Case analyses of low-carbon technology transfer from the co-benefit perspective

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Abstract

This article presents two case analyses of low-carbon technology transfer between Japan and China. One technology is waste heat recovery power generation in cement kiln (WHR system) and the other is co-processing of wastes using cement kiln, namely the CKK system (Conch Kawasaki Kiln System). The WHR system has significant co-benefit in the reduction of air pollutants and carbon emissions. The co-benefit of CKK technology is the improvement of local social welfare. There is no financial barrier for the application of WHR, whereas policy barriers exist for the diffusion of CKK technology. It is expected for the CKK system to enjoy preferential electricity pricing policy and tax reductions as are available for general waste-to-power facilities. The success in the transfer of target technologies may be attributed to the symbiotic business model comprising the related companies.

Introduction

China has been experiencing rapid economic growth while suffering from severe pollution. The pressure on greenhouse gases (GHG) emissions reduction has been also increasing in China. Correspondingly the Chinese government made considerable efforts in energy saving and pollution reductions. By 2015, energy consumption per unit gross domestic product (GDP) is to decrease by 16% and CO_2 emission per GDP is to decrease by 17% from 2010 levels. The emissions of major pollutants are to drop significantly (State Council, 2011). According to the 'US-China Joint Announcement on Climate Change' issued on 12 November 2014, China intends to peak in CO_2 emissions in around 2030 and make the best efforts to peak earlier (Xinhua News, 2014).

For a long time, air quality management and climate change mitigation have been treated as two distinct issues. However, more and more research has shown that measures for conventional air pollutant control and GHG emissions mitigation are more closely related than previously thought. Climate policy and pollution control policy explicitly factor into these synergies (Li *et al*., 2012). Considering the high priority for China to simultaneously resolve local pollution problems and global climate challenges and aiming to facilitate discussions on co-benefit strategies, this research carry out case analyses of international technology transfer and highlights good practices in the transfer and expansion of technologies with co-benefit effects from Japan to China.

Based on the review of the first adoption of target technologies in China, managers and technical experts in the technology adopting and supplying companies were interviewed to clarify their experiences and barriers for technology introduction and operation. The co-benefit effects of the technologies in carbon mitigation and pollution reduction were roughly estimated. Accordingly, policy suggestions are proposed for overcoming the barriers in the wider adoption of target technologies.

This article is arranged as follows. Section 2 explains how the two cases were selected, as well as the research activities. Sections 3 and 4 individually describe the two case studies in detail – that is, the features of the target technology, the first adoption by the company, the diffusion status of the technology, estimation of the technology co-benefit and the findings from hearing interviews. Section 5 summarizes the results of hearing interview to the technology supplier in Japan. Lastly, Section 6 gives a short summary.

Selection of the cases and research activities

This analysis selected two technologies with co-benefit effects as the research targets. Both technologies are used in the cement industry and originated from Kawasaki Heavy Industries, Ltd. (KHI) of Japan. One is waste heat recovery power generation in cement kiln (WHR system), and the other is the co-processing of wastes using cement kiln, namely the CKK system (Conch Kawasaki Kiln System). The two technologies are at different diffusion stages. Among which, the WHR system has been widely applied in China's cement industry, especially for the large plants that employ the new suspension pre-heated dry process (NSP). The CKK system is at the early phase of application in China. This analysis identifies the experiences enabling smooth diffusion of the WHR system and the difficulties involved with expansion of the CKK system, and provide meaningful evidence for co-benefit technology transfer.

The geographical locations of the two companies firstly adopting the target technologies are depicted in Figure 1. Both companies are subsidiaries of Anhui Conch Cement Company Ltd., namely Conch Cement, with headquarters in Wuhu city of Anhui Province. Case 1 is the WHR system, adopted by Ningguo Cement Plant (hereinafter NGP), located in the county-level city of Ningguo. Case 2 is the CKK system adopted by Tongling

Figure 1: Geographical location of the case studies

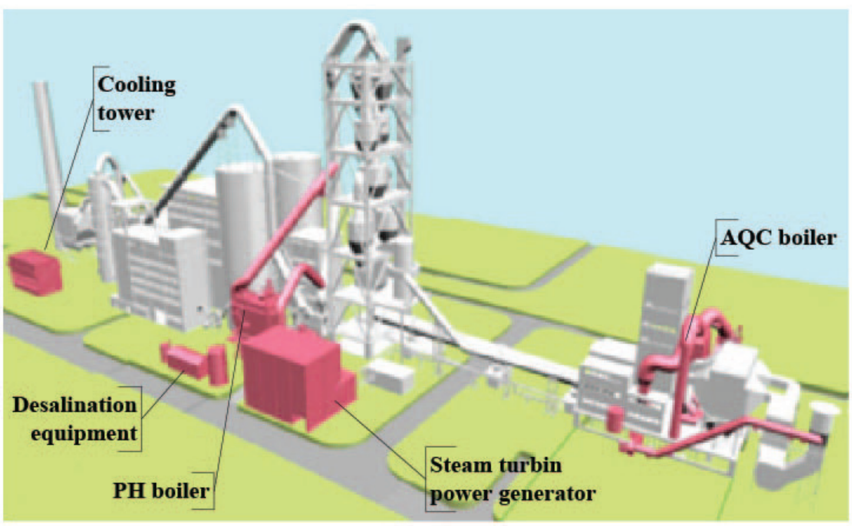

Figure 2: Technological process of WHR system (adapted by author from KHI, 2013)

Conch Cement Limited (hereinafter TLC), based in Tongling city.

The site visits and interviews in China were coordinated by China Cement Association (CCA). Before the visit, a list of questions was prepared for the technology adopting companies. To conduct a complete observation for the transfer and application of the target technologies, an additional visit to the technology supplier in Japan was arranged. The hearing interview with the manager in charge of target technologies in Japan was coordinated by Hyogo Environmental Advancement Association (HEAA) due to its link with the target expert.

Case 1: waste heat recovery power generation in cement kiln (WHR system)

Technological process and characteristics of WHR system

The technology process of the WHR system is simply depicted in Figure 2. In clinker production utilizing the new dry-type process, a mass of waste heat contained in cooler exhaust gas and pre-heater exhaust gas is recovered, respectively, by an air quenching cooler (AQC) boiler and pre-heater (PH) boiler. The superheated steam produced in these boilers is used to drive turbines, which then transform heat into mechanical energy and finally drive the power generator to produce electricity for use in cement production.

There are several features of the Kawasaki-Conch WHR system. Firstly, flashing technology is adopted in the thermodynamic system to achieve high efficient heat recovery. Another feature is the adoption of a low-pressure parameter design. The system can recover low-quality waste heat and achieve the lowest outlet gas temperatures as possible. Thirdly, a mixed steam type condensing turbine/generator is used. For a 5,000 t/d clinker production line, the actual power generation capacity can reach 9.5–10 MW. The fourth advantage of this system is the use of a horizontal PH boiler, which ensures high heat exchange efficiency by a mechanical hammering dedusting device, and requires less maintenance compared with vertical boilers.

Adoption of WHR system by NGP

In August 1995, the former China National Planning Commission and Japan New Energy and Industrial Technology Development Organisation (NEDO) signed an agreement for WHR system demonstration and committed the project implementation to NGP and KHI. This WHR system was equipped for a 4,000 t/d line in NGP as a pilot project involving Sino-Japan cooperation for integrative energy utilization and was the first case in China's cement industry. Construction commenced on 18 October 1996 and operations started on 6 March 1998. The designed capacity of this WHR system is 6.48 MW with an annual electricity generation of 54,000 MWh. A photo of the project signboard is shown in Figure 3.

Since the start of operation, this pilot WHR system has been running smoothly maintaining an actual capacity of 7.2 MW. The project is appreciated by the governments and experts of Japan and China owing to its outstanding social and economic benefits, and it plays a positive role in the diffusion of WHR technology in China.

Diffusion of WHR system in cement industry

Conch Cement took the lead in constructing a large-scale WHR system after the successful pilot project in NGP. By importing the advanced technology of KHI and key parts of PH boilers, Conch Cement and KHI constructed ten WHR systems with a total power generation capacity of 163 MW for 18 clinker production lines in 7 subsidiary factories by January 2005. For further diffusion of the WHR system, KHI and Conch Cement consecutively established three joint ventures during 2006 to 2009, as listed in Table 1.

The first one is Anhui Conch Kawasaki Engineering Co., Ltd. (ACK), which was set up in December 2006. This engineering company focuses on the design, procurement and installation of energy-saving and environmental facilities, with WHR systems as a core product. The other two companies are equipment manufacturers; one is Anhui Conch Kawasaki Energy Saving Equipment Manufacturing Co., Ltd (CKM), established in October 2007, and the other is Anhui Conch Kawasaki Equipment Manufacturing Co., Ltd (CKE), established in August 2009. As a result, the WHR system has been largely adopted in subsidiary plants of Conch Cement and other cement companies in mainland of China and outside China. Details of WHR diffusion by ACK are given in Table 2.

At the end of August 2013, a total of 256 clinker production lines based in 23 provinces and municipalities of China had been equipped with WHR systems. The number of power generation systems is 183, with a total power generation capacity of 2071.96 MW. There are also 11 WHR systems established for 19 clinker production lines abroad, most of which are based in other Asian developing countries. Their total power generation capacity is 152.01 MW.

Figure 3: Signboard of WHR pilot project in NGP (taken by author)

Table 1: Joint ventures established by KHI and Conch Cement

No.	Name and abbreviation	Date established	Main products	Investors and shares
1	Anhui Conch Kawasaki Engineering Co., Ltd. (ACK)	December, 2006	Design, procurement and installation of energy saving and environmental equipment	KHI: 50% China Conch Venture Holdings Limited: 50%
2	Anhui Conch Kawasaki Energy Saving Equipment Manufacturing Co., Ltd. (CKM)	October, 2007	Boiler, vertical mill and energy saving and environmental equipment	KHI: 50% China Conch Venture Holdings Limited: 50%
3	Anhui Conch Kawasaki Equipment Manufacturing Co., Ltd. (CKE)	August, 2009	Cement manufacturing equipment, i.e., NSP (New Suspension Preheater) and AQC (Air Quenching Cooler)	KHI: 50% Anhui Conch Cement Company Limited: 50%

Co-benefit effects of WHR system in NGP

During the site visits, actual operation results of the pilot WHR system in NGP from January to October 2014 were collected. The average electricity generation per ton of clinker production was stable at 35.81–38.89 kWh. The total electricity generation fluctuated monthly due to changes in the production amount of clinker; the highest was in the month of October with a total of 5271.9 MWh electricity being generated; the lowest was in July with a generation of 2579.2 MWh. During the first 10 months of 2014, a total of 46855.3 MWh was generated. If this figure was annualized, the electricity generation in 2014 would be 56226.4 MWh, and based on an average NGP electricity price of 0.70 Yuan/kWh, the economic benefit is around 39.36 million Yuan.

For estimation of the co-benefits of this pilot WHR system in NGP, the pollutants selected for the calculation are SO_2, NO_x and PM2.5 because these pollutants severely affect municipal air quality in China. Using the electricity generated in 2014 and the emission factors of CO_2 and air pollutants of East China grid, the co-benefits of the WHR system can be simply calculated. As a result, the pilot WHR system in NGP can avoid CO_2 emissions of

Table 2: Status of diffusion of WHR system by ACK (at the end of August 2013)

No.	Area	No. of production lines	Production line scale (t/d)	No. of power generators (Sets)	Total capacity (MW)
1	Anhui	50	270,200	29	443.26
2	Gansu	3	14,500	3	22.3
3	Guangdong	10	62,000	6	108
4	Guangxi	10	47,500	6	85.5
5	Guizhou	20	75,600	16	139.3
6	Hebei	18	74,500	15	179.3
7	Henan	7	40,000	6	75.6
8	Heilongjiang	3	15,000	2	27.1
9	Hubei	3	12,000	2	20
10	Hunan	12	58,500	10	103.3
11	Jilin	11	38,500	6	67.6
12	Jiangsu	19	89,000	11	158.1
13	Jiangxi	7	27,500	5	46.9
14	Liaoning	7	32,500	5	57
15	Inner Mongolia	3	15,000	3	21.7
16	Shandong	10	42,000	7	70.7
17	Shanxi	4	19,500	4	34.2
18	Shaanxi	13	57,000	9	105.1
19	Sichuan	11	49,000	11	87.6
20	Yunnan	17	48,000	14	84.2
21	Zhejiang	2	10,000	2	17.3
22	Chongqing	12	46,500	8	78.9
23	Xinjiang	4	23,200	3	39
Subtotal in China		**256**	**1,167,500**	**183**	**2071.96**
24	Parkistan	6	28,000	3	41.94
25	Thailand	7	42,000	4	70.3
26	Turkey	2	4,870	1	8.72
27	Myanmar	1	4,000	1	6.2
28	Viet Nam	3	20,600	2	24.85
Subtotal in abroad		**19**	**99,470**	**11**	**152.01**
Total		**275**	**1,266,970**	**194**	**2,223.97**

Sourced from: http://www.conchventure.com

43,496.7 tCO_2/a. Meanwhile, the reduction of SO_2 emissions is 98.4 t/a, the avoided emissions of NO_x is 91.1 t/a, and the reduction amount for PM2.5 is 17.43 t/a.

Findings from the hearing interview in NGP

After the study tour of the pilot WHR system in NGP, a meeting was arranged with the company managers and technical staffs. The discussion mainly covered the history of the pilot WHR project in NGP, and experiences for the adoption of this technology.

For the implementation of the pilot WHR system in NGP in 1990s, the former National Planning Commission (restructured and named National Development and Reform Commission (NDRC) as of March 2003) and the former National Building Materials Bureau (NBMB) were responsible for this project in cooperation with NEDO at the Japan side. At the business level, KHI and NGP cooperated for the installation and operation of the WHR system. KHI was responsible for the installation of equipment and training of the local staff. NGP provided support such as in the construction of civil facilities. From the economic viewpoint, the investment of the pilot WHR system was not attractive at the beginning due to the low price of coal and electricity. The price of coal was around 90 Yuan/t and the price of electricity was only 0.08 Yuan/kWh at that time. Currently, the price of coal is about 500 Yuan/t and electricity is around 0.5 Yuan/kWh in Ningguo city. Along with the increase in energy prices, the WHR system provided economic savings.

The equipment of the pilot system has been operated and maintained well. A total of around 0.85 billion kWh of electricity was generated over the past 16 years. As confirmed by NGP, the WHR system has encountered no problems with technology and maintenance. The power generation amount of the WHR system is around 40 kWh/t clinker. Investment in the WHR system was about 6,000 Yuan per kW. The total initial cost was 25–30 million Yuan for a WHR system with a power generation capacity of 3.5–4.2 MW. Due to the technology maturity and advantage in profitability, the WHR system was quickly diffused throughout the cement industry of China during 2007 to 2012. Subsidies from the government – for example, rewards for energy saving and income from the CDM projects, were useful for promoting the rapid diffusion of this technology.

One barrier mentioned by the interviewees for the adoption of WHR system in other areas of China is the difficulty in connecting to the regional power grid. Normally, electricity generated by the WHR system is used by the cement companies internally and would not be sold externally. However, the system has to be connected to the external power grid before it starts running. In some regions of China, power grid departments are reluctant to approve connection of the WHR systems of cement companies to the grid. This delays the construction and operation of related WHR systems in cement companies of the region. The joint venture, ACK, has been making efforts to export this technology to cement companies abroad, like India, Pakistan, Brazil, Thailand and Viet Nam, where over 20 WHR facilities have been established to date. Another possible direction for application of the technology is to use it in other sectors.

Case 2: co-processing of wastes using cement kiln (CKK system)

Technological process and characteristics of CKK System

The CKK system was developed jointly by KHI and Conch Cement. It is an environment-friendly waste gasification system. The technological process of the CKK system is depicted in Figure 4.

The CKK system is the first in the world to add a waste incinerator to an existing cement plant and combine the cement production and waste treatment processes. In this system, municipal solid wastes and/or sludge are gasified in the gasification furnace. The generated gases are injected into the cement production processes to effectively utilize the heat energy. Amounts of fossil fuels like coal used in cement kilns can be reduced and CO_2 emissions can be mitigated accordingly. The slag generated in the gasification furnace is used as raw material for cement production and, therefore, the final disposal of fly ash and slag from conventional waste incineration facilities is not necessary. In addition, the dioxins generated from waste treatment are completely decomposed in the cement kiln, which obviates the need for procuring specific equipment for the treatment of hazardous materials.

Besides the control of dioxins and recycling of slag, heavy metals are solidified into cement clinker within the national standard while these pollutants need to be treated by separate equipments in the mechanical grate incinerator (MGI) facility. It is usually difficult to control odorous pollutants in MGI, whereas under the CKK system, the garbage pit is enclosed and in a negative pressure state the odorous pollutants are sent to a gasification furnace for combus-

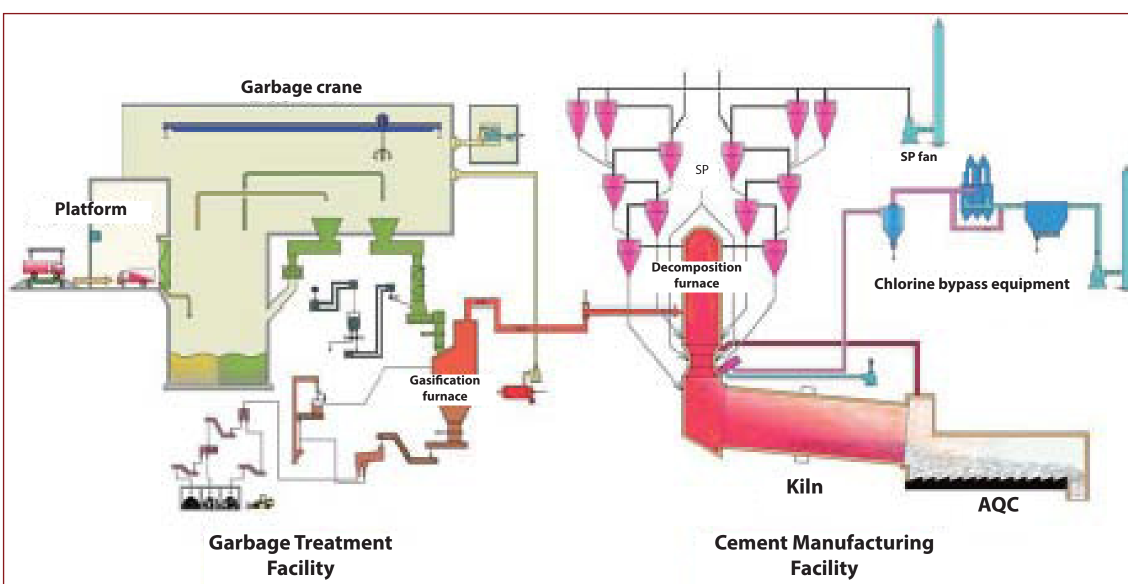

Figure 4: Technology process of CKK system (adapted by author from JASE, 2014).

tion. Leachate can be soundly processed in the CKK system. The leachate is injected into the gasification furnace or cement kiln and the organics are completely decomposed. In an MGI plant, leachate has to be treated by a sewage treatment station.

Since the waste treatment of the CKK system is built on the existing cement plant, the area needed is much smaller than an MGI plant with the same scale. The initial investment and operation cost of a CKK system are lower than MGI plants. For an MGI facility with a treatment capacity of 300 t/d, the investment is around 150 million Yuan. For the first application case in TLC, the actual investment was around 90 million Yuan. The operation cost for municipal solid waste treatment in an MGI plant is around 80 Yuan/t currently in China, while for a CKK system it is about 60 Yuan/t.

Adoption of CKK system in Tongling Conch Cement Ltd.

The CKK system was firstly adopted in TLC as a demonstration project. It was intended to utilize two TLC cement kilns, each having a production capacity of 5,000 t/d, for the treatment of 600 tons of municipal solid wastes per day. The final treatment amount is 0.2 million tons per year. Initial investment was estimated at around 150 million Yuan and operational costs for the treatment of per ton of waste are about 70 Yuan with a total cost of about 220 Yuan. The construction of the first CKK facility started in October 2008. This system, with a treatment capacity of municipal solid waste of 300 t/d was put into operation on 10 April 2010.

Tongling municipal government is responsible for the collection and transportation of municipal solid wastes to TLC. TLC is in charge of the storage, shredding and gasification of the wastes. Initially, the daily treatment amount was less than 300 t due to insufficient supply of municipal solid waste from the city. Since the second half of 2013 and along with the increase in waste collection, the daily treatment amount is around 310 t under stable operation.

Efforts to diffuse CKK system in China

The advantages of the CKK system have been gradually recognized in China. Some additional CKK systems have been planned, approved or under construction. The adoption status of CKK systems in China is given in Table 3. Among which, Guiding Conch built a CKK system with daily treatment capacity of 200 t. Unlike TLC, this project was financed by Guiding County government and has been operated by Guiding Conch since October 2013. The actual waste collection amount is around 100 t/d and the system is under intermittent operation with a daily treatment amount of 200 t. Another 14 CKK projects were at the agreement-signing stage with local governments at the end of 2014, either in the process of approval or in construction. The total treatment capacity of all 16 projects currently in approval, constructed or operation is 3,600 t/d.

Co-benefit effects of CKK system

The co-benefit effects of the CKK system can be estimated in comparison with other optional treatment of municipal solid wastes. There are normally three methods: sanitary landfill, incineration and composting. Sanitary landfill is the main

Table 3: Adoption status of CKK systems in China

No.	Province	Construction location	Capacity (t/d)	Status	Time
1	Anhui	Tongling (Phase I)	300	Operating	April 2010
2	Guizhou	Guiding	200	Operating	October 2013
3		Zhunyi	400	Signed agreements with the local governments and under approval or construction	
4		Guiyang	300		
5		Shuicheng	200		
6		Xishui	200		
7		Tongren	100		
8	Gansu	Pingliang	300		
9	Guangdong	Yangchun	200		
10	Chongqing	Zhongxian	200		
11	Hunan	Qiyang	300		
12		Shuangfeng	200		
13		Shimen	200		
14	Sichuan	Nanjiang	200		
15	Guangxi	Fushui	300		
16	Yunnan	Baoshan	200		
In total			3,600		

Note: In addition, around 8 CKK system projects are under application or planning in provinces of Guangxi, Hunan, Anhui, Shaanxi, Guangdong and Guizhou.

approach for the treatment of municipal solid wastes in China. Of the total amount treated, the share of sanitary landfill is around 72% and the share of incineration is 25% (Dai, 2014).

Information sourced from the Conch Cement website indicates that a CKK system with a treatment capacity of 600 t/d may avoid methane emissions from the landfill equivalent to 150,000 tCO_2 per year. For the pilot CKK system in TLC with a capacity of 300 t/d, its effects in CO_2 emissions reduction is about 80,000 tCO_2/a compared with a landfill of the same amount of municipal solid wastes.

There is no quantitative estimation of the co-benefit of the CKK system in comparison with MGI facility. However, according to a performance comparison of the TLC production line over 15 months before the CKK system was introduced and 46 months since the system started operation, clinker production was reduced by 6.72 t/h, electricity consumption per ton of clinker was increased by 2.85 kWh, standard coal consumption was reduced by 1.36 kg/t clinker, and waste heat recovery power generation was increased by 2.02 kWh/t clinker. Due to the high moisture of municipal solid wastes in Tongling city, the reduced coal consumption in cement kilns is almost balanced by the increase in electricity use for clinker production. The energy saving of the CKK system is realized as an increase in power generation of the combined WHR system. As confirmed by TLC, the benefit of the CKK system is mainly the contribution to social welfare due to the sanitary disposal of municipal wastes.

Findings from the hearing interview at TLC

An interview meeting was arranged with the manager and technical experts of TLC to hear about their experiences in operating the CKK system and opinions for the diffusion of this technology.

As of 26 November 2014, the CKK system in TLC treated a total of 460,132.8 tons of municipal solid wastes. The local government pays 185 Yuan per ton of municipal solid waste. The capacity of the CKK system in TLC for sludge treatment is 100 t/d (80% wet weight). The price for sludge treatment is only 135 Yuan/t currently and much lower than actual costs. The new price, assumed to be 316 Yuan/t is under negotiation with the government. Practical operation of the CKK system in TLC for over 4.5 years indicates various advantages of this technology, that is, ability to adapt to different waste composition, decomposition of dioxins, leachate treatment, control of odorous substances, recycling of waste and so on.

The CKK system has advantages in economic performance, too. As mentioned earlier, the total investment for TLC was 124 million Yuan including the common facilities for the second phase project. The investment for Guiding plant was 77–78 million Yuan with a capacity of 200 t/a. There are two business models for the CKK system application so far. One is the company self-investment like the CKK system in TLC. The other is a project invested in by local government – for example, the CKK system in Guiding Conch of Guizhou Province. In this case, the cement company is in charge of the operation for waste treatment and the local government pays only the operation fee to the cement company.

There do exist management and policy barriers for the adoption of the CKK system in China. Although certain policies have been issued to encourage the use of cement kilns for the treatment of wastes, there are lack of specific and operational policies. For example, the co-processing facilities are not included in municipal infrastructure plans. It is also difficult for the waste co-processing project to pass environmental impact assessments. Municipal solid wastes and sludge in China are currently managed by the administrative region, imposing geographical limits on the nearest treatment of wastes, especially for the operation of treatment facilities near borders of adjacent administration areas. An additional problem is the insufficient supply of wastes and sludge. Government departments in charge of municipal solid waste and sludge differ according to area. Cement companies have to negotiate with each of the cities in question. Some local governments do not authorize cement companies to handle wastes, and even for those that receive permission, the municipal department responsible for waste collection and transportation may be reluctant to supply sufficient wastes to the co-processing facilities due to benefit considerations. The fourth difficulty for cement companies to adopt the CKK system is that they cannot obtain sufficient economic compensation. The cost for the co-processing of municipal solid waste is around 130 Yuan/t, but many local governments would pay less than 100 Yuan/t. The cost for treating sludge exceeds 300 Yuan/t while payments currently are much less than this.

Some other barriers also exist. For instance, experts in charge of examining environmental impact assessment reports are reluctant to support these new kinds of project. Awareness of local governments is low. In consequence, it takes time to persuade these key stakeholders to recognize the advantages of waste co-processing in cement kilns. Another limitation is the location of cement companies. In northeast China, cement plants usually stop production for about 4 months over winter. During this period, countermeasures have to be considered for the waste storage or treatment by alternative approaches.

The interviewees in TLC expressed high expectations for the CKK system to enjoy preferential electricity pricing policy and tax reductions for the general incineration of municipal solid wastes. According to the 'Notice of National Development and Reform Commission on Improving the Price Policy of Municipal Solid Waste Incineration Power Generation' (NDRC, 2012), these facilities are paid by the grid electricity converted from the amount of municipal solid wastes transported into the plant. Each ton of municipal solid waste is tentatively converted to 280 kWh and the benchmark electricity price is 0.65 Yuan/kWh (including tax). This price is much higher than that of the grid electricity generated by coal-fired power plants with desulfurization systems. In addition, referring to MOF, SAT & NDRC (2008), the waste co-processing equipment, such as the gasification furnace and shredding

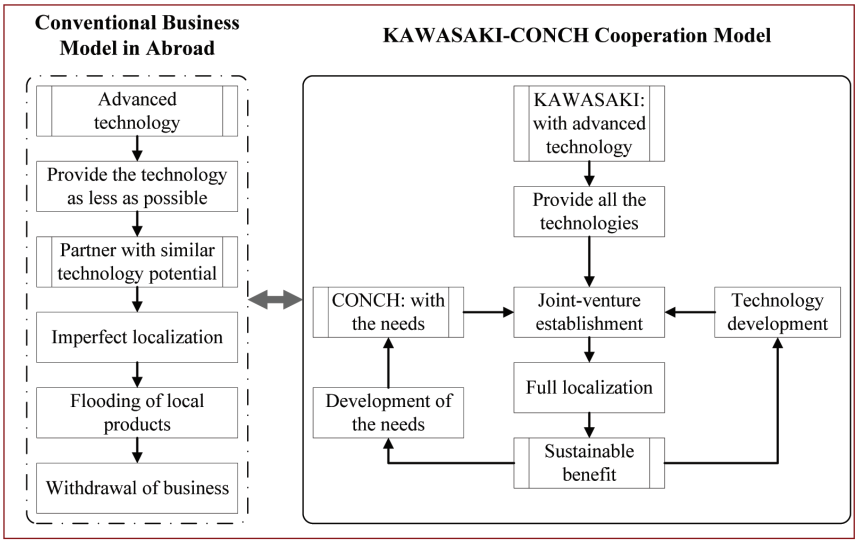

Figure 5: Business model of Kawasaki-Conch cooperation (adapted by author from KHI, 2013)

machine, should be eligible for the preferential tax policy but is still excluded. If included as a policy target, 10% of the investment for these equipments may be deducted from the corporate income tax. Providing these economic incentives would likely encourage cement companies to invest in the CKK technology.

Viewpoint of technology supplier in Japan

In order to obtain the opinions of the supplier of target technologies, an interview was arranged with the responsible manager of KHI. The results are as follows:

As mentioned earlier, KHI and Conch Cement established joint ventures to promote the application of energy-saving technologies, including the two technologies in this research. In the beginning, there was strong resistance to the technology cooperation internally at KHI. However, the final decision to provide the technology was attributed to the strong leadership of KHI top management at that time. Figure 5 shows the successful model of cooperation between KHI and Conch Cement in comparison with the conventional business model for the application of Japanese advanced technologies abroad.

Conch Cement is a cement manufacturing company and has needs for the technologies of KHI. It has no similar technology potential with KHI and there is no competitive relationship between the two companies. On the contrary, their advantages are complementary; KHI is strong in technology development and engineering design, while Conch Cement is strong in facility operation. Both sides have worked together for technology localization and further development. In the joint ventures, KHI is responsible for technology development and management – that is, design optimization, quality assurance and development of overseas markets and Conch Cement is responsible for procurement, engineering management and development of the domestic market in China. The interviewee at KHI mentioned that at the outset it was somewhat difficult to work together. However, the technology was gradually fine tuned to the local conditions. For technology development and improvement, some patents have been applied for jointly in both countries. Further efforts have been made in forming a patent network for the protection of intellectual property rights. KHI's view is that, as regards technology localization, relationships with local business partners requires mutual benefits, trust, top management leadership, as well as nurturing of technology and human resources for technology transfer to succeed.

The WHR system was only adopted by 13 Chinese cement plants in 15 years independently by KHI before the establishment of the joint venture in 2006, while cases of adoption rapidly climbed to 144 plants in 5 years during 2007–2011 after the joint venture was established. For the CKK system, there were initially some technical problems, mainly as regards inappropriate design due to lack of know-how of Chinese technical staff. Such problems were soon resolved under the guidance of KHI.

Regarding the transfer of Japanese technologies abroad, the NEDO criteria of the need to subsidize the pilot projects of technologies is problematic, as is the need for the candidate technology to be of the latest design and backed up by cases of successful implementation. These strict requirements act as a barrier to Japanese companies for obtaining financial support from NEDO, which therefore hinders the smooth transfer of technologies.

Summary

This study conducts case analysis from the perspective of transfer of co-benefit technologies from Japan to China. One is the WHR system, which has been largely diffused, and the other is the CKK system, which is at the preliminary stage of wide dissemination. Due to the lack of available information, the co-benefits of target technologies could only be roughly estimated. Through on-site visits and interviews at the technology adopting and supplying companies, the experiences and barriers for technology transfer and adoption were identified. For the WHR system, as the technology is mature and an economic advantage is present, there were no difficulties in its application. However, for the CKK system, there exist management and economic barriers hindering its wide adoption. It is a priority to enhance the awareness of stakeholders on the merits of waste co-processing in cement kilns. Economic incentives, such as financial subsidies, tax reductions for procurement of major equipment and appropriate payment for the wastes treated, need to be put in place to encourage cement companies to invest in this technology.

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