is competitive. Toxic waste is sent to an incinerator, located in the park, that is operated by Sita (an affiliate of Suez Environment). In principle and according to our interviews the situation is under control. Gas pollution is more difficult to control. The first means to minimize gas pollution is to attract investors that have limited gas emissions; again, the EIA functions as a filter to select the "good" companies. In contrast to wastewater it is not possible to organize the collection of waste gas at a single point of treatment, as the volumes are small and the nature of gas changes from one industry to another; in fact the polluter is the one who knows best the nature of the pollutant and the appropriate treatment.

... *and symbiosis*. Last but not least, SCIP is considered as a prime example not only regarding environmental protection, but also for industrial symbiosis and cascading: the output of one factory (by-product or waste) is the input of another, located close in the park. Zhang H. and al. (2009) emphasize that SCIP is one of the few eco-industrial parks (EIP) in China which have been designed as such from the outset: « *It is an EIP with new physical structure, and one of the few parks that base their design on the 3R approach (reduce, reuse, and recycle)* ». The article says that the principles of a circular economy

¹⁶ Sino French is a 50/50 joint venture, set up in 1985, between Suez Environment (formerly Lyonnaise des Eaux) and New World Infrastructure, the large group from Hong Kong.

have been implemented on three levels: clean production at the firm level, eco-industrial chains at the park level, and exchanges of materials and resources (external to the park) at the regional scale. The level of the industrial park seems, however, to be the most significant. The implementation of eco-industrial chains between different firms in the park is indeed a main thread of the planning and development of SCIP. The idea is to integrate on one site a whole industrial chain from upstream to downstream. From the huge cracker producing ethylene which is the cornerstone of the symbiotic system, intermediate products (acetylene, isocyanate, polycarbonate) result that feed factories specialized in the production notably of synthetic products ¹⁷. The same authors also suggest the existence of three subsystems producing ethylene, polycarbonate and poly-isocyanate, and including production of gas, steam and electricity: “ *In total, ten enterprises, or 37% of the total enterprises and 76.5% of the total investment, use resources effectively through the park eco-chains*”. Our interview with SCIP Sino-French Manager tends to confirm the substance of this industrial symbiosis.

Nevertheless, this circular industrial system has important limits. First, the system is not in fact a totally closed loop. For example, benzene is a raw material for BASF and Bayer, and is produced by SECCO in the park, but it can be bought by the first two companies on the market as well. The same is true for the cumen which is a raw material for GPCO in order to produce acetone and phenol. The variation of the prices on the external markets can then have an impact on the internal market. Second, there remain legal barriers. As in the case of Kalundborg discussed by Desrochers (2002), the standards can facilitate or prevent an exchange depending on whether they qualify a product as a raw material or waste. Some managers told us the case of a company that was producing some active carbon, even though it was not authorized to regenerate this product for reuse. EPB did an impact assessment study and determined that this product has to be incinerated. Finally, this upstream/downstream integration creates new situations of risk management: if a problem occurs on one of the links of the chain, then the malfunctioning immediately becomes systemic. For example, part of the production is based on the chemistry of chlorine; the needs of Tyuang (a Shanghai group) are around 500 t/d. With this input the company produces two components – MDI (Metyl) and TDI (Toluene) - that are strategic to elaborate final products for which there is a 15 per cent annual growth. Any problem in one factory of this supply chain has an impact upstream (the production excess has to be stored) and downstream (some factories must be stopped). In early 2012, the park was producing 350,000 tons of MDI per year with a market value of around 2,500 €/t, so that one day of production is worth 2.5 M€. Any disruption in the exchange chain has a clear financial impact. Another example is from October 2008 (at the outbreak of the current financial crisis) when the water consumption declined by 30% over several days because industries had stopped their production as they anticipated a slowdown in demand. Here, the impact on the water utility was direct.

¹⁷ These physical links are also the object of financial transactions: Secco sells its outputs to other industrial firms in the park.

The (eco-)industrial city-park of SIP

Suzhou Industrial Park (SIP or CSSIP, Chinese-Singaporean SIP, *Suzhou Gongye Yuan Qu* in Chinese) is a vast industrial city-park, located halfway between Shanghai and Suzhou and served by highways, a fast train¹⁸ and a canal. At the origins, in the mid-1990s, it was a rural area, and the development concerned 70 km² (including lakes), although in fact the first stage concerned only 8 square kilometers¹⁹. Several years later, SIP is a very successful estate: the district had 180,000 people in 2000, and 700,000 people in 2012. It has been recently expanded to 288 square kilometers. The new area is structured into 3 townships that have been developed separately by the municipality of Suzhou²⁰. The city-park is a flagship operation which is regarded as an exemplar in China, as much in terms of economic development and urban planning as in environmental protection. SIP is also considered in the literature as one of the most advanced eco-industrial parks in the country. It has been created in 1994 as an intergovernmental strategic partnership between the Chinese central government and the Singapore government. The general agreement was signed by the Chinese Premier and the President of Singapore. At that time the Chinese central authorities wanted to expand their first special economic zones and to focus on an FDI (Foreign Direct Investment)-oriented development model. The partnership was strategic as in this respect Singapore was a pioneer in Asia (Pereira, 2002). The City-State had chosen in the 1960s an FDI-oriented development strategy, which enabled an inflow of capital, technology and management skills, and has been very successful (rapid industrialization and high economic growth). At that time, considering the limited surface area of the City-State and after some developments in Indonesia, Singapore was seeking to expand its model of industrial parks. There was a mutual interest in this experience.

SIP is administratively equivalent to an urban district of Suzhou municipality. Its governance is atypical however. The China-Singapore Suzhou Industrial Park Development Private Limited Co. (CSSD) which is responsible for planning, development, financing and management is a global Sino-Singaporean joint venture, associating a large Singaporean consortium (led by the central government, and bringing together government departments and large private firms such as Keppel and Jurong) which has a 65% share and a large Chinese consortium (comprising the central government, the government of Suzhou, some central departments and large SOES) which has 35%. The other important administrative organ of the park is Suzhou Industrial Park Administrative Co. (SIPAC), established by the Chinese State Council to constitute the political authority of SIP. SIPAC is led by government officials of Suzhou, and also brings together representatives of Singapore (Inkpen and Wang Pien, 2006). The general agreement was expecting and planning for a wide knowledge "transfer" programme in many sectors: "*land-use planning*

¹⁸ Before Suzhou, a new station has been built, so that it takes 40 minutes to get to Shanghai central.

¹⁹ For the presentation at the origins see Baye and Lorrain, 1997, p. 105 suiv.

and development control, building control, environmental regulation, planning and management of industrial estates, public new towns and utilities management, and human resource management" (Inkpen and Wang Pien, 2006: 786). It was perceived as a perfect win-win game for the mutual benefit of the two partners and the investors: *"The tenants could 'enjoy the best of both worlds (Singapore and China)'. Transnational corporations could enter the highly lucrative Chinese market and gain access to the relatively cheap primary factors of production, while also enjoying high quality industrial infrastructure and administration"* (Pereira, 2004).

But this "best of both worlds" did not last long. In June 1999, the Singapore government announced that it would withdraw from the operation of SIP on 1 January 2001. The Singaporeans became minority shareholders: their share in the JV was reduced to 35% and the capital was restructured towards the Chinese part²¹. There are many explanations for this. For some observers, the operation of SIP was not profitable enough for Singapore, as they even saw significant financial losses. SIP only had 14,000 employees and 5,000 residents in 2000, far short of the initial targets (Thomas, 2001). It is a weak explanation as the development started first with the construction of the fixed assets (all the infrastructure) and then the arrival of industries, and later the inhabitants. In the balance sheet of the first five years there was a huge amount of capital expenditure and a limited income from land sales but this imbalance was part of the Singapore model. In fact, the crux of the matter is the conflict between the Singaporean and Suzhou authorities. Suzhou municipal government has always considered that this project was not "their" project and that it was promoted by the central government; their strategy has been constantly to redesign the balance of power to their benefit. Very rapidly they developed another industrial park, west of Suzhou old downtown: Suzhou New District (SND), whose dimensions, ambitions and characteristics were very similar to SIP. Created, planned, financed, built and managed directly by the City of Suzhou, SND has been the subject of municipal preferential policies (land leasing and development, customs, bank loans, project approval limits, import quotes and exchange control). The municipal government, sole shareholder of SND, has clearly supported SND at the expense of SIP, because revenues generated in SND were not shared with the Singaporeans (Thomas, 2001; Inkpen and Wang Pien, 2006). Furthermore, not only has the Chinese partner promoted a rival project, but they also absorbed and reproduced the Singapore expertise they acquired in SIP, against Singaporean interests (Pereira, 2002).

²⁰ The 3 new zones are north of the railway (with lakes), east of the existing zone, dedicated to logistics, south of the river + lakes, specialized in education with several international universities including Berkeley, Liverpool, National University of Singapore and Dayton (Ohio). There are no universities from France, Germany or Australia. Interviews in the park April 2012.

²¹ New partners entered to represent the Chinese part: 58% Chinese consortium (CCTV, Sinopec), 7% Suzhou New District listed in Shanghai, 5% Towngas, 20% Singapore consortium, around 10% Singapore private investors. Interviews in SIPAC, April 2012.

Despite the withdrawal of Singapore, SIP has emerged as a flagship industrial park, which is experiencing huge annual growth rates²². It today contains around 10,000 companies, of which 4,000 are international. Among these, there are around 200 of the top 500 companies worldwide²³. The main industrial activities are electronic, mechanical, pharmaceutical and health industries, so there is a concentration of rather light and low-polluting manufacturing industries. SIP is described in the literature as the "ultimate" free trade development zone in China. It works on the same mechanisms as other Chinese industrial parks, but the basic fixed assets of the urban fabric are of great quality. The equivalent of \$ 20 billion has been invested since the beginning, and the quality of management and infrastructure are far better than other operations.

Planning and utilities organization (see Annex C). SIP is an original territorial object: a huge "industrial park" but one that also includes major urban residential, commercial, administrative, education and recreational functions. The city-park has been planned from the outset in a functionalist and sectoral way: block by block, sector by sector. In addition, the low human occupancy as well as the completely flat topography that characterize the place made it possible to assemble this "urban machine" according to the view of the planners, with the least possible political, social and physical frictions. The result is a hyper-efficient, hyper-functional and hyper-matrix urbanism.

SIP presents another originality: infrastructure and utilities have played a major role in the success and the development of the city-park. The first priority in the Singaporean model was to make every effort to attract foreign investments²⁴. This naturally requires the creation of favorable tax arrangements, but in terms of development it begins with the construction of high-quality infrastructure. Road, electricity, water, gas, heat, sanitation, and telecommunications facilities and networks were the first material elements built in SIP, before the arrival of industries and residents²⁵. In short, as the SIPAC manager summarized, "*Infrastructures, underground networks and public utilities first*". This model requires huge capex (with a return on investment only over the long term), which is enabled in SIP by the outstanding Chinese and Singaporean political support, as well as capital injection. The Singapore consortium has notably built a power plant and a water treatment plant very quickly for the exclusive use of the park to ensure that the first industrial investors have a steady flow of electricity and quality water for their use (Baye et Lorrain, 1997: 105; Pereira, 2004b). SIP now has a treatment plant for drinking water (with a capacity of 450,000 m³/d), two wastewater treatment plants²⁶ (the first has a capacity of 150 000 m³/d, the second of 200,000 m³/d), a sludge treatment and dryer plant (which is

²² According to SIPAC, they register a rate of 20% in both fixed assets and in the number of firms located there. (April 2012)

²³ These foreign investments come mainly from Europe (25%), United States (24%), Taiwan, Hong Kong and Macao (22%), and Japan (13%) (SIPAC exhibition hall, April 2012)

²⁴ Several people we interviewed mentioned that the birds select the best "nest".

²⁵ Interview with SIPAC manager, April 28, 2012, see also Yuan and al., 2010

²⁶ Wastewater from industries is treated first by each company and then discharged along with domestic sewage into the sewage system and then transported to the treatment plants.

still very rare in China), and two co-generation power plants (the domestic waste and the toxic industrial plants are managed by different companies and treated outside of SIP²⁷). Another characteristic of the Singaporean model which is developed in SIP is the idea of territorial autonomy. Singaporean city-industrial parks are indeed conceived and planned to be as autonomous as possible, even to the point of ideally being territorial islands within national oceans: “*As far as possible, the aim is to separate the townships from dependency on the surrounding administration and infrastructure, reinforcing the goal of creating privileged pockets of investment*”, explain Perry Shaw and Yeoh (2000). Singaporeans want to rely as little as possible on national environments that do not match the requirement in terms of quality of infrastructure and of institutions; with autonomy the goal is to create “club effects”. The Chinese partner also had also an interest in this insularisation, which allowed it to develop a better control of the penetration of foreign capital and models.

Environmental protection and symbiosis. In both academic publications focusing on physical flows in SIP and in official brochures it is indicated that SIP has “become” an “eco-industrial park” during the 2000s. The reaction of the SIPAC manager in charge of environmental protection in the city-park²⁸ to this question is instructive. For him, there was “*no environmental turning point*” in the management of SIP. The environmental protection has *de facto* been a major concern early in the operation, from the design of the park: ensuring quality environmental services to businesses and building a good working and living environment for employees have constituted important elements in the strategy to attract foreign investment and create an international brand image. This environmental concern is materialised by high quality environmental facilities and services, as we have seen, as well as fancy landscaping, and a very advanced and quite strict environmental control.

Different procedures have been established²⁹. First, an upstream selection of firms located in the park includes an Environmental Impact Assessment procedure (EIA); this means that the heavy polluters are not accepted, but this raises a question about the global assessment of the environmental performance: if the polluting industries are excluded, the area has obviously a good environmental score, but the problem is transferred to other areas. Second, a specific control of pollutants released by the 100 largest companies in the park has been set up with sophisticated sensors. In addition, there is a control of the flow of wastewater based on online sensors that are installed in the 50 pumping stations across the park, and this allows a control for every 5-6 km² zone. Third, the capacity for control of the EPB has been improved. According to our interviews, the office of environmental protection of SIP today includes 12 people (compared to only 3 people more than 15 years ago), reflecting the growth of its resources and influence - although this number is still quite small compared to the size of the city-park.

²⁷ Interview with SIPAC and SIPDC managers, April 27 and 28, 2012.

²⁸ Interview, April 28, 2012

To further this environmental concern, since 2002 SIP's decision makers have paid attention to the circular economy concept and have begun to initiate or encourage the implementation of symbiosis within the park. But is this a real practice as some academics suggest or only the beginning of a long process? According to Mathews and Tan (2011), manufacturing industries of semiconductors, LCD screens, laptops and mobile phones have formed the first industrial chain, not only from electronic circuit design to the production of computers, telephones and televisions, but also by an "e-waste recycling system". *"Today SIP has enacted e-waste recycling across its IT value chain consisting of upstream electronic chemicals manufacturing through semiconductor and thin-film transistor LCD (TFT-LCD) production to downstream consumer products*». Zhang et al. (2009) estimate that this industrial symbiosis is significant: *"There is a relative complete system of LCD and semi-conductors industrial chain from upstream to downstream."* SIP authorities have also encouraged companies to reuse their wastewater for industrial purposes, by establishing incentive tools³⁰. However, this does not seem to be a massive phenomenon: *"SIP has the lowest rate [among the three eco-industrial parks studied in the article: SCIP, SIP and Baotou] of wastewater utilization because it is located in the southeast region, where the industrial water price is lower than in other regions."* (Zhang and al., 2009).

In fact, the most significant symbiotic operation in SIP is the recycling system that was established between a wastewater treatment plant, a sludge drying station and a cogeneration power plant all located close to each other at the southern extremity of SIP. This system constitutes "a first" in China, as it is the first experience of "urban symbiosis", involving exchanges of wastewater and energy between industrial and residential activities. The symbiosis thus associates three infrastructures: a wastewater treatment plant³¹, a sludge drying plant (designed by Degremont and operated by SIP Sino French Environmental Technology Co³²), and a cogeneration power plant (which is the largest in China, and both a power producer and a supplier of residential heat). The process starts with the problem of the wet sludges that are generated in huge volumes at the end of the treatment process³³.

- The nearby wastewater treatment plant produces 140 t/d of sludge (the other one located 7 km to the east produces around 160 t/d).
- The power plant generates steam and heat used to dry the sludge, in addition to their principal purpose of serving industries and residents.
- The dried sludges are reused as fuel (inputs) for the cogeneration power plant, where they are burned as an alternative to coal.

²⁹ Interview with SIPAC manager in charge of environmental protection, April 28, 2012.

³⁰ Interview with SIPAC managers, 28 April 2012

³¹ The wastewater comes from both industrial activities and households of the city-park. The sludge drying system is located very close to one WWTP (capacity of 150,000 m³/d, 140 t/d of wet sludges), while the wet sludges from a second one, with a capacity of 200,000 m³/d, are transported by trucks. We can estimate that 8 trucks with a capacity of 20 tons each can transport 160 t/d of wet sludges every day.

³² SIP Sino French Environmental Technology Co is the joint venture associating Sino-French (49%) and China-Singapore Public Utilities, a Chinese utilities company directly related to the administration of SIP (51%).

³³ Interview with SIP Sino-French manager, April 27, 2012.

- The power plant also reuses treated wastewater as cooling water.
- In addition, the ashes produced by the power plant are reused by a cement factory that produces materials for SIP

This symbiotic system, whose design began in 2009, became operational in April 2011. According to the managers, it should allow a reduction of 44,000 tCO₂-eq/year (including saving the use of 17,000 t/year of coal by recycling dried sludge as an energy source), and water savings of 3.8 million t/year (by using reclaimed water as cooling water). A significant urban symbiosis is thus implemented, offering synergies between a major part of the city-park's wastewater and an important part of the city-park's power production, and associating industrial and residential activities.

Conclusion

Our investigations in SCIP and SIP, two industrial parks which are considered as environmental exemplars in China, provide information about the substance of the ongoing change of accumulation regime in China. The two parks are important waymarks in China in terms of pollution control and treatment. By concentrating industrial activities in dedicated parks, strengthening enforcement of environmental requirements (improving standards and monitoring capacities), and calling upon international specialists (implementing an integrated and pooled management of utilities), SCIP and SIP present significant progress in reducing the environmental impacts of industrial production: better treatment of industrial waste and wastewater, reduction of energy consumption per unit of production. For example, standards for wastewater discharges in SCIP and SIP now are very strict, getting closer to those of the most developed countries³⁴. Our case studies show that these efforts have been driven by the combination of two factors: a growing domestic environmental pressure, and an offensive logic of international upgrading to attract the best global companies (environmental concern as the ultimate passport to the modernity of Chinese cities in the eyes of the world). The environmental readjustment of the current model is thus very clear. But the two parks demonstrate as well that they reach good standards as they can select the “good” companies under the Environmental Impact Assessment. But where are the most polluting companies going? And where are the large number of small companies: they are not located in the parks and they largely escape controls on their emissions. We consider that the performance of any project, in any country, has to be referred to the level of assessment.

Moreover, SCIP and SIP present concrete cases of the implementation of industrial and even urban (in SIP) symbiosis. This is the second step, which is much more ambitious: to transform the industrial production processes themselves, and to set the environmental requirements at the heart of the industrial process and no longer just downstream (end-of-pipe approach). This is the question of the change of accumulation regime, of the invention of a new development model. Industrial and even urban

³⁴ Interview, CEO of a utilities company, April 2012.

symbioses do exist, but the question concerns the scope and the weight of these symbioses in the overall energy and environmental weight of the parks? If SCIP presents a significantly new model of industrial park in China (according to our survey, the industrial symbiosis represents a sizeable proportion of material and energy flows involved in the overall production of the park, and is at the heart of its planning, development and success), the case of SIP raises more questions: industrial and especially urban symbiosis (the first in China) have been implemented, but the weight of these symbioses in the overall metabolism of the park appears limited, particularly if we include the energy consumption from transport in the environmental balance. The hyper functionalist urban machine of SIP significantly reduces the scope of symbiosis. Clearly, SCIP and especially SIP today do not constitute complete operations of a circular economy³⁵, at least from an international point of view (analysis is certainly different if we put on Chinese glasses). One is probably still far from the invention of a radically new regime of accumulation in China.

In a region that is considered in advance and more precisely after a survey in two industrial parks that represent innovation and exemplarity in China, the potential for "greening the cities" thus remains largely a general statement. Besides, Shanghai is at the forefront of the process. As it is upgrading its industrial base from heavy and nationally oriented industry to a more service and internationally oriented model, the municipal government is fostering environmental protection. But impoverished places and many cities do not have the same priorities, and they still focus on economic development. "*The priority is still immigrants and growth*"³⁶, as the country needs a minimum annual growth to absorb the flow of migrants from the rural areas. Big cities are growing, hundreds of cities are competing, construction is continuing, and this generates pollution (dust, energy, consumption of land and natural resources). A decarbonised economy remains a difficult prospect in China. Under the present regime of accumulation there is a gross ratio: 10,000 \$ of GDP/head is equivalent of 10t CO₂/head, that is 1 dollar of value added = 1 kg of CO₂³⁷. Emerging from our investigation, we propose four possible ways of thinking further about these questions.

1. The good level to measure results. The case of SCIP in particular demonstrates that if the objective is to reduce pollution the answer is "we can treat any wastewater". But the question is to which cost of energy. What is the marginal increase of energy? How is this energy produced and what is the GHG balance? Industrial parks are presented too frequently to the visitor as innovative islands, but they are not islands as they are connected to a wide ocean of cities. It therefore makes sense to consider first the links between industrial parks and cities, and second all the chains for energy or waste. These places are not autonomous in term of energy. Electricity is imported and is mostly generated with coal fired plants and their emissions of CO₂ and SO₂. Collection of solid waste, and particularly toxic waste, has been

³⁵ Interview, Professor of Tongji University, April 2012.

³⁶ Interview, Professor of Tongji University and consultant, April 2012.

improved but their treatment is carried out remotely. How are these infrastructures performing, and what is the GHG balance if the transportation is measured?

2. Figures. SCIP and SIP illustrate how it is important not only to consider variation but gross figures. If the energy consumed for one unit of GDP (energy efficiency) is decreasing by a proportion of 30%, and if the total GDP is increasing by 50% due to a larger population and a higher demand, the total energy consumed increases. China to this day still focuses on reducing pollution and improving energy efficiency, but not reducing quantities of energy consumption. Considering the figures in China demonstrates how it is difficult to combine a sober economy and a regime of growth.

3. Urban planning as a top-down template. The city- park of SIP shows how the spatial planning of a new development area determines the consumption of energy and natural resources generated by its activities. The hyper functionalist urbanism inevitably reduces the scope of environmental efforts undertaken. This point is certainly not specific to SIP. What is indeed striking to the visitor is the extreme homogeneity of the different new development zones in the Shanghai urban mega region (SIP, SND, Changshu, Kunshan, Wujiang, Lingang, Minhang, Jinshan). All of them combine two properties: the absolute combination of the principles of zoning, and of the power of the "growth machine" (Logan and Molotch, 1987). The layout of cities is clearly inherited from the "Charte d'Athènes"³⁸ (Hall, 2002; Le Corbusier, 1946) but what makes a difference to many other countries in the world is that these rules are not limited by other forces. First, China has a very top-down system of urban planning (despite the political decentralization in the 1980s): the national administrative organization reinforces homogeneity as planners must respect precise national rules and standards which are not flexible; for each new urban development, the proposals from planners have to be approved by the Party; all the planners have been educated in the same way (in five Universities³⁹, among which Tongji and Qinghua have the largest influence). Second, the property rights are weak⁴⁰, and there is no political opposition and no free press. Third, in this particular place, the Yangtse river delta, there are no geographical obstacles, and the land is flat. In order to maximize GDP growth as fast as possible⁴¹ (which is the main goal set by the central government), local planners and authorities effectively build cities as a factory (straight roads, huge blocks, 20 floor towers, cement)⁴². The present Chinese new development zones thus make us think more of a kind of unlimited "Charte d'Athènes" than a "model of sober development"⁴³, and clearly come

³⁷ Interview, Professor of Tongji University, April 2012

³⁸ Interview, Professor of Tongji University, April 2012.

³⁹ The 5 major planning departments: Tongji, Tianjin, Tsinghua, South East, Chongqing. In Tongji 3 schools are dealing with the city fabric: The Civil Engineering Dept, the College of Architecture and Urban Planning, the Schools of Economics and Management.

⁴⁰ The land is leased to developers and businesses for periods of 50-70 years. 60% of revenues of municipal governments are coming from land sales.

⁴¹ This hyper functionalist urbanism is also a response of Chinese policy makers to the fragmented and anarchical urban layout that characterized Chinese cities before the 2000s (Weiping Wu, 1999).

⁴² Interviews with several urban planners from Tongji University who teach and do consulting as well.

in contradiction with the Chinese official discourse on the promotion of a circular economy. The question is thus about how to transform practices in order to escape the path dependency?

4. The key role of central government. All our interviews emphasized the major role (not to say the all-out power) of central government and the strong top-down line of authority in China (the traditional Chinese approach): "*In China, everything starts and is decided from above*"⁴⁴. The urban planning process is a good example of these mechanisms and their impact all over the country. The change of planning practices requires a deep *aggiornamento* of urban planning objectives and principles in Beijing. In addition, the system of evaluation and promotion of local executives still focuses on short-term maximization of GDP growth and little integration of environmental requirements. Whereas the literature often emphasizes the responsibility of local authorities in the deficiency of environmental policy implementation in China, our survey shows that it is central government (even more than elsewhere) which holds the key to environmental protection. But we can assume that the same top-down mechanisms that contribute to reproducing the present situation could be reversed as well: if Beijing decides to change direction, then the change could be implemented very quickly all over the country. This challenge is one of the most important ones that China must meet in the next twenty years.

⁴³ See also the comments of Wang Shu, the Pritzker winner, concerning the planning system. The procedure of allocating plots of land for projects often separated from surrounding neighbourhoods (generates) isolated "colonies". Financial Times, May 25, 2012: 6.

⁴⁴ Interviews with several Professors of Tongji University, April 2012.

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Annex A: Circular economy (CE) and eco-industrial park (EIP) Chinese policies and programmes

The CE concept was formulated for the first time in China by academics in the late 1990s (Zhu, 1998) and then proposed by SEPA as a national environmental strategy. The central government has initiated measures to promote CE since 2002 and has officially selected it as a new development strategy in 2006 for the 11th Plan (2006-2011). Concretely, the Chinese government has introduced many regulations to implement the CE: first with the "Cleaner Production Promotion Law" introduced in January 2003, then with the "CE Promotion Law" approved in August 2008 and introduced in January 2009 (Geng et al, 2012). These laws set binding targets and make provision for penalties to market participants in case of non compliance.

Operationally, the main instrument created by the Chinese authorities to promote a circular economy consists of national "EIP" programs, which were carried out by various Chinese central administrations: first from SEPA since 2001, then from NDRC since 2004. Today, there are officially 60 national "EIP". The first ones were in Guigang (in Guangxi province) in 2000 and Yantai (Shandong Province) in 2001; then they focused on 2/3 in coastal areas (the most industrialized and most advanced of China), and particularly in the Yangzi delta region. Among the most significant include: Suzhou Industrial Park (SIP), Tianjin Economic-Technological Development Area (TEDA), Wuxi New District.

Following the development of these CE and EIP programmes, important scholarly attention has been dedicated to this subject in China and a plentiful literature has been produced since 2006 to analyze the implemented operations (Yiping Fang and al. 2006, Yuan and al. 2006, Yiping Fang 2008, Geng and Hengxin 2009, Geng and al. 2009, Zhang and al. 2009, Mathews and Tan 2011, Shi et al. 2012).

Annex B : Plan of SCIP (SCIP-AC, 2010)



Annex C : Plan of SIP (SCIP-AC, 2010)

