# Estimating Chinese Unified Carbon Market Size

## Implications of a Giant Four-billion t-$CO_2$ Market

Shen Zhongyuan
Senior Coordinator
Energy Conservation Group
Global Environment & Sustainable Development Unit

## Introduction[1]

After China experimentally opened seven local carbon markets from 2013 to 2014, the unified nationwide carbon market planned to open in 2017 has been attracting global interest. This unified market is expected to be huge in scale and lead to major changes in climate change initiatives in the world. Early this year, China requested enterprises with energy consumption above a certain level in some specific industrial sectors to submit $CO_2$ emission reports[2] (hereinafter referred to "emission reports") in preparation for opening the unified market, where standards for regulation targets were revealed. This action has led interests to further grow in the Chinese unified carbon market. The author is particularly interested in these developments and would like to further study the size of China's unified carbon market, i.e., $CO_2$ emissions subject to regulations[3] and consider implications of the market size.

## 1. Estimation method

Basic data for the estimation are energy conservation targets of the top 16,078 energy consuming enterprises in industrial sectors specified in 2012 to implement the top-10,000 energy-consuming enterprises program (hereinafter referred to as the top-10,000 enterprises program). The minimum annual energy consumption for enterprises subject to the top-10,000 enterprises program is 10,000 tce (= ton of standard coal equivalent), the same as for the emission report request. Therefore, using the top-10,000 enterprises program to identify enterprises subject to the emission report request may allow the carbon market size to be estimated.

[1] The author would like to thank Senior Coordinator Takahiko Tagami and Senior Researcher Kiyoshi Komatsu of the Global Environment & Sustainable Development Unit for providing precious comments for this paper. However, the author is responsible for the whole of this paper.
[2] National Development and Reform Commission, "Notice to surely implement preparations for launching a national carbon emissions trading market"
[3] A carbon market size may be conceived as simple emission volume or trading volume/value (influenced by the vigorousness of trading or liquidity). This paper briefly describes the market's annual trading volume or economic value based on carbon prices, while refraining from estimating the volume or economic value directly as data are still very insufficient.

### 1.1 Identifying enterprises

As 18 categories in eight industrial sectors (see Table 1) are subject to the emission reports, whether each enterprise belongs to any of these categories mush be checked to use the top-10,000 enterprises program for identifying enterprises subject to the emission reports.

For this paper, the author adopted mainly three methods to identify those enterprises. First, the author used enterprise names to identify their business categories as far as possible. For example, enterprises named XX Coal Power Station and XX Cement Plant (strictly, clinker enterprises must be identified, see Note for Table 1) may be identified as belonging to the power generation and cement categories, respectively. With this method, the author identified 14 of the 18 categories, excluding ethylene, carbide, synthetic ammonia and methanol.

As for the four remaining categories, enterprises may be named XX Chemical Factory or XX Coal Chemical Plant, making it difficult to use enterprise names alone to identify their categories. Therefore, the author used a list of enterprises (on a production capacity basis) in the four categories as clarified in a book on China's oil and petrochemical industries in 2014. Some enterprises were found to have produced two or more of the four products including ethylene, synthetic ammonia and methanol.

Finally, the author used websites and the like to identify enterprises whose names alone cannot be used for the identification. For example, this method was used for such enterprise names as XX Energy Co.

Using the abovementioned methods, the author identified 4,191 specific enterprises as falling into business categories subject to the emission report request (see Table 1).

### 1.2 Estimating energy consumption

Given that energy data published in the top 10,000 enterprises program represented energy conservation targets for individual enterprises, energy consumption must be estimated separately. This paper deems the energy conservation targets to represent a 10% energy consumption cut. This means that 10 times of the energy conservation target equals to the energy consumption. By using this methodology, however, energy consumption slips below 10,000 tce for 62 of the 4,191 identified enterprises. Given that the 62 enterprises account for only 0.1% of the identified enterprises' total energy consumption, however, the author refrained from adjusting the energy conservation rate[4].

Based on the energy conservation rate of 10%, energy consumption for enterprises subject to the top-10,000 enterprises program amounts to 2.08 billion tce (avoiding double electricity counting), representing 64% of China's total energy consumption in 2010. The

[4] The author also gave consideration to the fact that some enterprises for the top-10,000 enterprises program are priority enterprises irrespective of the 10,000 tce threshold.

percentage indicates no large deviation from what the government published as “more than 60%,” indicating that the 10% energy conservation rate assumption is proper.

### 1.3 Estimating $CO_2$ emissions

In estimating $CO_2$ emissions, the author first aggregated identified enterprises’ energy consumption into categories, then broke down energy consumption into energy sources, and finally computed $CO_2$ emissions by energy source. For breaking down energy consumption, the author used the energy consumption structure for each category in China Energy Yearbook 2014. For electrolytic aluminum, copper and other business categories for which no category is available, the author used the energy consumption structure for sectors to which these categories belong[5]. For computing $CO_2$ emissions by energy source, the author used the emission factors stipulated in the Greenhouse Gas Emission Computation Methods And Reporting Guidelines (2013).

As given in Table 1, the final consumption sector’s electricity consumption was excluded to avoid double counting of electricity in aggregating primary energy consumption. A similar procedure was taken for aggregating $CO_2$ emissions.

### 1.4 Estimation errors

Given that the emission reports are not directly available, the author used the top-10,000 enterprises program. Therefore, various influential factors are expected to generate estimation errors. Major influential factors include production changes arising from the consolidation of enterprises, enterprise identification errors (including counting failures), energy consumption estimation errors and energy consumption structure estimation errors. Furthermore, enterprises subject to the existing seven local markets could participate in the unified market on different conditions[6]. Enterprises subject to the emission report request could not necessarily be subject to the real carbon market. Therefore, estimation results may have to be considered flexibly.

[5] For electrolytic aluminum, for example, the author used a breakdown for the nonferrous metal sector.
[6] Xinhuanet report “Unified Market to Open in 2017”
http://news.xinhuanet.com/politics/2015-12/10/c_128517550.htm

## 2. Estimation results

**Table 1 Estimation Results**

| Sector (8) | Business category (18) | Number of enterprises | Energy consumption (Mtoe) | Average consumption (Mtoe) | $CO_2$ emissions (Mt-$CO_2$) | Average emissions (Mt-$CO_2$) |
|---|---|---|---|---|---|---|
| **Petrochemical** | | **118** | **68** | **0.6** | **234** | **2.0** |
| | Crude oil processing | 96 | 36 | 0.4 | 126 | 1.3 |
| | Ethylene (*) | 22 | 31 | 1.4 | 108 | 4.9 |
| **Chemical** | | **77** | **34** | **0.4** | **140** | **1.8** |
| | Carbide (**) | 21 | 1 | 0.0 | 3 | 0.2 |
| | Synthetic ammonia (**) | 29 | 22 | 0.7 | 90 | 3.1 |
| | Methanol (**) | 27 | 11 | 0.4 | 46 | 1.7 |
| **Non-metal** | | **1,557** | **150** | **0.1** | **639** | **0.4** |
| | Cement (***) | 1,247 | 135 | 0.1 | 574 | 0.5 |
| | Sheet glass (***) | 310 | 15 | 0.0 | 65 | 0.2 |
| **Steel** | Crude steel | **414** | **275** | **0.7** | **1,405** | **3.4** |
| **Nonferrous metal** | | **256** | **34** | **0.1** | **206** | **0.8** |
| | Electrolytic aluminum | 188 | 31 | 0.2 | 189 | 1.0 |
| | Copper | 68 | 3 | 0.0 | 17 | 0.2 |
| **Paper-pulp** | Pulp, paperboard, etc. | **498** | **37** | **0.1** | **183** | **0.4** |
| **Aviation** | | **20** | **6** | **0.3** | **18** | **0.9** |
| | Passengers, cargoes | 16 | 6 | 0.4 | 18 | 1.1 |
| | Airports | 4 | 0 | 0.0 | 0 | 0.0 |
| **Total final energy consumption** | | **2,940** | **604** | **0.2** | **2,826** | **1.0** |
| **Electricity** | | **1,251** | **377** | **0.3** | **1,498** | **1.2** |
| | Power generation | 666 | 295 | 0.4 | 1,175 | 1.8 |
| | Cogeneration (****) | 573 | 80 | 0.1 | 320 | 0.6 |
| | Power grids | 12 | 1 | 0.1 | 3 | 0.3 |
| **Total primary energy consumption** | **(Excluding double counting of electricity)** | **4,191** | **968** | **0.2** | **3,667** | **0.9** |

Notes:
(*) Excluding enterprises identified as crude oil processing enterprises.
(**) Excluding enterprises identified as crude oil processing or power generation enterprises. Some enterprises could fall into the three categories simultaneously.
(***) While clinker enterprises are subject to the emission report request, it is difficult to identify clinker enterprises for this paper. Therefore, the author identified only cement enterprises, assuming cement enterprises with 10,000 tce in energy consumption as clinker enterprises. Similarly, the author assumed sheet glass enterprises as glass enterprises.
(****) A total of 186 heat supply enterprises are not covered. Their energy consumption totals about 9.9 Mtoe.

**Table 2 Outline of region-by-region breakdown of estimation results**

| Region | Administrative districts (31) | | | Number of regulated enterprises | Energy consumption shares for regulated enterprises |
|---|---|---|---|---|---|
| Eastern (11) | Beijing | Tianjin | Hebei | 1,908 | 52% |
| | Liaoning | Shanghai | Jiangsu | | |
| | Zhejiang | Fujian | Shandong | | |
| | Guangdong | Hainan | | | |
| Central (10) | Jiangxi | Inner Mongolia | Jilin | 1,360 | 33% |
| | Heilongjiang | Anhui | Jiangxi | | |
| | Henan | Hubei | Hunan | | |
| | Guangxi | | | | |
| Western (10) | Sichuan | Chongqing | Guizhou | 923 | 15% |
| | Yunnan | Tibet | Yunnan | | |
| | Gansu | Qinghai | Ningxia | | |
| | Xinjiang | | | | |
| Total | | | | 4,191 | 100% |

**2.1 Enterprises subject to regulations**

The number of enterprises subject to regulations was estimated at 4,191. Remarkably, power generation enterprises account for the largest share of 1,253 firms, followed by 1,247 cement enterprises. Pulp and paperboard enterprises number more than 400. Crude steel enterprises also number more than 400. While the aviation sector is subjected to the emission report request, only a few enterprises in this sector are subjected to the top-10,000 enterprises program (Table 1).

The total number includes 1,908 enterprises located in eastern China, 1,360 in central China and 923 in western China (Table 2).

**2.2 Energy consumption subject to regulations**

Primary energy consumption by the enterprises subject to regulations totals 968 million tons of oil equivalent, accounting for 37.8% of China's total in 2010. The seven sectors' final energy consumption totals 604 million toe, accounting for 33.2% of China's total in 2010.

Energy consumption of power generation enterprises account for the largest share, followed by crude steel enterprises and cement firms. Average energy consumption per enterprise is the highest for ethylene enterprises, followed by synthetic ammonia enterprises and crude steel firms.

Of the energy consumption by the enterprises subject to regulations, eastern China accounts for 52%, central China for 33% and western China for 15%.

### 2.3 $CO_2$ emissions subject to regulations

$CO_2$ emissions by the enterprises subject to regulations are estimated at 3.67 billion t-$CO_2$, accounting for 48.0% of China's total $CO_2$ emissions in 2010. The percentage is close to the local average share for the existing local markets (Figure 1). With double counting $CO_2$ of electricity, $CO_2$ emissions total 1.5 Gt-$CO_2$ for power generation enterprises, followed by 1.41 Gt-$CO_2$ for crude steel enterprises and 0.57 Gt-$CO_2$ for cement enterprises. Among business categories with emissions at 100 Mt-CO2 or more are electrolytic aluminum with 190 Mt-$CO_2$, pulp and paperboard with 180 Mt-$CO_2$ and ethylene with 110 Mt-$CO_2$.

Among the business categories, ethylene posts the largest average $CO_2$ emissions per enterprise at 4.9 Mt-$CO_2$, followed by 3.4 Mt-$CO_2$ for crude steel and 1.2 Mt-$CO_2$ for power generation.

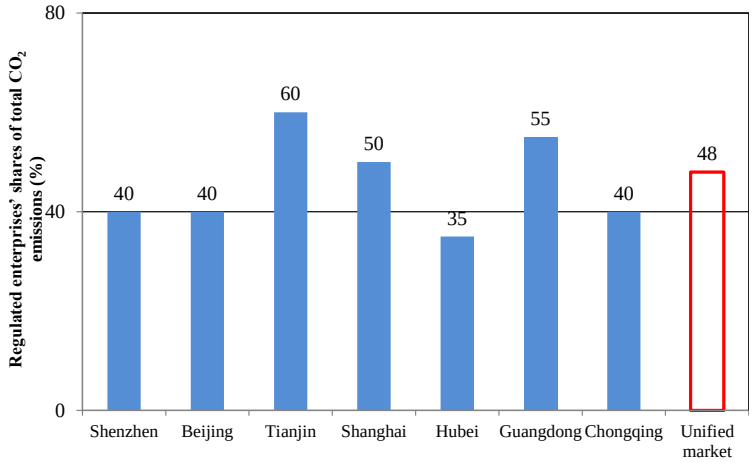


**Figure 1 Comparison between regulated enterprises' shares of total $CO_2$ emissions**

## 3. Unified Carbon Market Size

As mentioned above, the size of China's unified carbon market is estimated at 3.67 Gt-$CO_2$ (Figure 2).

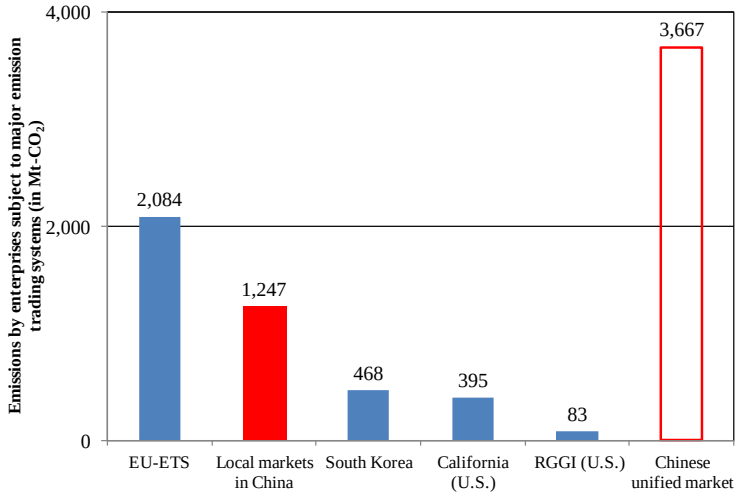


**Figure 2 Comparison between $CO_2$ emissions by enterprises subject to major emission trading systems in the world**

Depending on the treatment of heat supply enterprises[7] out of coverage in this paper and enterprises subject to the existing local markets, the unified market size may expand close to 4 Gt-$CO_2$, two times as large as the European market represented by the EU-ETS (European Union Emission Trading System), which is the largest carbon market in the world. This means that China will replace the EU as global carbon market leader, with the global carbon market size almost doubling.

The unified market size (total $CO_2$ emissions) can be converted into an economic value, though with greater uncertainties. If the carbon price is assumed at \$5-10/t-$CO_2$[8], the economic value works out at \$20-40 billion (more than 2-4 trillion yen). If China designs a futures market for $CO_2$ emissions and develops relevant financial products to boost annual trading volume three to four times as is the case with the EU-ETS, carbon emission trading volume in China may reach \$60-160 million (more than 6-16 trillion yen).

## Conclusion

In this paper, the author identified specific enterprises subject to regulations and estimated the size of China's unified carbon market. The objective of the estimation is considering implications of the size rather than attracting attention to the market size itself.

If such large carbon market is built, China will acquire a tool to surely realize $CO_2$ emission reduction that its government has promised. Given that the Chinese government places clear, great expectations on the introduction of non-fossil fuels to realize targets in its INDC

[7] See Notes for Table 1.
[8] Prices at the existing local markets have been reported at between 31and 67 yuan for 2013 and between 23 and 53 yuan for 2014 (1\$=about 6.5 yuan).

(Intended Nationally Determined Contributions) while falling short of giving sufficient considerations to energy conservation as noted by Shen (2015), the need for building the unified carbon market is understandable. Over a long term, China's unified carbon market may grow smoothly and cooperate with the EU-ETS and South Korea's ETS[9] in some manner, expanding its influences on the global carbon market. In this sense, China's establishment of the unified nationwide carbon market may be significant.

As a carbon pricing regulation approach, the ratio of the volume of greenhouse gas emissions subject to carbon emission trading systems to that of GHG emissions subject to carbon tax now stands at 2 to 1. If China introduces the unified market, the ratio may reach 3 to 1, leading carbon emission trading systems to become a more influential regulation tool.

If the giant carbon market is created, demand for energy conservation and low-carbon technologies probably grow faster. Particularly, such demand is expected to substantially increase in electricity and steelmaking sectors. As China is expected to procure such technologies throughout the world, enterprises with advanced energy efficient technologies will largely benefit. By having clarified the demand for technologies by industrial sector and category, as well as enterprise and region, the author hopes that this paper will contribute to international technical cooperation with China.

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[9] For example, China and South Korea have reportedly agreed to link their carbon markets. http://news.sina.com.cn/o/2015-12-22/doc-ifxmttme6128950.shtml