Study on air pollution control measures in port areas

[Abstract]

With more global environmental problems occurring in recent years such as climate changes and sea level rises due to global warming, and air and ocean pollution ascribable to the emissions of harmful substances from ships, environmental protection measures are required in ports under an international framework. Air pollution due to emissions of harmful substances from ships is in particular an urgent issue as evidenced by the fact that MARPOL Annex IV went into effect in May 2005.

In this study, data were collected in and out of Japan on "shore-side electricity supply to the ships at the berth" aimed at reducing carbon dioxide (CO2), nitrogen oxides (NOx) and other harmful substances emitted from ships by supplying electricity required by the ship at the berth using an shore-side electricity supply system rather than generating electricity by an onboard system. The environmental effects and cost of shore-side electricity supply were identified. Adopting shore-side electricity supply instead of electricity generation by a system on board a ship at the berth using fuel with a sulfur level of 2.7% is expected to reduce NOx and CO2 emissions by more than 95% and 50%, respectively. The cost of shore-side electricity supply will be nearly the same as the cost of electricity generation by an onboard system if 8.46 ships use a berth in a year (on the assumption of a mean annual connection time of 700 hours per ship). If only one ship uses a berth, however, the cost of shore-side electricity supply will be double to triple the cost of electricity generation by an onboard system. If shore-side electricity supply is to be adopted on a wider scale, providing support and building an organizational setup for reducing the costs including the initial costs will be required.

The 4,965-ton cargo-passenger ship Salvia Maru was used for testing shore-side electricity supply at the Takeshiba Pier of Tokyo Port. Safe, reliable and quick work methods and manpower deployment were examined.

1. Study items

(i) Collection and organization of data on shore-side electricity supply in and out of Japan

(ii) Identification of the environmental effects and cost of shore-side electricity supply

(iii) Testing on shore-side electricity supply for practical operation

2. Methods of study

(i) Collection and organization of data on shore-side electricity supply in and out of Japan

Data were collected and organized on the regulations and recent developments concerning the shore-side electricity supply in and out of Japan. Examples of shore-side electricity supply in and out of Japan were also collected.

(ii) Identification of the environmental effects and cost of shore-side electricity supply

The environmental effects and cost of shore-side electricity supply were identified based on the "Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments Task 2a Shore-side Electricity" (August 2005, Entec UK Limited), a European Union (EU) document.

(iii) Testing on shore-side electricity supply for practical operation

The cargo-passenger ship Salvia Maru was used for testing shore-side electricity supply at the Takeshiba Pier of Tokyo Port from connecting cables to operating a power source on board the ship. Safe, reliable and quick work methods and manpower deployment were examined. For the testing, 150A and 300A cables were used.

3. Results of study

(i) Collection and organization of data on shore-side electricity supply in and out of Japan

1) Regulations and recent developments concerning shore-side electricity supply

【Kawasaki City】

The "guideline for controlling the emission of air pollutants from ships" developed in December 2000 based on an ordinance concerning the preservation of living environment through pollution control and other measures stipulates that the city government should take measures for using shore-side electricity sources in cooperation with ship-related stakeholders

【International Maritime Organization】

Discussions were made at MEPC55 (55th meeting of the Marine Environment Protection Committee) in October 2006 on the standardization of shore-side electricity supply and the revision of MARPOL Annex IV related to the standardization.

-The majority of member countries did not agree to the revision of MARPOL Annex IV although they recognized the need of standardization.

-The work of standardization was assigned to ISO/TC8 (ISO's technical committee on ships and marine technology).

【European Union】

The European Commission (EC) made recommendations for accelerating the use of shore-side electricity supply in May 2006 (2006/339/EC).

-Member states should take note of the advice on the cost-effectiveness and practicability of using shore-side electricity to reduce emissions for different types of ships, routes and ports.

-Member states should review the methods of shore-side electrical connections in compliance with international standards.

-Member states should consider offering economic incentives to the users of shore-side electricity.

-Member states should promote awareness of shore-side electricity among maritime authorities, port authorities, classification societies and other organizations.

-Member states should provide support to port authorities and industry in shore-side electricity supply.

-Member states should report to the Commission on the action for reducing ship emissions in ports.

【State of California, United States】

The new California rules of December 2006 regulate fuel oil and permit the use of alternative methods, e.g. the use of shore-side electricity and the installation of exhaust gas recirculation systems.

2) Examples of shore-side electricity supply

Shore-side electricity is used mainly in daily life in Japan. The capacity of shore-side equipment ranges from three to 300 kVA and the voltage from 100 to 600 V. Shore-side electricity is used for driving freight loading facilities at Kobe, Muroran, Nanao and Saeki Ports. The shore-side equipment has a capacity of 500 to 1,000 kVA.

The United States (State of California) and Sweden among other countries have been taking the initiative in adopting shore-side electricity supply (Table 1).

Table 1 Outline of shore-side electricity supply in other countries

	Port of Pittsburgh (California)	Port of Los Angeles (California)	
	POSCO	China Shipping	NYK Line
Year shore-side electricity supply started	1991	2004	2007
Type of ship	Four bulk cargo ships (38,000 DWT)	17 full container ships (5,700 TEU)	One full container ship (6,200 TEU)
Electricity supplied	440 V, approximately 0.5 MW	440 V, 7 MVA, nine cables	6.6 kV, 7 MVA, two cables
Other	-Without blackout -Cables are on the ship.	-With blackout -Cable reels and other facilities are on the barge.	-Without blackout -Cable reels and other facilities are on the barge.

	Port of Long Beach (California)	Port of Juneau (Alaska)	Port of Gothenburg (Sweden)
	BP	Princess Shipping	
Year shore-side electricity supply started	2007	2001	2000
Type of ship	Two oil tankers	Five large passenger steamers	Regular-line ferryboats
Electricity supplied	6.6 kV, 10 MWA, three cables	6.6kV、7～11MW	1～1.5MW
Other		Both electricity and steam are supplied.	Continues serving as a hotel

Note: Blackout means the extinguishment of lights during a switchover from shore-side to onboard electricity.

(ii) Environmental effects and cost of shore-side electricity supply

1) Environmental effects

Adopting shore-side electricity supply instead of electricity generation with an auxiliary engine on board a ship at the berth using fuel with a sulfur level of 2.7% is expected to reduce NOx, SOx and CO2 emissions by 97%, 96% and more than 50%, respectively.

Note: Emissions from shore-side electricity supply have been calculated based on the emissions from electricity generation at power plants.

2) Costs of introducing and operating shore-side electricity

The cost of introducing shore-side facilities (electricity infrastructure and port facilities) is approximately 27 to 231 million yen per berth although the cost varies according to the electricity consumption by the ship. The cost of installing onboard facilities ranges from 13 to 46 million yen per ship.

Shore-side facilities
- Electricity infrastructure: 20 to 83 million yen/berth
- Port facilities: 7 to 148 million yen/berth

Onboard facilities: 13 to 46 million yen per ship

Notes

Electricity infrastructure cost is the cost of supplying electricity to the port (cost of installing and repairing a substation).

Port facilities costs include the costs of frequency translators and of burying cables.

The cost of operating the shore-side electricity supply system is 2.1 to 13.7 million yen/year at a high voltage of 600 V to 7 kV, nearly the same as the cost of onboard electricity generation using C heavy oil (Table 2)

Table 2 Costs of operating shore-side electricity supply system(at a high voltage) and onboard electricity generation(using C heavy oil) when the ship is at the berth

	Small ships	Intermediate ships	Large ships
Shore-side electricity supply (cost of electricity)	2.1 million yen/year	5.3 million yen/year	13.7 million yen/year
Onboard electricity generation (cost of fuel)	1.9 million yen/year	4.9 million yen/year	12.3 million yen/year

Note: The cost of operating the shore-side electricity supply system has been calculated based on the assumption of the use of a berth by 8.76 ships in a year.

The costs shown above have been estimated on the assumption of installation and operation of a shore-side electricity supply system in Japan based on EU data. The specific costs of introduction vary according to whether frequency translation is required or not in a particular area or the size of the ship. The costs of operation also vary according to the electricity price, fuel price, number of ships per berth in a year and other factors. Cost comparison should therefore be made carefully.

(iii) Shore-side electricity supply system operation tests

Shore-side electricity supply system operation tests were conducted and safe, reliable and quick work methods and manpower deployment were examined.

-The time required for connecting four 150A cables through the activation of the onboard electricity source is approximately seven minutes.

-The work of cable connection requires four workers, two on the shore and two on board the ship.

-When handing cables manually without using any cable reel, using four 150A cables rather than two 300A cables is more convenient because the former are easier to handle.

Shore-side connection box

Onboard connection box

Operation test