This paper is part of the Proceedings of the 24th International Conference on Modelling, Monitoring and Management of Air Pollution (AIR 2016)
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Air pollutant emission reduction effects of the Cap-and-Trade System in South Korea

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Abstract

The Seoul Metropolitan Area (SMA) in the Republic of Korea is a densely populated area, consisting of the major part of Gyeonggi, Seoul and Incheon. The SMA takes up only 12% of the total national land area in Korea, yet accounts for 49% of the total population, with a population density over 4 times higher than Korea's average population density. The Master Plan is formulated every 10 years and is modified after 5 years if formulation is necessary. There are 3 methods of calculating emission quantities, namely, continuous emission monitoring systems (CEMS), using emission factors and intermittent measurements. Those who intend to install facilities emitting the pollutants subject to total volume control exceeding the emission volume prescribed by law in an atmosphere control zone have to obtain permission and in order to obtain permission optimal prevention facilities have to be installed. Early in the system, the effects of CTS were weak because of over allocation and there was no regional allocation but from 2013 the effect of CTS has become more noticeable and it is expected that the effects will be stronger after 2017 because the regional allocation is reduced from that year. The air concentration of NO_X, SO_X of Seoul did not improve significantly in 2014. There is a limit to improving air quality only using CTS.
Keywords: cap and trade, air pollution, air pollutants, emissions reduction, emission estimation, NO_X, SO_X, *allocation.*

1 Introduction

The Seoul Metropolitan Area (SMA) in the Republic of Korea is a densely populated area, consisting of the major part of Gyeonggi, Seoul and Incheon. The SMA takes up only 12% of the total national land area in Korea, yet accounts for

www.witpress.com, ISSN 1743-3541 (on-line)
doi:10.2495/AIR160051

49% of the total population, with a population density over 4 times higher than Korea's average population density. Thus, the air quality in the SMA deteriorated during the 1970s with rapid industrialization [1].

Since the 1980s, the air quality in the SMA has been improved by various government efforts but, compared with other mega-cities in the world, the level of air pollution in the SMA is 1.7–3.5 times higher [2] and the annual cost of the social damage caused by air pollution has been estimated to be about 10 billion US dollars [3]; the adverse health effects from air pollution are also serious [4].

To solve the problem mentioned above, a "Special Act on the Improvement of Air Quality in Seoul Metropolitan Area (Special Act)" was enacted in 2003 and enforced in 2005. To implement the Special Act, the "Seoul Metropolitan Air Quality Control Master Plan (Master Plan)" was formulated; the first Master Plan (1MP) in 2005 and the second Master Plan (2MP) in 2013. The Cap-and-Trade System (CTS) on air pollutants is one of several measures in the Special Act and Master Plan.

In 1MP it was planned to decrease the annual air concentration of NO_X of SMA to 22ppb in 2014 but it was 33ppb [5]; in 2013 over-allocation was mentioned [6]. In 2MP it was aimed to decrease by 21ppb in 2024; 21ppb is the WHO guideline.

This study tries time series analysis of CTS effects in terms of allocation rate. This way is different from preceding studies [7–11] that compared the base year with the target year. The data used in this paper are official and are managed by the Korea Environment Corporation.

2 The Cap-and-Trade System in Korea

2.1 Master Plan

The Master Plan is formulated every 10 years and is modified after 5 years if necessary. To reinforce the effects of CTS 1MP was modified in 2010 and the area and facilities of CTS were expanded in 2MP.

2.2 Emission estimation

There are 3 ways of calculating emission quantities, namely, continuous emission monitoring systems (CEMS), using emission factors and intermittent measurements. Large emission sources have to calculate emission quantities using CEMS by the Clean Air Conservation Act (CACA) and the emission quantities from CEMS are recognized as emission quantities of CTS. In addition, the range of emission facilities which have to use CEMS by calculating emission quantities is expanded in CTS.

The method of emission factors is to calculate emission quantities using activities such as the amount of fuel consumption and emission factors decided by CACA. If it is impossible to use the emission factors method the intermittent measurements method is applied to calculate emission quantities.

Table 1: Master Plan.

		1MP		2MP
Period		2005–2014		2015–2024
Criteria (and)	Pollutants	NO_X, SO_X,		
	Area	Seoul, Incheon[1], Gyeonggi[2]		
	Annual emissions after preventive facilities (above)	2008.1–2009.6	2009.7–2015	2016–2024
		NO_X: 30t, SO_X: 20t	NO_X: 4t, SO_X: 4t	NO_X: 4t, SO_X: 4t
	Annual emissions[3] before preventive facilities (or above)	80t	20t	10t
Place business		121–126	270–321	–
Total emission		26–28Kt	22–33Kt	–
Allocation factor		2008.1.1–2012.11.6		After 2012.11.6.
		group by similar facilities		each facility

[1]except Ongjin-gun (include only Yeongheung-myeon)
[2]except Gwangju-city (1MP), Anseong-city (1MP), Yeoju-city (1MP), Pocheon-city (1MP/2MP), Yeoncheon-gun (1MP/2MP), Gapyeong-gun (1MP/2MP), Yangpyeong-gun (1MP/2MP),
[3]sum of NO_X and SO_X and TSP.

2.2.1 Continuous measurement

CEMS of Korea, Tele-monitoring System (TMS) measure the concentration and flow rate of emission gas in the stack and transmits the data to the agency in real time. CEMS is a relatively high accuracy compared to other emission calculation methods and CTS emissions over 90% are estimating emissions in this way.

2.2.2 Emission factors

The emissions factor method is to calculate the emissions (E) by emission factors (EF), preventive facilities efficiency of pollutant removal (r), activities such as fuel consumption amount.

$$E = EF \times A \times (1 - r) \tag{1}$$

2.2.3 Intermittent measurement

This method is to calculate by measuring pollutant concentration in its own business. The numbers of measurements are defined in the CACA once a week to twice a year, depending on the size of the facility.

2.3 Permission

The person who intends to install facilities emitting the pollutants subject to total volume control exceeding the emission volume prescribed by law in an atmosphere control zone shall obtain permission and in order to obtain permission the facilities have to have optimal prevention facilities installed. Permission levels are possible only to comply with local emission allowances.

2.4 Allocation

There are two types of allocation; regional and business. Regional allocation is set for emission allowances within the area of each region. A source-specific emission allowance is allocated by business and allocated in the local level.

2.4.1 Regional

Regional allocation established in 2MP was decided, taking into account the economic growth rate and range expansion of CTS, technical improvement.

Table 2: Regional emission allowance.

	Year	Seoul	Incheon	Gyeonggi
NO_X	2015	1,891	17,594	27,117
	2016	1,802	17,443	28,948
	2017	1,713	17,264	28,979
	2018	1,590	16,588	27,827
	2019	1,465	16,059	26,146
	2020	1,340	15,506	24,588
	2021	1214	14,837	22,898
	2022	1090	14,165	21,204
	2023	975	12,960	18,793
	2024	861	11,754	16,379
SO_X	2015	35	11,452	6,136
	2016	35	11,434	6,049
	2017	35	11,416	5,962
	2018	35	11,120	5,908
	2019	35	10,827	5,853
	2020	35	10,535	5,800
	2021	36	10,250	5,748
	2022	36	9,183	5,693
	2023	36	8,679	5,419
	2024	36	8,172	5,146

2.4.2 Business

Allocation of business occurs every 5 years. The estimation type of allocation has been amended 4 times up to now. A third amendment conducted on the 2012 allocation type was changed. Before the third amendment, allocation factors were fixed by facilities group having similar emission characteristics. This way of allocation is beneficial for a business to install the best available control technologies but over allocation may occur. For the third amendment, allocating by each business was introduced to solve an over allocation situation.

2.5 Transfer

Trading of emission allowances allocated is possible only with the same pollutant and same year, and there are no quantitative restrictions. It is limited only when the total amount exceeds the local emission.

The remaining amount of emission allowances during the year may be transferred to the following year in the range that does not increase an emission allowance the following year.

2.6 Voluntary agreement

Where a business operator under total volume control establishes a plan to reduce the emission of pollutants subject to total volume control below the relevant total permissible volume of emission and enters into a voluntary agreement with the Minister of Environment (MOE), the MOE may provide several benefits to the business operator.

1. Support of financial resources necessary to carry out a voluntary agreement;
2. Reduction of the amount equivalent to the volume reduced above the total permissible volume of emission allocated in the previous year when imposing dues.

3 Result

3.1 Allocation and emission

3.1.1 NO_X

2009 emissions compared to 2008 decreased by 1,851t. In 2010, the business of CTS increased 55% compared to the previous year. From 2010 until 2013 there was no significant change in emissions but in 2014 emissions decreased by a relatively large proportion.

The ratio of emission–to–allocation was increased from 0.43 in 2008 to 0.86 in 2013 and in 2014 the emissions were sharply reduced.

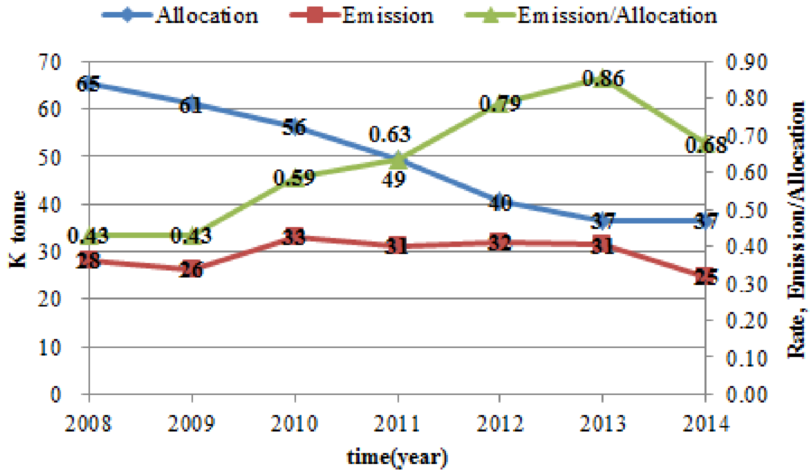

Figure 1: NO_X amount of allocation and emission.

3.1.2 SO_X

There was no significant emission reduction until 2013 but the ratio emission of allocation increased to 0.87 in 2013 and in 2014 the emissions reduced sharply.

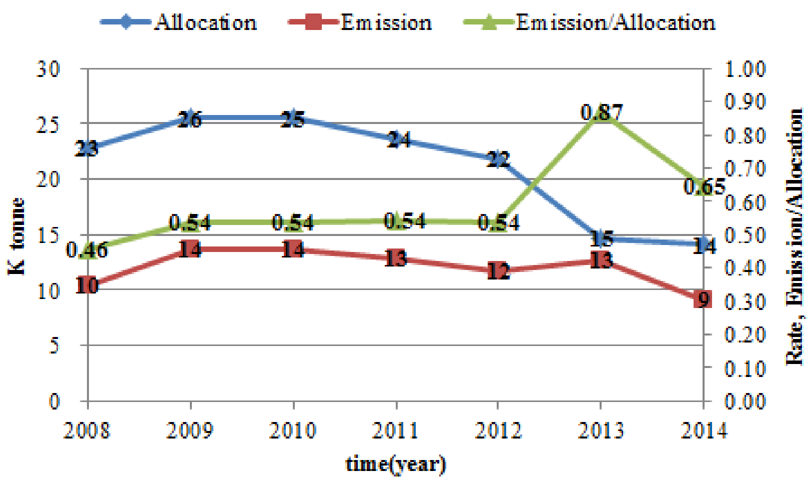

Figure 2: SO_X amount of allocation and emission.

3.2 Transfer

The ratio (transfer/allocation) showed a tendency to increase gradually until 2013 and the price of allowance increased continuously.

Table 3: The ratio transfer of allocation.

		2008	2009	2010	2011	2012	2013	2014
NO_X	Transfer/allocation (%)	1.4	0.5	1.0	1.4	4.6	5.5	3.3
	Price of allowance (10^3₩/t)	6.2	22.6	130.7	114.0	69.2	233.8	311.2
SO_X	Transfer/allocation (%)	0.5	0.9	6.7	6.6	6.4	19.8	3.9
	Price of allowance (10^3₩/t)	202	48	52	52	90	178	268

3.3 Reduction method

The large reduction methods are classified into three categories; fuel change, improving control facilities and facility shutdown. The highest number of reduction methods used was in 2012.

Table 4: Number of reduction methods.

		2008	2009	2010	2011	2012	2013	2014
NO_X	Fuel change	4	4	10	27	39	32	14
	Improving control facilities	8	5	7	13	21	23	18
	Facility shutdown	15	5	42	58	53	48	26
SO_X	Fuel change	6	6	14	33	47	31	19
	Improving control facilities	2	-	5	1	4	5	3
	Facility shutdown	12	-	22	25	24	19	10

4 Conclusion

Until 2012 the effects of CTS were not clearly revealed. The emissions were reduced dramatically in 2013 because the allocation method was changed and the second allocation was started in that year.

In the case of CTS of Korea, the reduction effects of emission are caused when the ratio emission of allocation is above 0.8. Therefore, the appropriate allocation is important in order for CTS to succeed.

The ratio (transfer/allocation) was the highest in 2013 but the price of allowance was the highest in 2014; it reflects that the CTS effects are continuous.

Early in the system, the effects of CTS were weak because of over allocation and no regional allocation but from 2013 the effect of CTS became more obvious and it is expected that the effects will be stronger after 2017 because the regional allocation is reduced from that year.

The air concentration of NO_X, SO_X of Seoul did not improve significantly in 2014 [5]. There is a limit to improving air quality only using CTS.

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