

STRATEGIES FOR THE REDUCTION OF GREENHOUSE GASES EMISSIONS FROM CONTAINER TRANSPORT FOR THE HANSHIN PORT, JAPAN

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Introduction

The contemporary economic arguments are that gateway ports, such as the Hanshin Port of Kobe and Osaka and their surrounds, play a key role in supporting both social and economic development. The Kinki region forms an important backbone to the Japanese economy generating 17% of national GDP with a population of 21 million within a radius of 150 km of the ports (City of Osaka, 2015). Good trade performance is an essential ingredient for sustaining economic growth, productivity, living standard and life style. To bolster the international competitiveness of Japanese ports the national government on 6 August 2010 designated the Hanshin ports as "strategic international container port". Many port authorities around the world, however, face difficulties in ensuring a balance between the competing interests of the logistical business of ports, the local communities and the environment.

The containerisation of freight movements since the late 1960s (The first container wharf in Kobe port opened in 1967) has been one of the most significant transport system changes to generate environmental backlashes (Rimmer and Black, 1982). The metropolitan regions of Kobe and Osaka provide a case study of greenhouse gases (GHG) emissions from ships and container trucks as one specific environmental issue. The aim of the paper is to identify the Hanshin port's strategies for the reduction of GHG emissions and to compare these strategies with those adopted by the Port of Long Beach California (POLB) – regarded as one of the world's leaders as a 'green port'. Benchmarking is one methodology adopted in practice to improve port performance and efficiency (European Conference of Ministers of Transport, 2000, p. 189).

The structure of this paper is as follows. First, we give a brief description of the Hanshin port focusing on logistics. Then we explain the strategy of modal shift to encourage the reduction of GHG emissions. Thirdly, we describe another strategy: the development of an inland port – the Hanshin Inland Container Depot in Yasu City, Shiga Prefecture. Fourthly, the facility measures to reduce GHG emissions in the Hanshin port are described. Finally, best practice adopted by the Port of Long Beach California (POLB) are summarised and contrasted with the strategies in the Hanshin Port.

Description of the Hanshin Port

History of the Hanshin port

The Hanshin port was nominated by the Kobe port and the Osaka port in 2004 to be selected as one of the "super hub ports" amongst more than 1000 ports and harbours in Japan. Revising the Customs Law and the Port Regulation Law in December 2007, all ports in Osaka bay were consolidated under the name of Hanshin port. However, all ports are still managed by four separate port authorities: Kobe City, Osaka City, Hyogo Prefecture and Osaka Prefecture (Figure 1).

Since other Asian hub ports had expanded their value, the Japanese government response was to additionally centralise both the volume of container freight and port investment. Finally, in 2010 the government designated two "strategic international container port": the Keihin port in eastern Japan; and the Hanshin port in western Japan. The



Figure 1: Hanshin Port Areas

*Port authorities are in parentheses
*Edited from "Port of Osaka Entrance and Departure Manual" Port & Harbor Bureau City of Osaka, 2010

Keihin port represents the ports of Tokyo, Kawasaki and Yokohama. The Hanshin port, as a strategic international container port, refers to the Kobe port and the Osaka port.

Trends in freight and ships in Kobe port and Osaka port

The trends in freight have dramatically changed in Kobe port. Since the time the Kobe port experienced a boost in freight volume in 1960s, a steady increase - mainly from domestic freight - flowed for about 25 year. It was in 1995 that the freight volume decreased by half due to the Great Hanshin Earthquake. Although there was a temporary increase of freight because of the redevelopment of damaged infrastructure, there has not been any significant increase in freight tonnage since 1999. The Osaka port, on the other hand, has had a continuous increase in freight, primarily due to international freight movements (Figure 2).

The number of ships entering Kobe port has significantly decreased since 1971 while the total size of the ships has gone up to 300 million just before the earthquake. The average size of ships has grown to 5000 gross ton. After the earthquake, the number and total size of ships dropped as sharply as freight volumes. This situation, except the effect of the earthquake, can be similarly described for Osaka port (Figure 3). International shipping accounts for about 20% in the number of ships and about 70% in size both in Kobe and Osaka port.



Figure 2: Total freight (left) and international freight rate (right) in the two ports.
Data: Annual report of Kobe port, Annual report of Osaka port.



Figure 3: The number (left) and total size (right) of ships entered in the two ports
 Data: Annual report of Kobe port, Annual report of Osaka port



*Osaka includes int'l empty containers until 1991

Figure 4: International container freight (left) and the number of container (right) in the two ports

Data: Annual report of Kobe port, Annual report of Osaka port

Trends in Container shipping

A container ship made a first docked at Kobe port in 1967 and at Osaka port in 1969. Container freight volumes in the Kobe port had gone up to 42 million tons in 1994, significantly above Osaka port with 13 million tons. This difference has been shrinking to 35 and 32 million tons, respectively, in 2014. International freight is now dominated by containers (71% of freight tonnage in Kobe port and 88% in Osaka port). The number of international

containers handled in Kobe port remains on the same level after the earthquake at around 2 million TEU, while this number in Osaka port has been steadily increasing to 2.2 million TEU in 2014 (Figure 4).

Collectively, the Hanshin port has 19 container berths - 10 in Kobe and 9 in Osaka - and provides 382 container services per month linking to the rest of the world with 87 routes (Table 1). Domestic feeder networks also offer 94 services per week to 32 ports (mainly from/to Kobe port). A ferry network links to 14 ports with 99 services per week.

Route	Number of service	Frequency /month
North America West Coast	5	20
North America / Europe	3	16
Europe / Mediterranean	2	8
Oceania	5	22
South East Asia	32	132
China	29	122
Korea	10	60
Nakhodka	1	2
Total	87	382

Table 1: Container routes and frequency of Hanshin port
Data: Kobe-Osaka International Port Corporation

Strategy of modal shift

Review of environment policy in Japan

Based on the environment policy of the national government, municipal governments develop their own programs. Regarding GHG emissions, after the Kyoto Protocol in 1997, the Japanese Government set its target reduction rate by 6% on average from 2008 to 2012 compared to the base year 1990. This commits all businesses and organisations in Japan to take part in reducing emissions. Kobe City and Osaka City have formulated plans to reduce the emissions with target rates as shown in Table 2.

	2010	2015	2020	2050
Japan	▲ 6% *	-	▲ 25%	▲ 80%
Osaka City	▲ 7%	-	▲ 25%	▲ 80%
Kobe City	▲ 6%	▲ 10%	▲ 25%	▲ 80%

* Average rates from 2008 to 2012.

Table 2: Target rates of the reduction of greenhouse gases emissions
(carbon dioxide equivalent, compared to the year 1990)

According to the "National Greenhouse Gas Inventory Report of JAPAN (2015)", the total GHG emissions in the FY 2013 were 1,408 million tonnes (in carbon dioxide equivalent) with carbon dioxide (CO₂) emissions accounting for 93% with 1,311 million tonnes in which fuel combustion has a 95% share. As for the breakdown of CO₂ emissions within the fuel combustion, energy industries make up 43% followed by manufacturing industries and construction at 26%, transport at 16%, and all other sectors at 10%. In comparison to the FY 1990, total CO₂ emissions increased by 13% and emissions from transport increased by 8%. The main factor of the increase in the transport sector is passenger vehicles and personal use. This has been compensated by a decrease in emissions from freight transport, where the initiatives in the transport sector are to promote highly energy-efficient vehicles, such as hybrid vehicles, and greater public transport utilisation for passengers.

Freight transport or logistics is required to improve the efficiency of their system and promote "modal shift". Modal shift refers originally to a change of transport mode from truck to rail or ships that are called eco-friendly transport modes. The concept of the modal shift in Japan has expanded to the use of rail or marine transport (Lee 2014). Since the modal shift has long been considered as an initiative to increase eco-friendly transport, and subsequently to reduce the GHG emissions, the Japanese government established a certification of modal

shift with "Eco-Rail Mark" and "Eco-Ship Mark". In addition, national and local governments offer subsidies to encourage modal shift.

Encouragement of modal shift

Osaka City has offered subsidies to encourage the modal shift from 2005 and Kobe City from 2006 using its domestic feeder transport network. A company can take a subsidy of 2000 yen per TEU (up to 10 million yen) when it changes the transport mode from trucks to ships via the ports of Osaka or Kobe. When it newly uses a maritime transport via the port, or even increases the freight volume through the port, it is also eligible for subsidies. The cities expanded the range of modal shift subsidies after it was designated a strategic international container port in order to implement dual objectives of collecting container freight and reducing the GHG emissions. Today, there are four contents of the modal shift for container freight from/to Kobe port: use of marine transport; use of railway transport; reduction in trucking distance; and round-use of containers (round-use will be described the next section).

The subsidy by Kobe City has increased container freight by 142,064 TEU and reduced GHG emissions by 121,294 tons for seven years (Table 3). For Osaka City, the policy attracted 205,087 tons of freight to Osaka port and reduced emissions by 20,106 tons in the first three years. Government subsidies for modal shift can attract container freight to the Hanshin port and can reduce the GHG emissions.

	Number of Cases	Amount of the subsidy (000 yen)	Reduction of the emissions (ton-CO2/year)	Increase of freight (TEU/year)
2006	3	3,117	7,534	6,187
2007	3	8,375	8,089	14,038
2008	10	18,284	17,758	18,955
2009	10	30,934	34,413	21,084
2010	20	n.a.	25,300	22,300
2011	22	28,854	10,700	19,100
2012	30	51,126	17,500	40,400
Total	98	n.a.	121,294	142,064

*Predicted figures in 2011 and 2012

Table 3: The results of modal shift subsidy from Kobe City

Data: Kobe City press release on web pages

Strategy of an inland port

Container round-use

In general, containers for international trade are carried between ports and shippers' points. The import containers landed at a port are delivered to shippers' point by drayage truck. After discharging, empty containers are hauled back to a container terminal in the port. Meanwhile, exporters need to pull empty containers from the container terminal when they load cargoes, and the full containers then travel to the port. The Japanese government has promoted the round-use of containers to reduce the transport of empty containers. The "round-use" means a use of containers for export cargo after unloading import cargo (Figure 5).

Another round-use was investigated in 2010 with the relocation of containers in the Hanshin port. Since Osaka port has more import container trade than export container trade and Kobe port has more export container trade, empty containers need to be moved from Osaka port to Kobe port. An experiment of modal shift - from trucks to barges - for the relocation of about 6,000 empty containers in the Hanshin port created the estimation of the effect for GHG emission reduction. The result shows a possible reduction by 78% (Kinki Transport Bureau).

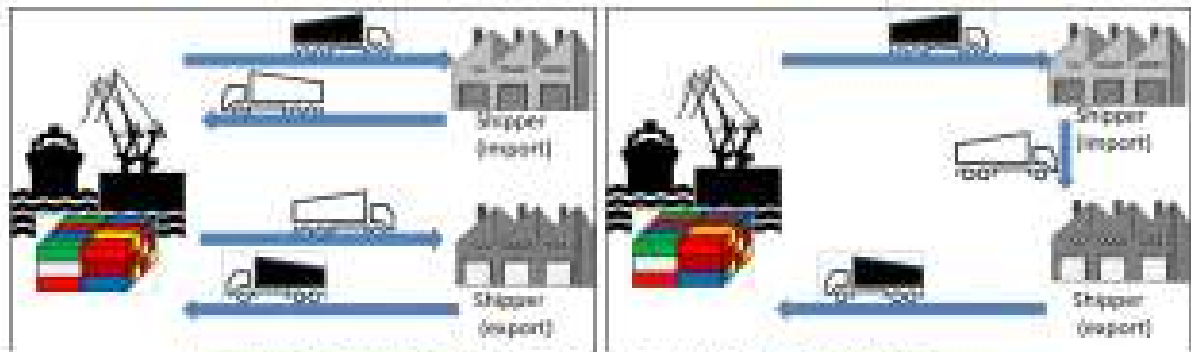


Figure 5: General use (left) and round-use (right) of containers

According to a report from Japan Institute of Logistics System (JILS), about 53,000 empty containers are annually transported to/from the Hanshin port with about 5,000 tons of the GHG emissions. If those empty containers are round-used, considerably more GHG emissions will be reduced.

Hanshin inland container depot

The Hanshin port has been reviewing its existing land transport system for maritime container logistics with the construction of an inland port as the collection base of container cargo. It is working on the reinforcement of its cargo collection functions in order to reduce the logistics costs of shippers and improve the efficiency of logistics. As a first step, in 2012 the Hanshin Inland Container Depot (ICD) - about 100 km away from the port shown in Figure 6 - was established in Shiga Prefecture to support the round-use of containers (City of Osaka 2015).



Figure 6: Location of the Hanshin Inland Container Depot

It is expected to reduce GHG emissions since the empty containers do not need to be carried back to the port and stocked in the ICD. Road transport will decrease in kilometres and ton-kilometres, which results in the reduction of emissions. The ICD may foster a modal shift because the shippers can gain easy access to maritime containers and so cut the logistics costs. In addition to the handling of containers in the port, traffic congestion around the port would be relieved. With those objectives, the use of ICD has been encouraged by additional subsidies from Osaka City and Kobe City.

Strategy of innovations and regulations

Innovation in ships and port facilities

In addition to encouragements of modal shift and the round-use of containers, innovations for ships and port facilities have been developed in Japan. For instance, energy-efficient ships called "Super Eco Ship (SES)" appeared. The number of SES is currently 23 and most of them are tankers. Regarding container ships, NYK (Nippon Yusen Kaisha)'s environment-friendly ships "NYK Super Eco-ship 2030" received a frontier design award at the 2009 Good Design Awards organized by the Japan Industrial Design Promotion Organization. "NYK Super Eco-ship 2030" is currently under development aiming to reduce GHG emissions by 69% with the use of clean energy such as LNG-based fuel cells, solar cells and wind power.

In ports, the use of shore power for docking ships has been introduced. Ships keep burning fuel even when at a berth in a port. When ships can use shore power, such as electricity instead of burning fuel, the GHG emissions from ships can be reduced. In the Hanshin port, a demonstration experiment was conducted at the Osaka port in 2009 and it ended up merely as an experiment. According to calculations by Ministry of Land, Infrastructure and Transport (MLIT), shore power can lead to a cut of CO₂ emission by from 40 to 50% and nitrogen oxides

(NO_x) and sulphur oxides (SO_x) by 98%. One million tons of GHG emissions are expected to decrease annually if all coastal ships use the shore power while at berth.

Hybrid cranes for containers are also encouraged. A hybrid crane is expected to reduce the energy consumption by 40% and to reduce 60 to 70 tons of emissions per year. Although there are a few transfer cranes of hybrid type in the Hanshin port, it is difficult to force business to replace all cranes with a hybrid type because of the high capital costs involved.

Regulations of air pollution from transport

After the effectuation of MARPOL 73/78 Annex VI (Regulations for the Prevention of Air Pollution from Ships), the Japanese government has regulated air pollutants, including NO_x and SO_x, from ships. For land transport in Japan, the Automobile NO_x PM Control law (1992) restrains traffic of diesel-powered automobiles that are not equipped to filter NO_x and particulate matter. Since Kobe City (2004) and Osaka City (2009) enacted their own regulations to prevent the access of substandard automobiles, all drayage trucks to/from the Hanshin port are already equipped with filters to reduce pollutants.

Towards a green port

Strategies of the Port of Long Beach

The Ports of Los Angeles and Long Beach comprise the largest port complex in the United States where they handle a fourth of all container cargo traffic in the United States. Acting as a major gateway for US–Asian trade, the Port of Long Beach (POLB) occupies 13 km² of land with 40 km of waterfront in the city of Long Beach. The Green Port Policy was adopted by the POLB in 2005 in an effort to reduce pollution in the growing region of Los Angeles/Long Beach. The guiding principles of the Green Port Policy are to protect the community from the harmful environmental impacts of port operations, to distinguish the port as a leader in environmental stewardship and compliance, to promote sustainability, to employ the best available technology to avoid or reduce environmental impacts, and to engage and educate the community. In 2007, the Port of Long Beach continued its environmental efforts by implementing the Clean Air Action Plan, an air quality program adopted by the Ports of Long Beach and Los Angeles.

In recognition, the Clean Air Action Plan was given the most prestigious award from the American Association of Port Authorities, the Environmental Management Award, in 2007, and this is one indicator that POLB is one of the world leaders in “green ports”. The Clean Air Action Plan also tackled truck emissions when the port’s Harbor Commission approved a Clean Trucks Program that banned old diesel trucks by October 2008. The program, outlined in the San Pedro Bay Ports Clean Air Action Plan, is expected to modernise the port trucking industry and reduce truck-related air pollution by 80% by 2012. Diesel-powered harbour short-haul (drayage) trucks are also a major source of air pollution so the Clean Trucks Program called for drayage truck owners to scrap and replace old, polluting trucks working at the port, with the assistance of a port-sponsored grant or loan subsidy. The program includes truck concession requirements to identify “clean” trucks, ensure reliable short-haul service, and improve air quality, security, and safety. Trucks that meet the US Federal 2007 emission standard produce 80% less air pollution than older trucks. As most of these older, polluting trucks would remain on the public roads for many years, the port offered financial incentives and optional financing plans to encourage truck owners to scrap and replace their older trucks.

The Green Flag Incentive Program was set up to encourage ships to slow down in order to improve air quality. This program had provided a 15% dockage fee reduction to vessel operators who slow their ships to 12 knots (22 km/h) or less from 20 nautical miles (approximately 37 km) of the harbour and expanded a 25% discount and 40 nautical miles. In the first three years, more than 90% of ships voluntarily reduce their speed to 12 knots, reducing air pollution by more than 650 tons a year. The program now prevents more than 1,000 tons a year of air pollution.

The POLB has constructed landside infrastructure for shore power. A California law, Shore Power Regulation, mandated in 2014 that half of all shipping lines must use shore-side electricity at berth and each fleet must reduce its total emissions by 50% and 80% in 2020. Shipping lines face financial penalties for not complying with the regulation.

Each year the Port conducts an annual inventory of air emissions from port-related sources, using the latest data and methodologies, to track progress for improving air quality. Sources of port-related emissions include ocean-going vessels, heavy-duty trucks, harbour craft, cargo-handling equipment and railroad locomotives that emit diesel particulate matter, NO_x and SO_x, all of which have been known to affect human health and contribute to the formation of smog. From 2005 to 2013, the POLB has cut diesel particulates by 82%, nitrogen oxides by 54% and sulphur oxides by 90%. Greenhouse gases were lowered by 20%. The reduction in pollutants came despite a slight increase of 0.3% in containerised cargo activity in the same period.

Hanshin port's issues in comparison to Port of Long Beach

Benchmarking is a management term about comparing an organisation's policies, services, programs and strategies based on similar industry organisations. The aim is to use comparisons on performance to check areas where there are improvements to be made in terms of greater efficiencies. Benchmarking took hold as a business tool following the release of a research paper by Kaplan and Norton (1992). Therefore, we aim to compare the strategies of Hanshin port's with those of POLB to stimulate further endeavours that might reduce GHG from ships and trucks.

As clarified above, it is possible to find regulations and subsidies/incentives both in the Hanshin port and in the POLB. However, subsidies in Japan have been provided primarily to shippers not transport operators. Drayage trucks and shipping lines are only targets of air pollution regulation. In addition, too many subsidies have been poured into encouraging modal shifts. Since modal shift in Japan has long been considered as one of the most significant environment measures, the Hanshin port tends to attach a high value at modal shift, i.e. a change from container truck transport to container ship transport, and the container trucks are only regulated to improve the emissions. Shippers can enjoy various subsidies for modal shift. For example, MLIT distributes incentives under the names of the Modal Shift Promotion Program, the Green Logistics Partnership Program and the CO₂ Emission Control Program. Many cities, as port authorities, also encourage modal shift with some subsidies. Furthermore, similar subsidies are in fact competing against each other.

It is preferable to invest in objects that can directly contribute to reduce the GHG emissions from ships. One option is an introduction of incentive program to vessel operators such as the Green Flag Incentive Program. The Environmental Ship Index, identified by World Ports Climate Initiative, could be also useful as an incentive for shipping lines. Another option is port facilities such as shore power. Estimates of the costs to provide shore power are US\$3.5M per terminal and US\$1.5M per berth (based on evidence from the Port of Los Angeles in 2006). In the retrofitting of ships there are a number of factors to consider, including age and type of ships. Conservative estimates put conversion costs at greater than US\$1M per ship. Shore power is most beneficial when vessels are at berth for extended periods of time. It would be a way to redistribute port authorities' subsidies from modal shift to retrofitting of ships to accommodate shore power.

Conclusion

Ports throughout the world face the challenge of reducing their environmental footprint, including reducing greenhouse gas emissions. The metropolitan regions of Kobe and Osaka (the recently designated Hanshin Port) have provided a case study of the issues with greenhouse gases (GHG) emissions from ships and container trucks as one specific environmental impact of ports. The aim of the paper was to identify the Hanshin port's present strategies for the reduction of GHG emissions and to compare these strategies with those adopted by the Port of Long Beach California (POLB) – regarded as one of the world's leaders as a "green port" – thereby to improve port performance and efficiency. The research methodology was to review port authority documents that have been published or are readily available on the ports' websites, and to conduct semi-structured interviews with port officers in Kobe and Osaka.

We have given a brief description of the Hanshin port focusing on its logistics. The strategies of modal shift to encourage the reduction of GHG emissions have been outlined – primarily through subsidies. The Hanshin port has another strategy that was described: the

development of an inland port – the Hanshin Inland Container Depot in Yasu City, Shiga Prefecture. This is expected to reduce GHG emissions since the empty containers do not need to be carried back to the port and can be stocked in the depot. The facility measures to reduce GHG emissions in the Hanshin port were described noting the promising future developments of on shore power for docking vessels and the substitution of hybrid cranes. Finally, best practice adopted by the PCLB was summarised and contrasted with the strategies in the Hanshin Port. In Japan, subsidies have been targeted primarily towards shippers and not to transport operators. Drayage trucks and shipping lines are only targets of air pollution regulation. In addition, too many subsidies have been poured into encouraging modal shifts. The Port of Long Beach, California, has invested in objects that can directly contribute to reduce the GHG emissions from ships, such as shore based power supply.

The research reported in this paper represents some preliminary reporting of a large comparative study of Sydney ports (Port Jackson and Port Botany), Gothenburg port (Sweden), the Los Angeles ports and the Osaka port. We are concerned with the wider impacts of containerisation and logistics on urban systems (see for example, Rimmer and Black, 1982; Black and Styhre, 2015). More specifically, in terms of the impacts that container ships and container trucks have on GHG emissions we plan to conduct a comparative study of ships in these four ports. The aim of these comparative, “benchmarking” studies is to further improve the environmental efficiencies of port and associated logistics.

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