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The Study on Cost of Application of International Emission Control Areas for China

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Abstract: In order to control the air pollution caused by ships and improve ambient air quality, China set up three domestic emission control areas (DECAs) in 2015 in the Pearl River Delta, the Yangtze River Delta and Bohai Rim (Beijing-Tianjin-Hebei) waters. In order to meet the emission requirements established at the 70th meeting of the Marine Environmental Protection Committee (MEPC), China intends to apply for the establishment of three international Emission Control Area (ECA) in 2030 for these DECAs. This paper discusses existing technologies to reduce emissions of nitrogen oxides (NO_x) and sulphur oxides (SO_x), and examines the abatement costs for the shipping industry in the year 2030 to comply with this action. Based on an examination of the literature and data collected for this study, four traditional alternatives, low-sulphur fuel, sulphur scrubbers/exhaust gas cleaning systems (EGCS), selective catalytic reduction (SCR), and exhaust gas recirculation, are analyzed. The analysis finds that switching to low-sulphur fuel is the best technical solution for SO_x emission reduction, and the installation of SCR is the best technology for reducing nitrogen. In addition to traditional emission reduction technologies, the use of shore power facilities and liquefied natural gas (LNG), two alternatives welcomed by China's green shipping industry, are also considered in this paper. The expected average abatement cost of these alternatives in the year 2030 are USD 2.866 billion, 0.324 billion, 1.071 billion, 0.402 billion, 0.232 billion and 0.34 billion, respectively.

Key words: emission control area; abatement cost; abatement technology; sulphur reduction; nitrogen reduction; clean energy

1 Introduction

Shipping carries about 90% of the world's cargo annually and plays an important role in international trade and the world economy (Jiang et al., 2014). Large amounts of exhaust gas emitted by shipping activities put a large burden on the global environment and human health (Incentive et al., 2012). Therefore, The International Maritime Organization (IMO) adopted a revised "The International Convention for the Prevention of Pollution from Ships" (MARPOL) Annex VI that includes stipulations for the reduction of SO_x and NO_x emissions from ships (IMO, 2018). For any fuel used on board, global sulphur had to be reduced to 0.5% as of January 1, 2020. At the same time, IMO allows countries with special needs to establish Emission Control Areas (ECAs) where more stringent controls on SO_x and/or NO_x can be imposed (IMO, 2018). For ships built after 2015 that operate in the North America ECA, NO_x emissions will have to comply with Tier III standards. New ships that operate within the North Sea and Baltic Sea ECAs and are built after 2020 must also meet Tier III NO_x emission standards.

To comply with the IMO requirements for SO_x and NO_x emissions, China's Ministry of Transport (MOT) issued a document concerning regulations for domestic emission

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control areas (DECAs) in 2015; this document requires shipowners to adopt new emission reduction technologies.

Currently, two technological options are available for sulphur removal: switching to low-sulphur fuel or installing exhaust gas cleaning systems (EGCS). There are also two technological options available for nitrogen removal: selective catalytic reduction (SCR) uses a catalyst to reduce nitrogen oxides to nitrogen and water, while exhaust gas recirculation (EGR) redirects exhaust gas back into the combustion chamber to lower the engine combustion temperature and control NO_x emissions. Beyond these alternatives, the substitution of conventional fuels with LNG and shore power application are highly recommended. In conclusion, this paper estimates the abatement costs of these six reduction measures: low-sulphur fuel, EGCS, SCR, EGR, shore power application, and LNG.

2 Brief comparison of emission reduction alternatives

2.1 Switching to low-sulphur fuel

Compared with after-treatment technologies, switching to low-sulphur fuel is the easiest abatement technique to adopt. There are two aspects to abatement costs for switching to low-sulphur fuel. Firstly, existing boiler and diesel engine systems, involving but not limited to fuel supply systems, combustion devices, and monitoring and display systems, have to be retrofitted to be compatible with low-sulphur fuel, and this might entail expenses for shipowners. Second, abatement costs can also result from price differences between fuels with different sulphur content.

2.2 Installing exhaust gas cleaning systems

Installing a sulphur scrubber in an EGCS can reduce sulphur emissions by 98% (Kristensen, 2012). There are two types of EGCS: wet and dry. Wet types make use of one of two technologies: An open exhaust scrubber that uses seawater as a “detergent” to wash sulphur dioxide emissions or a closed exhaust scrubber that uses alkaline freshwater to reduce sulphur emissions. Dry type scrubbers spray limestone or magnesium oxide directly into a ship’s exhaust gas to reduce sulphur oxide emissions. Installing either type of EGCS can entail significant cost. According to data from the classification society DNV GL (Marcus, 2019), as of Sep 5, 2019, over 3000 ships, both newly built and existing, were scheduled to have scrubbers fitted or already had had systems installed to comply with the IMO 2020 sulphur cap. Due to the cost, storage, loading, purity requirements and other factors associated with magnesium oxide, closed exhaust scrubbers are generally not selected by shipowners, while open desulfurization towers are most welcomed by crew member. The international manufacturers of EGCS systems include Alfa Laval, Wärtsilä, DuPont, Zach, and Mitsubishi. China’s EGCS manufacturers include CSIC 711, Weihai Zhongyuan Shipbuilding Technology Co. Ltd., Shandong Pesen Environmental Technology Co. Ltd., Weihai Puyi Ship Environmental Protection Technology Co. Ltd., and Shanghai Blue Soul Environmental Protection Technology Co. Ltd. According to major manufactures, most shipping companies are taking a wait-and-see attitude towards EGCS systems, particularly because of the impact that installations may have on operations.

2.3 Installing selective catalytic reduction system

Installation of a SCR system offers a method for nitrogen oxides abatement that complies with Tier III emission standards. SCRs use urea as a reducing agent to catalytically reduce nitrogen oxides to nitrogen and water. The China Classification Society (CCS) has published the *Preset Guide for Selective Catalytic Reduction of Ship Systems* to provide technical guidance for SCR system presets. Because they have high removal efficiency of 70% to 90%, create less secondary pollution and rely on mature technology, SCRs are cost effective and increasingly applied to vessels, especially vessels with four-stroke engines and auxiliaries.

2.4 Installing exhaust gas recirculation system

EGR is based on redirecting a part of the exhaust gas back into the combustion chamber to lower the combustion temperature and reduce the nitrogen emissions to meet Tier III emission standards. Because it can be installed in a small space, it is possible to integrate an EGR with a desulfurization device on the ship to reduce nitrogen as well as sulphur dioxide emissions.

2.5 Installing shore power application

China’s Port Coastal Power Layout Plan states that more than 50% of the passenger roll berths, cruise ship berths, containership berths and specialized berths with dry bulk of 50000 tons or more in major ports and ECA should have the capability to supply shore power by the end of 2020. Ports with high demand and good conditions are encouraged to achieve 100% shore power coverage of berths. There will be a total of 493 specialized berths with the capacity to supply shore power in major ports and ECA by the end of 2020, including 366 in coastal areas and 127 along inland rivers.

2.6 Liquefied natural gas ships

As an alternative to conventional fuels, clean-energy LNG can significantly reduce the amount of nitrogen and sulphur pollutants emitted by ships. Substituting LNG for fuel oil as a ship’s power source results in almost no sulphur emissions and a 35% to 85% reduction of nitrogen emissions (Panasiuk et al., 2013). There are two main types of LNG engine systems for ships: LNG injection engines, and dual-fuel diesel electromechanical systems on LNG carriers. The main cost of an LNG ship is the cost of purchasing or constructing the LNG ship, including the cost of the ship’s electromechanical system, the LNG storage tank, the LNG transfer line and the LNG filling facilities.

3 Cost estimates of emission reduction alternatives

3.1 Cost of switching to low-sulphur fuel

Coastal and ocean-going vessels normally use heavy fuel oil (HFO) #180 or blended oil. This means shipowners have to retrofit their vessels with special low-sulphur oil tanks and fuels pipelines to switch to a low-sulphur fuel. Documentation for the North American ECA indicates that the use of low-sulphur oil equipment results in a 0.5%–2% cost increment (USEPA, 2019). The findings of the United States Environmental Protection Agency (USEPA) show that the cost of retrofitting equipment for ships with low-speed diesel engines is from USD 1.50 kW^{-1} to USD 4.90 kW^{-1}. Ships with medium-speed diesel engines cost from USD 3.10 kW^{-1} to USD 7.50 kW^{-1} to retrofit (USEPA, 2009). Field studies conducted by our research group for several ship manufacturers indicate that the cost of retrofitting varies according to the size of vessels, but the cost of retrofitting one ocean-going vessel is generally in the range of USD 1.4 million to USD 2.1 million.

Switching costs are generated by calculating the price difference between fuels with 0.5% sulphur content (0.5% S) and 0.1% sulphur content (0.1% S) fuels. This paper calculates switching costs based on the average daily fuel price at Shanghai Port. The average price difference between 0.1% S fuel and 0.5% S fuel is USD 137.20 t^{-1}.

3.2 The cost of exhaust gas cleaning systems

The cost of retrofitting a ship varies depending on the degree of modification required, and generally costs 40% more than a new build (Jiang et al., 2014). Depending on ship type and tonnage and the scrubber technology chosen, purchase and installation of a scrubber system in the US or Europe costs between USD 0.7 million and USD 4 million. The cost of installation is an additional 40% to 50% of the cost of equipment. Field studies from international manufacturers of EGCS systems show that the price of foreign equipment is higher than that of Chinese-made equipment. The cost of a domestic open exhaust scrubber system ranges from USD 80 kW^{-1} to USD 120 kW^{-1}. Additional fuel fees, which account for 1%–3% of fuel costs, are included in the operating cost of the scrubber.

3.3 The cost of selective catalytic reduction systems

The principal costs of installing an SCR include the costs of the reactor, the monitoring system and the control system, all of which vary in price depending on ship type and size. The operating cost of a system depends on the amount of urea used and the cost of catalyst regeneration. Different agencies quoted different prices, as shown in Table 1. According to the experience of the ECA in the United States, the investment in SCR equipment required for large ships ranges from nearly USD 40 kW^{-1} to USD 135 kW^{-1}. Operating costs is an additional 7% to 10% of the cost of fuel (IMO, 2014). According to the Baltic Marine Environmental Protection Agency (BMEPC, 2016), the average cost of SCR technology to reduce NO_x is USD 1425 t^{-1} to USD 1996 t^{-1}, and the cost of reducing nitrogen emissions is USD 4684 t^{-1} to USD 6560 t^{-1}. According to the Danish Maritime Administration (DMA) (Incentive et al., 2012), shipowners invest USD 30 kW^{-1} to USD 70 kW^{-1} on SCR equipment and USD 6 kW^{-1} to USD 15 kW^{-1} for installation, plus an additional USD 5 MWh^{-1} to USD 12 MWh^{-1} for operations. NRDC data shows that the cost of installing an SCR is USD 15 kW^{-1} to USD 20 kW^{-1}, an additional 30% to 40% of the cost of equipment. Operating costs, including the cost of urea, equipment depreciation renewal costs and equipment cleaning costs are 7%–10% of fuel costs.

Table 1 The cost of selective catalytic reduction system

Source	Equipment cost	Installation cost	Operating cost	Urea cost
ECA	USD 40–135 kW^{-1}	–	7%–10% of the fuel cost	–
NRDC	USD 50 kW^{-1}	USD 15–20 kW^{-1}	USD 0.08 kWh^{-1}	10–15 L MWh^{-1}
DMA	USD 30–70 kW^{-1}	USD 6–15 kW^{-1}	USD 5–12 MWh^{-1}	–

In conclusion, our estimates of SCR costs are based on data from a range of agencies as well as from a series of field studies of different manufacturers. Based on the above research and analysis, this study determines the equipment cost for an SCR system is USD 30 kW^{-1} to USD 80 kW^{-1}, installation fee is 30%–40% of equipment cost, operating costs is 7%–10% of fuel cost.

3.4 The cost of exhaust gas recirculation systems

The European Union produced EGR cost estimates at the 66th meeting of the Marine Environment Protection Committee (MEPC) (IMO, 2014). These show that the unit cost of EGR equipment is generally USD 60 kW^{-1} to USD 80 kW^{-1}, and operating costs are about 4%–6% of the fuel costs when operating in the NO_x ECA. China's NRDC determined that EGR equipment costs USD 51 kW^{-1} to USD 62 kW^{-1}, operating costs are USD 2.8 MWh^{-1} to USD 4.1 MWh, and fuel consumption is 0.6g kWh^{-1}. According to data provided by the engine manufacturers, such as the Shanghai Marine Diesel Engine Research Institute and the Weifang Power Co. Ltd., equipment costs for EGR are USD

50 kW^{-1} to USD 70 kW^{-1}, the installation fee is 20%–30% of equipment cost, and operating costs are USD 2.8 MWh^{-1} to USD 4.1 MWh^{-1}.

3.5 The cost of installing shore power application

The cost of using shore power includes construction costs for shore power facilities, shipboard equipment retrofitting costs, the berthing time of inbound vessels and cost of electricity consumed during berthing. Transmission costs for port berths are generally between USD 300000 and USD 4 million; these are determined by port location, electricity demand, voltage and frequency, and ship type. The electricity fee charged by the port of Rotterdam is USD 4.3 million per berth, while the cost of two berths in the port of Gothenburg is only USD 276088. The cost of one shore power facility in Long Beach is between USD 10 million and USD 150 million, and the cost of a European cruise ship berth ranges from USD 1.84 million to USD 86.6 million (SCG, 2012). To use shore power, it is necessary to install a good deal of shipboard equipment, such as power lines, switchgears, power transformers, communication systems, modified voltage controllers, and on-board generator governors, the costs of which range from USD 300000 to USD 2 million per ship in the United States or the European Union (SCG, 2012). According to data from the Ministry of Transport, the cost of shore power equipment for inverter systems in China is about USD 350000 MW^{-1}, and the cost of non-frequency shore power equipment is USD 180000 MW^{-1} (MOT, 2018).

4 Results and discussion

4.1 The cost of Sulphur Oxides abatement

4.1.1 The cost of switching to low-sulphur fuel

The result here is based on the assumption that the price differences between fuels in 2030 will be roughly similar to current price differences. Given that assumption, the cost of using low sulphur oil has been calculated by using the average difference in fuel prices paid by ships using fuels with different sulphur contents in Shanghai in January 2017 and May 2018. Therefore, the cost of switching to low sulphur oil can be expressed as:

$$C = Q_N \times P_L - P_H + W \quad (1)$$

where P_L is the price of low-sulphur oil and P_H of high-sulphur oil, Q_N is the oil consumption, and W is other costs.

Based on VECC data, oil consumption in the ECA in 2030 will be 33.86 million tons, with Chinese ships accounting for 60% of the consumption. It is assumed that all ships sailing and berthing in the ECA have switched to 0.1%S fuel; thus, the cost of changing oil increases from USD 2.25 billion to USD 6.029 billion, with the average increase USD 2.787 billion. Details are listed in Table 2.

As of 2017, there were 12624 shipping vessels in China, of which 10318 were coastal vessels and 2306 were ocean-going vessels. We assume that the cost of retrofitting ranges from USD 14139 to USD 21207 per ship. The cost of retrofitting to comply with ECA regulations is shown in Table 2.

Table 2 The cost of switching to low sulphur oil (unit: billion USD)

Costs	Highest	Lowest	Average
Switching oil cost	6.029	2.250	2.787
Retrofit cost	0.095	0.063	0.079
Total	6.124	2.331	2.866

4.1.2 The cost of installing an exhaust gas recirculation system

Two-stroke diesel engines are the principal pieces of equipment for EGCSs and these are installed on ocean- going vessels and coastal vessels of over 6000 tons. Our estimate of the cost of installing EGCS is based on the quantity of Chinese ocean-going vessels and coastal vessels of more than 6000 tons and less than 8 years old, excluding foreign vessels, and is expressed as:

$$Ce = K \times P_M + I + M \quad (2)$$

where K is the total power of installed vessels, P_M are the equipment costs, I stands for installation fees, and M stands for maintenance costs.

By the end of 2017, the total power of the main engines on oceangoing ships and coastal ships of 6000 tons or more and less than 8 years old was about 21790887 kW. Assuming that the lifespan of the EGCS is 20 years, the fuel consumption of a medium speed diesel engine is about 200 g kWh^{-1} with sailing time of approximately 180 days per year. The cost of using EGCSs is shown in Table 3.

Table 3 The cost of using EGCS (unit: billion USD)

Year	Costs	Highest	Lowest	Average
20 years Total cost[a]	Equipment cost[b]	5.615	1.743	3.679
	Installation cost	1.307	0.697	1.002
	Maintenance cost	0.160	0.019	0.090
	Total cost	7.082	2.459	4.771
2030	Equipment cost[c]	0.281	0.087	0.184
	Installation cost[c]	0.065	0.035	0.050
	Maintenance cost	0.160	0.019	0.0895
	Total cost	0.510	0.141	0.324

Note: "a" means ships of 6000 tons and less than 8 years ship old; "b" means equipment prices in China; and "c" means 20-year average price. Interest payments on money borrowed to finance equipment purchases are not counted.

4.2 The cost of Nitrogen Oxide abatement

4.2.1 The cost of installing selective catalytic reduction systems

According to China's requirements for the control of Nitrogen Oxide from ships, new ships with engine power greater than 37 kW must meet Tier III requirements. That is, new ships with engine power greater than 37 kW must be equipped with an SCR or alternative equipment to meet the nitrogen oxide control requirements. The cost of an SCR is expressed as:

$$Cs = K_s \times P_{Ms} + I_s + M_s \tag{3}$$

where K_s is the total power of vessels installed with SCRs, P_{Ms} is equipment costs, I_s stands for installation fees, and M_s stands for maintenance costs.

In China, there were approximately 86670 ships with 37 kW or more of engine power in 2018; the total power was 424245568 kW. AIS data shows that there were 5596 ships berthing and navigating in China, Europe and United States in 2016 and 2017, including 832 Chinese ships. The cost of using SCRs is shown in Table 4.

Table 4 The cost of using SCR (unit: billion USD)

Costs	Highest	Lowest	Average
Equipment cost [c]	1.109	0.416	0.763
Installation cost[c]	0.444	0.125	0.285
Maintenance cost	0.037	0.010	0.024
Total cost	1.591	0.551	1.071

Note: "c" means 20-year average price. Interest payments on money borrowed to finance equipment purchases are not counted.

4.2.2 The cost of installing exhaust gas recirculation systems

Installing a SCR system with an EGCS requires a lot of space, so this is not a preferred solution for ship owners. In such cases owners choose to install an EGR. Thus the proportion of ships with EGRs installed in this scenario is the same as the proportion of ships with EGCSs installed. The cost of using an EGR is shown in Table 5.

Table 5 The cost of using EGR (unit: billion USD)

Costs	Highest	Lowest	Average
Equipment cost[c]	0.068	0.056	0.062
Installation cost[c]	0.020	0.011	0.016
Maintenance cost	0.385	0.264	0.325
Total cost	0.474	0.330	0.402

Note: "c" refers to the 20-year average price. Interest payments on money borrowed to finance equipment purchases are not counted.

4.3 The cost for LNG vessels

Deniz et al. (2016) believes that LNG is a promising alternative for marine diesel. Retrofitting existing engines and fuels system requires three to four times more expense than traditional vessels. Approximately 4500 ships can be fitted with the modifications needed to use LNG fuel; the cost of retrofitting ranges from USD 657900 to USD 1135800. Assuming that all of the ships suitable for modification are converted to LNG fuels by the year 2030, and the total conversion cost would total USD 2.961 billion to USD 5.921 billion. Over a 20-year period, the average annual cost ranges from USD 0.148 billion to USD 0.296 billion. Moreover, relevant agencies predict that China will build 20 to 30 new LNG ships every year. This paper assumes that 25 LNG vessels will be added each year, and that the construction cost of each new LNG vessel is USD 7 million to USD 13 million. The cost for LNG is shown in Table 6.

Table 6 The cost for LNG vessels (unit: billion USD)

Costs	Highest	Lowest	Average
Retrofit cost[c]	0.296	0.148	0.222
New-build cost[c]	0.013	0.007	0.010
Total cost	0.309	0.155	0.232

Note: "c" means 20-year average price. Interest payments on money borrowed to finance equipment purchases are not counted.

4.4 The cost for installing shore power facilities

China's Port Power Distribution Plan requires that the construction of shore power facilities be completed at 257 berths in China's major ports and the ports within ECA before 2030. According to the *Statistical Bulletin on the Development of the Transportation Industry in 2017*, as of 2017, China had 10318 coastal transportation vessels and 2306 ocean-going vessels, a total of 12624. We assume that 80% of the ships will install equipment to access shore power by 2030, and that the cost of upgrading is USD 0.3 million to USD 1 million per ship. The cost of applying shore power application is shown in Table 7.

Table 7 The cost for applying shore power (unit: billion USD)

Costs	Highest	Lowest	Average
Construction cost[c]	0.012	0.012	0.012
Retrofitted cost	0.505	0.151	0.328
Total cost	0.517	0.163	0.340

Note: "c" means 20-year average price. Interest payments on money borrowed to finance equipment purchases are not counted.

5 Conclusions

Based on our calculations: a total of USD 2.331 billion to USD 6.124 billion will be invested to switch to low sulphur fuel; a total of USD 0.141 billion to USD 0.51 billion will be invested for EGCSs, a total of USD 0.551 billion to USD 1.591 billion will be invested for SCR systems; and a total of USD 0.33 billion to USD 0.474 billion will be invested for EGR systems if a DECA is established. The cost for of building LNG vessels or converting existing vessels will be USD 0.155 billion to USD 0.309 billion, and investments in shore power applications will amount to USD 0.163 billion to USD 0.517 billion.

References

Baltic Marine Environment Protection Commission. 2016. Baltic Sea NECA application. Baltic Marine Environment Protection Commission, Finland., 1–95.

Deniz C, Zincir B. 2016. Environmental and economical assessment of alternative marine fuels. *Journal of Cleaner Production*, 113: 438–449.

Incentive Partners, Litehauz. 2012. Economic impact assessment of a non-emission control area in the North Sea. Ministry of the Environment, Environmental Protection Agency, Denmark, 6–105.

International Maritime Organization. 2014. Information about the application status of Tier III compliant technologies. International Maritime Organization, England, 4–18.

International Maritime Organization. 2018. Special area under MARPOL. International Maritime Organization, England, 1–56.

Kristensen.H O. 2012. Energy demand and exhaust gas emissions of marine engines. *Clean Shipping Currents*, 1(6): 18–26.

Jiang L P, Jacob K, Leise P C. 2014. The costs and benefits of sulphur reduction measures: Sulphur scrubbers versus marine gas oil. *Transportation Research*, D(28): 19–27.

Ministry of Transport. Report on how to develop powerful transportation [EB/OL]. 2018-03-21.

Marcus Hand. 2019. Live from Nor-shipping 2019—80% of scrubbers are open-loop: DNV GL. https://www.seatrade-maritime.com/news/asia/80-of-scrubbers-being-installed-are-open-loop-dnv-gl/.

Panasiuk I, Lebedevas S. 2013. The comparison of technologies to reduce the toxicity of ship exhaust gas. The 8th International Conference on Transbaltica 2013，Vilnius: 153-158.

SCG (Starcrest Consulting Group). 2012. Global LNG bunkering infrastructure as of January 2014. www.ops.wpci.nl/costs/investments.

USEPA. 2009. Proposal to designate an emission control area for nitrogen oxides, sulphur oxides and particulate matter. Environmental Protection Agency, USA, 1–74.

USEPA. 2019. Proposal to designate an emission control area for Nitrogen Oxides, Sulphur Oxides and Particulate matter, technical support document, chapter 2: Emission Inventory. Environmental Protection Agency, USA, 8–63.

中国申请国际排放控制区的成本研究

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摘　要：为控制船舶大气污染，改善环境空气质量，2015 年中国首次设立了珠三角、长三角、环渤海（京津冀）水域船舶排放控制区。为满足海洋环境保护委员会第 70 次会议中有关更严格的船舶排放控制的要求，中国拟于 2030 年设立经国际海事组织审议通过的国际排放控制区。本文对现有的 NO_x 及 SO_x 减排技术进行探讨，对中国设立国际排放控制区给其航运业带来的减排成本进行分析。基于文献调研及数据分析，文章分别计算了使用低硫燃油、废气清洗系统（Exhaust Gas Cleaning Systems, EGCS）、选择性催化还原技术（Selective Catalytic Reduction, SCR）、废气循环技术（Exhaust Gas Recirculation, EGR）四种传统除氮除硫技术的减排成本。结果表明，使用低硫燃油为硫减排的最佳技术方案，安装 SCR 为氮减排的最佳技术方案。除了传统的减排技术，本文还计算了使用岸电系统及 LNG 两种绿色能源的减排成本。计算数据显示，六种减排方案的减排成本分别为 28.66 亿, 3.24 亿, 10.71 亿, 4.02 亿, 2.32 亿和 3.4 亿美元。

关键词：排放控制区；减排成本；减排技术；硫减排；氮减排；清洁能源