2010 International Conference on Biology, Environment and Chemistry
IPCBEE vol.1 (2011) © (2011) IACSIT Press, Singapore

Accounting and Analysis of the Cost of Air Pollution Control in Urban

Song cheng
Institute of Environmental Science and Engineering
Environmental Engineering Department
Chang'an University, 710061
Xi'an, P.R. China
Email:song_cheng88@163.com

Yang jian-jun
Institute of Environmental Science and Engineering
Environmental Engineering Department
Chang'an University, 710061
Xi'an, P.R. China
Email:yangjianjun_05@163.com

Dong xiao-lin
Institute of Environmental Science and Engineering
Environmental Engineering Department
Chang'an University, 710061
Xi'an, P.R. China
Email: Dxlin@chd.edu.cn

Wu ying-chao
Institute of Environmental Science and Engineering
Environmental Engineering Department
Chang'an University, 710061
Xi'an, P.R. China
Wuyingchao521@126.com

***Abstract*—With the analysis model of control cost per-unit, the cost of air pollution control was accounted in Xi'an from 2000 to 2007 in this paper. Based on the accounting results, the gross amount and the structure of control cost were analyzed. Environmental economic indicators were used in analytical process, such as the virtual control cost, the index of pollution control cost deduction from GDP and the environmentally adjusted domestic product. The results showed that the key control pollutants are smoke and SO_2. The ratio of the VCC to ACC showed that the air pollution control expenditure remains inadequate, so the investment for air pollution control should be increased progressively. The index of pollution control cost deduction from GDP in air pollution was less than the national average.**

Keywords- air pollution control; the cost of pollution control accounting; environment valuation in physical terms and monetary terms;the virtual control cost(VCC); the index of pollution control cost deduction(IPCCD) from GDP; environmentally adjusted domestic product(EDP)；the control cost per- unit(CCPU)

I. INTRODUCTION

The cost of environmental pollution control accounting is an important part of the green gross domestic product (GGDP) accounts, which mainly includes pollutants accounts in physical terms and environment valuation accounts in monetary terms. From the angle of the practical consequences caused by pollution, the latter is more reasonable than the former. But based on the present technology, to build dose response relation between physical loss and environmental pollution is very difficult. So the method of the cost of pollution control is used to account the environment valuation in monetary terms in Xi'an from 2000 to 2007. On the basis of the accounting results, the gross amount and the structure of air pollution control cost are analyzed. The paper provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. It is intended to meet the needs of environment protection and management policy makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment as well as serving as a tool for strategic planning and policy analysis to identify more sustainable development paths. Moreover, it may provide some references for researching in GGDP of Xi'an.

II. THE COST OF AIR POLLUTION CONTROL

A. The Intension of Pollution Control Cost

The cost of environmental pollution control includes the actual control cost (ACC) and the virtual control cost (VCC). The ACC is actual expenditure for pollution control, including the fixed assets depreciation expense, maintenance cost, labor cost, electrical bills as well as various material consumption cost. Generally the annual operating costs in wastewater, gas and the solid waste treatment are thought as the ACC.[1] The VCC refers to the costs which should be used to control various pollutants discharged into the environment. The physical accounts and the ACC of pollutants determination are basic works of the VCC .[2]

B. The Accounting Model of Pollution Control Cost

At present, there are five models used to account the cost of pollution control, which are the marginal control cost model [3,4], the discharge standard token model[5], the control cost coefficient model[6], the analog model[7] and the control cost per-unit (CCPU) analysis model[5]. By reason of statistical data easily gotten, simple procedure and easily understood, the analysis model of CCPU is used to account the cost of air pollution control in this paper. Basic calculate formulas are shown in (1) and (2).

$$\text{The ACC}=\sum(\text{the amount of control}\times\text{the ACC per-unit}) \quad (1)$$

$$\text{The VCC}=\sum(\text{the amount of emission}\times\text{the VCC per-unit}) \quad (2)$$

Because the VCC pre-unit is difficult to be determined, the date of the ACC per-unit can be regarded as the VCC pre-unit by its definition[8].

III. COST ACCOUNTING OF AIR POLLUTION CONTROL

Two main parts must be considered in cost accounting in Xi'an, namely the cost of industrial air pollution and the cost of air pollution in urban life.

A. The Cost of Industrial Air Pollution Control in Xi'an

1) The accounting of industrial air pollutants in physical terms

a) To calculate the emission of industrial NO_x

Because there aren't statistics about the emission of industrial NO_x in the Statistical Yearbook of Xi'an (2000-2008) and the Report on Xi'An Environmental Status (2000-2008), the discharge coefficient of industrial NO_x in Shaanxi province is used to calculate the emission of NO_x in Xi'an. The formula is shown in (3). The specific calculating results are shown in Table Ⅰ.

$$\text{the NO2 discharge coefficient of industrial output value} = \frac{\text{the amount of industrial } NO_X \text{ discharge(ton)}}{\text{industrial output value(100 million Yuan)}} \quad (3)$$

b)Statistics of industrial air pollutants in physical terms

According to the Statistical Yearbook of Xi'an and Shaanxi province, and the emission of industrial NO_x calculated, the statistical data of main air pollutants in Xi'an are shown in Table Ⅱ.

c)The related data of industrial gas control

The related data of industrial gas control cost is shown in Table III.

2)The cost accounting of industrial air pollutants control

a) the accounting of the ACC

According to the Statistical Yearbook of Xi'an and the Report on Xi'an Environmental Status, the industrial air pollutants of Xi'an mainly are smoke, dust, SO_2 and NO_x. However, there is no effective method of NO_x control, the actual control amount of NO_x is very small，so the ACC of NO_x could be considered approximately to zero. During the accounting process, the annual operating cost of treatment facilities is used as the ACC of industrial air pollutants. The formulas of the ACC of smokedust and SO_2 are shown in (4) ~ (7).

$$\text{the ACC of industrial } SO_2 = \text{the ACC of industrial gas} \times \frac{\text{the number of desulphurization facilities}}{\text{the number of gas control facilities}} \quad (4)$$

$$\text{the CCPU of industrial } SO_2 = \frac{\text{the ACC of } SO_2}{\text{the amount of } SO_2 \text{ reduction}}, \quad (5)$$

TABLE I. THE CALCULATING OF THE EMISSION OF INDUSTRIAL NO_X IN XI'AN (2000~2007)

item \ year	2000	2001	2002	2003	2004	2005	2006	2007
The amount of the industrial NO_X emission in Shaanxi (ton)	—	—	—	—	—	—	202500	234200
The industrial output value of Shaanxi （100 million Yuan）	1714.18	1946.94	2205.98	2708.86	3389.88	4109.32	5248.39	6587.41
the industrial NO_X discharge coefficient of Shaanxi	38.5833	38.5833	38.5833	38.5833	38.5833	38.5833	38.5833	35.5527
The industrial output value of Xi'an （100 million Yuan）	639.48	736.15	837.94	975.08	1185.32	1308.56	1557.35	1979.86
The amount of the industrial NO_X discharge in Xi'an (ton)	24673*	28403*	32330*	37622*	45734*	50489*	60088*	70389*

Data Source: the Statistical Yearbook of Xi'an(2001-2008); the Statistical Yearbook of Shaanxi(2001-2008)

Note: * Shows that the data is calculated by the industrial NOx discharge coefficient of Shaanxi Province and Industrial output value of Xi'an City.

TABLE Ⅱ. THE PRACTICAL OUTPUT OF THE KEY INDUSTRIAL POLLUTANTS OF XI'AN (2000~2007) Unit: ton

item \ year		1999	2000	2001	2002	2003	2004	2005	2006	2007
SO_2	emission	92573	87003.51	78604.53	71778.58	71749.25	90508.1	94341.39	91674.20	98155.37
	reduction	6733	6394.8*	5777.4*	5275.7*	5273.6*	6728.8	9423.53	11000.28	17666.82
smoke	emission	66837	66653.02	30295.51	33195.53	38325.83	43767.0	39541.28	38344.52	24362.73
	reduction	458996	442406.42	334853.18	426517	497093.3	591938.1	566809.97	783767.72	645604.01
dust	emission	68795	64759.19	90917.7○	57113.7○	42134.2○	28223.9	25975.53	19564.05	10197.82
	reduction	34643	40031.55	72053.95	58656.36	57169.93	57358.1	58358.06	47868.06	38908.66
NO_x	emission	—	24673●	28403●	32330●	37622●	45734●	50489●	60088●	70389●

Data Source: the Statistical Yearbook of Xi'an(2001-2008); the Statistical Yearbook of Shaanxi(2001-2008)

Note: * shows that the data is calculated by the average ratio of 0.0735 which derived from the accounted for the control and discharge of SO2 in 1999 and 2004;
○ shows that the data is calculated by the fitted equation (y = 0.0257x2-0.468x +2.4345, R2 = 0.9957);
● shows that the data is calculated by the industrial NOx discharge coefficient.

TABLEIII. THE RELATED DATA OF INDUSTRIAL GAS CONTROL COST OF XI'AN (2000~2007)

item \ year	2000	2001	2002	2003	2004	2005	2006	2007
the operating cost of gas treatment facilities （million Yuan）	13.496△	20.122	90.50	25.938	26.285	25.398	114.934	40.68

the number of facilities gas treatment facilities	552※	823	882	878	972	950	840	846
the number of desulphurization facilities	190*	283*	304*	302*	335*	327	175	209

Data Source: the Statistical Yearbook of Xi'an(2001-2008);
Note: △ shows that the data is calculated by the operating cost of gas control per-facility in 2001;
※ shows that the data is the average of 1999 and 2001;
* shows that the data is calculated by the ratio of the number of gas control facilities and the number of desulphurization facilities in 2005.

$$\text{the CCPU of industrial smoke and dust} = \frac{\text{the ACC of industrial gas} - \text{the ACC of } SO_2}{\text{the number of smoke and dust control}} \quad (6)$$

$$\text{the ACC of industrial smoke and dust} = \text{the number of smoke and dust control} \times \text{its CCPU} \quad (7)$$

b) The accounting of the VCC

The VCC of key pollutants in industrial gas could be calculated in (8)~(10). Accounting results of industrial gas in Xi'an are shown in TableⅣ.

$$\text{the VCC of industrial } SO_2 = \text{the emission of } SO_2 \times \text{the CCPU} \quad (8)$$

$$\text{the VCC of industrial smoke dust} = \text{the emission of smoke dust} \times \text{its CCPU} \quad (9)$$

$$\text{the VCC of industrial } NO_x = \text{the emission of NOx} \times \text{its CCPU} \quad (10)$$

TABLE Ⅳ. THE ACC AND THE VCC OF XI'AN INDUSTRY GAS (2000 ~ 2007) unit: million Yuan

item \ year		2000	2001	2002	2003	2004	2005	2006	2007
the ACC	SO_2	4.645	6.919	31.193	8.922	9.059	8.7423	23.9446	10.0498
	Smoke	8.117	10.865	52.137	15.261	15.704	15.101	85.752	28.889
	Dust	0.734	2.338	7.170	1.755	1.522	1.555	5.237	1.741
Total		13.496	20.122	90.50	25.938	26.285	25.3983	114.934	40.6798
the VCC	SO_2	63.165	94.168	424.427	121.40	121.824	87.548	199.5747	55.8504
	Smoke	1.223	0.983	4.058	1.177	1.161	1.053	4.195	1.090
	Dust	1.188	2.950	6.982	1.294	0.749	0.692	2.141	0.456
	NO_X	0.4527	0.9216	3.952	1.155	1.2133	1.3451	6.5742	3.1497
Total		66.0287	99.0226	43.9419	125.026	124.9473	90.6389	212.4849	60.5461

B. The Cost of Air Pollution Control in Urban Life

Because the gas from urban life is difficult to centralized control, its ACC can be considered approximately as zero. Therefore, the VCC of urban life gas is calculated in this paper.

1) The method of the VCC accounting

The method of the VCC accounting about urban life gas is shown in (11).The CCPU of urban life gas could use the corresponding CCPU of industrial gas.

$$\text{The VCC of urban life gas} = \text{the emission of pollutant} \times \text{the CCPU} \quad (11)$$

2)The accounting results of the VCC

The emission of urban life gas are calculated and shown in TableⅤ.The VCC of urban life gas are shown in TableⅥ.

C. The Accounting Results Of Air Pollution Control

The accounting results of air pollution control are shown in TableⅦ.

IV. THE ANALYSIS OF AIR POLLUTION CONTROL COST IN XI'AN

A. The Analysis Of the total and the Structure of Control Cost

1)The investment for air pollution control remains inadequate in Xi'an

According to TableⅦ and Fig.1, the maximum ratio of the VCC to the ACC reached 5.7 times in 2001. Although the cost of air pollution control increased to 114.94 million in 2006, the ratio of the VCC to the ACC was still 2.1 times. So the investment for air pollution control should be increased progressively in Xi'an.

TABLE Ⅴ. THE NUMBER OF URBAN LIFE GAS DISCHARGE IN XI'AN (2000 ~ 2007)

item \ Year	2000	2001	2002	2003	2004	2005	2006	2007
the number of urban life SO_2 discharge	13680*	12359*	11286*	11281*	14227	14908	14268	5789
the number of urban life smoke and dust discharge	31001○	14091○	15440○	17826○	20362	20813	7595	8397
the number of urban life NO_X discharge in xi'an	13054●	15028●	17106●	19906●	24198●	26714●	31793●	37243●
the number of industrial NO_X discharge in ShaanXi	—	—	—	—	—	—	20.25	23.42

the number of urban life NO_X discharge in ShaanXi	—	—	—	—	—	—	10.71	6.76

Data sources: the Statistical Yearbook of Xi'an(2001-2008); the Statistical Yearbook of shaanxi (2001 ~ 2008); the Report on Xi'An Environmental Status (2001 ~ 2008)
Note: * shows that the data is calculated by the ratio (6.38) of SO2 discharge between the industry and urban life in 2004
○ shows that the data is calculated by the ratio(2.15) of dust discharge between the industry and urban life in 2004
● shows that the data is calculated by the ratio(1.89) of NO_X discharge between the industry and urban life in 2006

TABLE Ⅵ. THE VCC OF URBAN LIFE GAS IN XI'AN (2000~2007) unit: million Yuan

item \ year		2000	2001	2002	2003	2004	2005	2006	2007
The VCC	SO_2	9.937	14.801	66.729	19.085	19.154	13.830	31.058	3.293
	Smoke and dust	0.5688	0.4572	1.8874	0.5473	0.5402	0.5545	0.831	0.3757
	NO_x	0.239	0.4876	2.091	0.6111	0.642	0.7117	3.4785	1.6665
合计		10.7448	15.7458	70.7074	20.2434	20.3362	15.0962	35.3675	5.3352

TABLE Ⅶ. THE COST OF AIR POLLUTION CONTROL IN XI'AN (2000~2007) unit: million Yuan

item	2000	2001	2002	2003	2004	2005	2006	2007
The ACC	13.496	20.122	90.50	25.938	26.285	25.3983	114.9336	40.6798
The VCC	76.7735	114.7684	510.1264	145.2694	145.2835	105.7351	247.8524	65.8813
total	110.2695	154.9004	620.6464	191.2374	191.6085	151.1834	382.846	126.6311

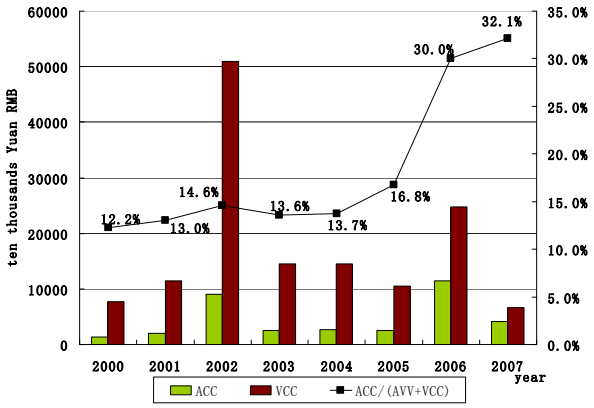

Figure1. The comparison between the ACC and the VCC of air pollution in xi'an(2000~2007)

2) The key pollutants of air pollution control of Xi'an are smoke, dust and SO_2

According to TableⅣ, the key pollutants of air pollution control in Xi'an are smoke dust and SO_2.The ACC of smoke dust and SO_2 accounts for exceeding 90 per cent of the total ACC. Especially the ACC of smoke dust accounted for 60 % of the total ACC from 2003 to 2005. The ACC of SO_2 accounted for 24.7%~34% of the total ACC between 2000 and 2007.

B. The Accounting Of EDP In Air Pollution

1) The analysis of the IPCCD from GDP

The IPCCD from GDP is the ratio of the pollutants VCC to GDP, which reflects the quality of economic and environment, and reflects a minimum investment for air pollution control should be paid. The IPCCD from GDP changed from 0.04% to 0.62% between 2000 and 2007 in Xi'an, which was less than the national average.

2) The accounting of EDP in air pollution

The EDP in air pollution is to subtract the VCC from GDP.The accounting result are shown in TableⅧ.

TABLEⅧ THE ACCOUNTING RESULTS OF EDP IN AIR POLLUTION IN XI'AN (2000~2007)

item \ year	2000	2001	2002	2003	2004	2005	2006	2007
The VCC (million Yuan)	76.774	114.76	510.126	145.27	145.28	105.74	247.85	65.881
GDP of Xi'an (billion Yuan)	688.5	734	823.5	940.4	1095.9	1270.1	1450	1737.1
The pollution reduction index of GDP (%)	0.11	0.16	0.62	0.15	0.13	0.08	0.17	0.04
The EDP in air pollution (billion Yuan)	687.7	732.85	818.4	938.95	1094.4	1269.1	1447.6	1736.4

V. CONCLUSION

1) The analysis model of the CCPU is used to account the cost of air pollution control in Xi'an from 2000 to 2007.

2) The investment for air pollution control of Xi'an remains inadequate, and the investment should be increased progressively.

3) The IPCCD from GDP and EDP in air pollution are used to analyze the environmental costs of economic development. The IPCCD from GDP in air pollution is far lower than the nation's average, except for 2002 in Xi'an.

ACKNOWLEDGMENT

The research is sponsored by the Natural Science Basic Research Program of Shaanxi Province, (SJ08-ZT07-2)

Ministry of land and natural resources in arid and semi-arid areas of open water resources and environmental research laboratory

REFERENCES

[1] State Environmental Protection Administration.Study Report 2004 for Green National Economic Accounting(Public Preview),2006.

[2] Mao guo-ping.A Study on the Resource-Environment-Economy Relationship of Hunan Province Based on Input-Output Analysis and Product Life Cycle Assessment. Central South University,2009.

[3] Shao Yulin .Study on Cost Function of Industrial Pollution Control in Tianjin. Urban Environment & Urban Ecology,vol12,pp 29-32.1999.

[4]Ye han-dong,Li yu-hong. The Research on Reasonable compensation for pollution reduction methods. East China Electricity,vol(6),pp11-13,2003.

[5] Tan ya-rong. The research on the method of theEnvironmental pollutants control cost per-unit. Productivity Research,vol(24),pp52-53,2007.

[6] Yang jin-tian, Wang jin-nan.Reform And Design Of Collection Of Drainage Dues In China. Beijing: China Environmental Science Press,pp65,1998.

[7] Dong xiao-lin.the applied research on of environmental and economic indicators System of regional development in Shaanxi Province，2010，unpublished.

[8] Xi'an Environmental Protection Bureau. http://www.xaepb.gov.cn..

[9] State Environmental Protection Administration. World Bank. Study Report for construction Green National Economic Accounting.2006.