Quantitative evaluation of energy - efficient technology diffusion
- In the case of Coke Dry Quenching (CDQ) technology of steel sector in China

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Overview

Although international technology diffusion is indispensable for reducing energy consumption and CO2 emissions, there has been little discussion regarding technology transfer processes in recipient countries. Inr many studies, attention has been paid to the supply side of energy–efficient technologies in developed country

Most previous studies have not focused on the process of technology acquisition in quantitative manner. Tan et. al (2009) surveyed China's scale-up and diffusion mechanisms of low carbon technologies by examining cases for coal-fired power generation technology, wind energy technology, and blast furnace top gas recovery turbine (TRT) technology in the steel sector. It drew on information collected from direct interviews with industry leaders, policymakers, and technology practitioners, focusing on developing countries, which face very difficult challenges.

This paper sheds light on the technological catch-up process of Coke Dry Quenching (CDQ) system in the steel sector. The author estimated actual operating conditions based on UN CDM (Clean Development Mechanism) datasets from and qualitative informationfrom existing literature. The r technology catch-up status in China can be derived from the estimation itself. At the same time, an examination of this catch-up process, reveals an enabling environment created through regulation and market-commercialization in China.

CDQ technology is a proven technology with the co-benefits of recovering the waste heat from the coking process and producing on-site steam or electricity. It contributes to the reduction of air-pollutants (SOx, NOx) and water utilization at negative cost. In 1985, CDQ was first introduced to the Chinese steel sector by Nippon Steel Company (NSC[1]) under a technology cooperation contract. Later, through Japan Green Aid Plan (GAP)[2], NSC constructed a CDQ plant for the Shougang Group in 2001 as a pilot project. NSC had launched a joint venture Beijing JC Energy & Environment Engineering Co., Ltd. with 60% ownership in 2003.

The Chinese steel industry gradually gained technological skills learning through pilot projects and developed their domestic production abilities through these steps. The installation of CDQ was mandatory regulated as industry entry permission and expansion condition by China government in 2005, 2008 (Yang 2012). In 2012, CDQ was installed in 80% of steel plants[3], 67% of which had been provided by Chinese capital as of as 2011 (Japan Iron & Steel Federation 2011).

The CDQ technology was invented in the 1920s in Switzerland, and the former Soviet Union succeeded in constructing a commercial pilot plant. A Japanese steel producer and manufacturer purchased CDQ license from the Soviet Union and the first CDQ equipment was installed in Japan in 1976 as a countermeasure for the oil crisis. After that, capacity expansion, pollution control and commercialisation advanced in Japan (Rogan 1978, Miura et. al 1980). It is estimated that the CO2 reduction potential of CDQ technology is 21 Mt-CO2 in the Asia-Pacific region according to a APP[4] diffusion survey.

The author finds that although in terms of energy saving technologies represented by CDQ, rapid technological catch-up and scale-up has occurred in China, there is a 9% difference in the operation ratios of actual operation bases installed by Chinese capital and those installed by China-Japan joint ventures. The author concludes that distinctions can be made in design, refractory materials, and operation & maintenance, based on evaluation, expert interviews and technical literature (Tsinghua case study 2009, Ma et.al 2011).

The ex-post evaluation of actual operating conditions (represented by the Plan Achievement Rate of CDQ) of 13 projects shows that the Plan Achievement Rate of CDQ provided by Chinese capital is 83% , whereas those by China-Japan joint venture capitals is 92% on average. Usually, in Japan, the CDQ operating ratio is 95% on a calendar basis (Watanabe & Hamasaki 2012). It is suggested that differences in operating conditions may cause reduced CDQ operation efficiency as a whole.

[1] Current Nippon Steel & Sumitomo Metal Corporation
[2] GAP is lead by the Ministry of Economy, Trade, and Industry (METI), Japan, and implemented by the New Energy Development Organization (NEDO)
[3] State Council of China, 12th FiveYear Plan
[4] The Asia–Pacific partnership on clean development and climate lead by U.S. Department of State

As is the case with other energy efficient technology, technology recipient countries in other emerging countries enjoy the benefits of introducing technologies brought by Chinese industry at low cost. It was suggested that CDQ technologies in the developing process might rapidly spread in emerging countries such as India. This study indicates some possibilities of overestimations of energy saving potential when using assumptions of Best Available Technologies (BAT) at the same operation level in developed countries. Further evaluations for other technologies requires sufficient data.

Methods

Ex-post evaluations of installed technologies are conducted to examine the actual operating condition of installed CDQ equipment using United Nation's CDM reports, such as Project Design Documents (PDD) and Monitoring Reports of registered projects. Thirteen registered CDM projects with CDQ in China were observed.

In this study, "Plan Achievement Rate of CDQ (%)" was estimated. This index is defined as the "Monitored amount of electricity generation of installed CDQ" divided by the "Planned amount of electricity generation using PDD".

$$\text{Plan Achievement Rate of CDQ (\%)} = \frac{\text{Monitored amount of electricity generation (kWh)}}{\text{Planned Amount of electricity generation (kWh)}}$$

This paper draws on international data from IEA, potential estimations by APP (The Asia–Pacific partnership on clean development and climate lead by the U.S. Department of State), and SOACT (State of the Art Clean Technologies of Handbook) published by APP.

Engineering magazines on operating analysis of CDQ technology published in Japan and China and press releases by individual companies were also examined. Furthermore, interviews with experts from the steel sector have contributed to deepen our analysis. These conversations were a part of a series of surveys conducted in 2012 by IEEJ and TECUSE (Technology Transfer under Sustainable Economy) Project of Tokyo University.

Results

The evaluation of the "Plan Achievement Rate of CDQ (%)" reveals that there is a difference of around 9 % between Chinese capital (host, and later technology introducing country) and China-Japan joint venture capital (original provider of the technology). Further evaluation on other technology is required with sufficient data series.

On average, CDQ provided by Chinese capital shows 83%, and that provided by China - Japan joint venture capital shows 92%. The author finds that distinctions can be made in design and refractory materials of CDQ (Ma et.al 2011) from expert interviews and technical reports in china. Further evaluation supported by sufficient data is needed in future studies.

Conclusions

The author observed rapid technological catch-up and scale-up in China, with numerical evidence, by strong international support from both government and the private sector. It is suggested that while technology-importing countries are able to enjoy the benefits of introducing new technologies at lower cost, unaccomplished products flow into markets of third countries such as India.

Our results indicated that as to major technology transfer including material improvement such as refractory and highly trained operation & maintenance (O&M) skills, there is an implicit barrier to be overcome as is the case with other environmentally sound technologies.

Also, it is suggested that there are possibilities of overestimations of energy-saving potential. Because most potential evaluations were premised on current technical and O & M levels for energy intensive industries achieved in developed countries, which may need to be modified to represent second-best technology adoption in emerging countries.

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