Technology Innovation and Industrial Revolution for Sustainable Development in China

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Summary: A great deal of efforts and remarkable progresses towards sustainable development has been seen in China in the past decade. Technology innovation and industrial revolution are of significant, including the implementation of cleaner production, eco-industrial development and circular economy, which have been reviewed in this paper.

Keywords: Sustainable Development; Science & Technology; Industrial Revolution; China;

Introduction

According to the United Nations Development Program (UNDP) China, a major challenge that China faces is “how to maintain economic growth and avoid destruction and pollution of the natural resource base” (UNDP China: U.N.’s Brief Assessment of China's Development Challenges, 2001). To meet this challenge, sustainable development strategies, plans and policies were formulated and implemented, and a number of major research projects and proposals for sustainable development were carried out in China with the supports from the World Bank (WB), UNDP, and the United Nations Environment Program (UNEP). After UNCED 1992, China issued Ten Strategic Policies on Environment and Development for China and stated that China must adopt sustainable development strategy as its basic strategy. In March 1994, the State Council issued China’s Agenda 21, the first state-level follow-up document to the United Nations Agenda 21 in the world. Strategy measures and action planning for sustainable development were included. Some departments also formulated their own Agenda 21 documents, such as National Environmental Protection Agency, Ministry of Forestry, National Bureau of Oceanography and so on. In March 1996, the Ninth Five-Year Plan for National Economic and Social Development and Outline for Long-Term up to the year 2010 also took sustainable development as the critical strategy of China’s social and economic development.

Being a powerful tool to promote sustainable development, Science and Technology is highlighted in China. It is pointed by the Outline for Long-Term Target up to the Year 2010, the dissemination of technology science and technology has contributed a lot to solve major environmental problems and support sustainable development at different levels and in variable ways in China. Sustainable development strategy has promoted technology innovation and industrial revolution at the same time. This paper will only focus on the development and implementation
1. Cleaner production implementation

Being a better way for industrial pollution control and an effective approach to change the economic growth patterns, cleaner production has been proven to be an inevitable choice and a guarantee for sustainable development in China. It sets a significant landmark for the development and the civilization of modern industry.

As early as 1980s, some Chinese enterprises were engaged in technical innovations called ‘zero-waste techniques’. These successful cases had provided experiences and examples in promoting cleaner production in China. In 1993, the Second National Working Conference on Industrial Pollution Prevention and Control highlighted cleaner production as a critical measure for harmonizing the environment with economic development, thereby attaining sustainable development. It means that the strategy for industrial pollution control should be shifted from the end of pipe control approach to whole production process management and adoption of cleaner production. Promotion of cleaner production was also documented into some important documents, such as Ten Strategic Policies on Environment and Development for China and China’s Agenda 21. Since then, many efforts have been made in awareness raising, training, policy review, demonstration projects, and international cooperation on cleaner production. Some remarkable progress has been made. For example, many multilateral/bilateral cooperation projects on cleaner production have been carried out with the World Bank, Asia Development Bank, UNEP, and the governments of Canada, Norway and the Netherlands; National and more than 10 sectoral or local cleaner production centers have been established; Jiangsu, Liaoning province and Taiyuan city have systematically promoted and implemented cleaner production at provincial or municipal levels.

These early-stage efforts prepared the basic awareness and capacity for wide-adoption of cleaner production in China and led to many significant steps in government policies. In May 1997, State Environmental Protection Administration (SEPA) issued the policy documents on promoting cleaner production in environmental protection activities. In May 1999, State Economy and Trade Commission (SETC) issued the ‘Notice on Promoting Cleaner Production via Demonstration Projects’. Ten cities and five industrial sectors have been identified as national demonstration sites on cleaner production. These cities are: Beijing, Shanghai, Tianjin, Chongqing, Shenyang, Taiyuan, Jinan, Kunming, Lanzhou and Fuyang. The sectors include petrochemical industry, metallurgical industry, chemical industry (nitrogen fertilizer, phosphate fertilizer, chlor-alkali and sulphuric acid), light industry (pulp and paper, fermentation and beer-brewery) and ship building. These important decisions show that China has scaled-up cleaner production implementation from the enterprise level to the regional and sector levels. In April 2000, Taiyuan municipality has issued its Regulation for Promoting Cleaner Production, which is an important step in promoting cleaner production with legislative measures. On the National Working Conference on Population, Resource and Environment held on
March 11, 2001, President Jiang Zemin called for ‘phasing out technically backward and high polluting enterprises, products, and production processes; and to control industrial pollution with source reduction measures, such as technology innovation and cleaner production’. The promotion of cleaner production’ is also included in the outline of the National Tenth Five-year Plan. More recently, the National People’s Congress has issued “Cleaner Production Promotion Law” in May 2002. In the process of cleaner production promotion and implementation, the Cleaner Production Working Group on Cleaner Production (CPWG) of China Council for International Cooperation on Environment and Development (CCICED) played catalytic roles as an advisory body to the central government on the overall strategies for cleaner production implementation in China.

Cleaner production implementation has brought environmental and economic benefits simultaneously to China. The total amounts of pollutants have been reduced and the costs for products have been cut down because of higher ecological efficiency has been reached. Most of the enterprises can get the investment back with 2-3 years from the reduction of cost and reduce the pollutant discharge with much lower cost than end of pipe treatment. Table 1 shows the investments and benefits of three cleaner production options for ammonia synthesis process in FuYang chemical plant, AnHui Province.

<table>
<thead>
<tr>
<th>Items</th>
<th>Option 1</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>Ammonia recovery</td>
<td>Sulfur recovery</td>
<td>System automation</td>
</tr>
<tr>
<td>Total Investment 10^4 yuan</td>
<td>139</td>
<td>234</td>
<td>325.5</td>
</tr>
<tr>
<td>Increased annual cash flow 10^4 yuan</td>
<td>216.73</td>
<td>26.65</td>
<td>126</td>
</tr>
<tr>
<td>Investment payback time Year</td>
<td>3</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Net Present value 10^4 yuan</td>
<td>1081.44</td>
<td>-39.41</td>
<td>600.97</td>
</tr>
<tr>
<td>Return rate of the investment %</td>
<td>50</td>
<td>6.93</td>
<td>35.68</td>
</tr>
<tr>
<td>Investment NPV ratio %</td>
<td>778.1</td>
<td>-16.84</td>
<td>184.63</td>
</tr>
<tr>
<td>Reduction of pollutants Ton</td>
<td>NH₃ 2400 to water NH₃ 2000 to air</td>
<td>COD 400</td>
<td>Can not be quantified at present time</td>
</tr>
</tbody>
</table>

However, the promotion of CP in China is still far from satisfied. With “Cleaner Production Promotion Law” taking into effects, China’s cleaner production is stepping into a new era where opportunities and challenges coexist.
2. Ecological Industrial Development

Eco-Industrial Park (EIP) is an industrial system of planned materials and energy exchanges among enterprises to minimize energy and raw materials use, minimize waste discharge, and build sustainable economic, ecological and social relationships. It can be considered as the application of cleaner production principles to a group of industries as a whole. As another effective sustainable development strategy, the EIP concept has been seriously recognized by authorities and communities in some industrial regions in China. Some economic development zones developed earlier in China, such as those in Dalian, Tianjin, Yantai and Suzhou, are trying to play active roles in EIP experimentations. Currently, the above four have been listed as the pilot parks in the project of “Environmental Management of Industrial Estates” by UNEP. Meanwhile, the city of Guigang in Guangxi province, Quzhou in Zhejiang province, Nanhai in Guangdong province, put forward their EIP construction proposals in succession just in the first two years of the 21st century, all with local authorities active participation.

Being the first EIP initiative, Guigang EIP is established by the Guitang Group, a state-owned enterprise that operates China’s largest sugar refinery. In this park, a cluster of companies are running in a way to reuse their by-products and thereby reduce their pollution. The complex includes: an alcohol plant, pulp and paper plant, toilet paper plant, calcium carbonate plant, cement plant, power plant, and other affiliated units. The goal of the initiative is to reduce pollution and disposal costs and to seek more revenues by utilizing by-products. Quzhou EIP, featuring with webs of material exchanges among dozens of chemical plants of various sizes, is now an industrial center that targets downstream specialty chemical users of Juhua’s commodity chemicals and by-product outputs, and other manufacturing plants that could utilize mineral and biomass resources in the region. Nanhai EIP is a greenfield site focusing on environmental protection industry, which has a largely potential market in China. By introducing some green businesses outside, this park features with virtual business networks.

Though China’s EIP is still in the cradle, it has shown a promising future. By combining cleaner production at enterprise level, many existing or newly-built industrial parks are being planned and constructed according to industrial ecology principles, such as the parks in Xi’an, Changsha and Qingdao City.

3. Circular Economy

Circular economy, also called material close economy or life cycle economy, advocates that economy should be constructed on the base of material recycling. According to circular economy, the traditional development pattern with linear flows of resources-products-wastes should be replaced by a new one with circular flows of resources-products-reclaimed resources. Just like Eco-industrial Parks, circular economy is also in the cradle to be implemented as the key strategy for sustainable
development in China. Recently, some provinces like Liaoning, Jilin, Heilongjiang, Fujian and Shanghai Municipality have accepted the concept of circular economy and are carrying out the corresponding plans.

Being China's traditional industrial base, Liaoning province currently faces serious challenges from both economic restructuring and environmental protection. Liaoning circular economy program, which was facilitated by SEPA and Liaoning local government in 2001, brings a good opportunity to meet these challenges. The essence of Liaoning program is to incorporate the concept of circular economy into the adjustment of economic structure, the transformation of industrial sectors, and thus the fulfillment of sustainable development. Shanghai, a mega-city in East China, is another pioneer to implement circular economy. As early as the middle of last decade, Shanghai incorporated circular economy into its Agenda 21 and then included it into its tenth Five-Year Plan for National Economic and Social Development. Currently, Shanghai municipal government has set up special initiatives to promote and implement circular economy at four different levels: intra-entrepreneur level (for example Shanghai Baoshan Iron & Steel Co. and Shanghai Automobile Co.), inter-entrepreneur level (for example Shanghai Chemical Industrial Region and Jinqiao Industrial Park), inter-sectors level (for example Shanghai Rubbish Treatment and Disposal Sector.), and global level (for example, ecological residential project and the development of Chongming Island).

Both Liaoning and Shanghai bring a good starting point for the implementation of circular economy. Their successes and failures will benefit other cities in China. Currently, Guiyang, Panzhihua and other cities begin to plan their own circular economy activities.

Concluding Remarks

Being the most three successful tools for implementing sustainable development, cleaner production, EIP and circular economy have brought significant impacts on China’s industrial processes, products and even consumption pattern. By incorporating sustainable development strategies and principles into enterprises, industrial parks, and provincial and municipal decision levels, they build a conceptual bridge connecting industrialization and sustainability. These efforts on technology innovation and industrial revolution have put China’s industrial development on a road to sustainable development.