Green port development in Hong Kong – reduction of marine and port-related emissions

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Abstract
The impact of air pollutant emissions from shipping and port operations towards environment and health is a pressing global concern. The marine and port sectors have contributed significantly to the growth of the supply chain industry and the economic development, while, at the same time, the pollutant emissions rising from ships and port-related operations have inflicted adverse public health concerns. Leading ports and terminals continuously impose measures to reduce the greenhouse gas emitted during vessel berthing. Hong Kong, being the third largest container port in the world and having the second cruise terminal running into operation, urgently requires comprehensive green port operations and practices. This paper evaluates and benchmarks the latest measures conducted by the leading ports over the world in reducing the greenhouse gas emissions from ship and port operations. International regulations, onshore power supply, vessel speed reduction, and fuel switching are analyzed. Recommendations on the future green port development in Hong Kong are proposed.

Keywords: Greenhouse gas emission, maritime logistics, port, green harbour

1. Introduction

The development of green marine and port operations is a pressing global concern (Chan, 2013; Doherty and Hoyle, 2009; Galbraith et al., 2008). In Hong Kong, the impact of the Greenhouse gas (GHG) emissions from marine and port-related activities have come to the attention of scholars, industrial practitioners, environmental advocates, and government (Ng et al., 2013; Yau et al., 2013). The Chief Executive of the Hong Kong Special Administrative Region (HKSAR), Leung Chun-ying, has pledged to make combating pollution one of his top priorities during his five-year term. He announced plans in January 2013 about submitting new legislations by the fourth quarter of 2013 on the requirement of oceangoing vessels to switch to low sulphur fuel when berthing at Hong Kong. Over the years, there is no regulation in Hong Kong capping the sulphur content in fuel used by vessels within its waters. The major reference is the Annex VI to the International Convention for the Prevention of Pollution from Ships (MARPOL Annex VI) of International Maritime Organization (IMO). It caps the global sulphur content of marine fuel at 3.5% starting from January 2012. The Environmental Bureau of Hong Kong released a Clean Air Plan for Hong Kong in March 2013, calling for a mandatory switch to fuel with a maximum of 0.5% sulphur content for all ocean-going vessels (OGVs) at berth, the use of cleaner marine diesel for other vessels, and the implementation of on-shore power facilities for the new Kai Tak Cruise Terminal in Hong Kong. There is a need for Hong Kong to develop a cleaner port through the implementation of various programs, including benchmarking studies against good port practices over the world, mandatory fuel switch legislation, vessel speed reduction, and the use of on-shore power facilities in the terminals.

Marine and port sector has contributed highly to the economic development of Hong Kong, but at the same time, it has an adverse impact to the public health of residents living close the ports. The global carbon emissions from fossil fuels have increased significantly in the recent years, over 16 times from 1900 to 2008. Transportation, including road rail, air, and marine transportation, is the third largest global emission sector. International shipping is estimated to have emitted 870 million tones, which is 2.7% of the global emissions of carbon dioxide (CO_2) in the same year. The Port of Los Angeles (POLA) indicates that pollution from one vessel call is equivalent to about 69,000 diesel truck miles. A recent survey indicates that following 1.2 million adults for two decades showed that exposure to pollutants such as Particulate Matter (PM) as well as nitrogen (N_2) and sulphur dioxide (SO_2) is directly linked to an 8% increase in Lung Cancer Deaths (Turner et al., 2011; Arden Pope III et al., 2002).

Transport and Housing Bureau in Hong Kong revealed in November 2013 that there are 190,859 numbers of vessels arriving Hong Kong in 2012, including 106,380 from cargo vessels and 84,479 from passenger vessels. There are nine container terminals operated by five operators in Hong Kong. Besides the container terminals, there are two cruise terminals, Kai Tak Cruise Terminal and Ocean Terminal. The two terminals are receiving six mega cruise ships per month from June 2013 to December 2014. With over thousands of residents living near the container and cruise terminals, there is an urgent need to increase the awareness of the industry, citizens, and the next generation the importance of protecting the harbor environment for a better health and living environment in Hong Kong. This paper evaluates the GHG emissions situation in the terminals, benchmarks the green port initiatives against other ports in the world, and reviews the possible green port programs to be carried out in Hong Kong.

2. Ship emission impact towards harbour front

Hong Kong was the world's third largest container port in 2012, after Shanghai and Singapore (World Shipping Council, 2013). The container terminals are situated in Kwai Chung and Tsingyi, located in the north-western part of the harbour, with 24 berths of about 7,694 metres of deep water frontage. It covers a total terminal area of about 279 hectares which includes container yards and container freight stations. The nine container terminals have a total handling capacity of about 20 million TEUs (20-foot equivalent units) which helps maintain Hong Kong as a major port of Southern China. In the meantime, the emissions from the port and its related activities affect the health of every citizens and visitors in Hong Kong. Emissions from ships, trucks, locomotives, and cargo-handling equipment give rise to serious health problems, including asthma emergencies, cancers, heart attacks, and premature deaths. Chan (2013) estimated that SO_2 emissions from vessels are leading to 365 premature deaths each year in Hong Kong, in addition to an increased number of hospital-bed days, outpatient visits, and the costs of productivity losses.

Besides the nine container terminals, the two cruise terminals, Kai Tak Cruise Terminal (Kai Tak) and Ocean Terminal, will receive six cruise liners per month from June 2013 to December 2014. 59% of cruise liners berthing at Kai Tak from June 2013 to December 2013 are owned by the Royal Caribbean. Similarly, 44% of cruise liners berthing at Ocean Terminal during this period are Carnival owned. Current emissions from an OGVs via the use of bunker fuel contains 2.8% to 3.5% sulphur content while low sulphur fuel contains only 0.5% SO_2 content, with a 70% reduction emission (Ng, 2013). Environmental advocate estimated that the SO_2 concentration is equivalent to the emission from 2,800 to 3,500 road vehicles. The CO_2 emission of an OGV is equivalent to two to five times of an aircraft (Friends of the Earth, 2013). Mega cruise ships consume large amount of fuel to maintain the needs on board even when they are docked. Advocates urged the need of the cruise ships to switch fuel at berth. Mariner of the Seas, Royal Caribbean International and Sun Princess, Carnival have committed switching fuel at berth. The number of cruises on fuel switching commitment is still lower than expected. Ng (2013) estimated that there will be 43 tonnes of SO_2, 44 tonnes of NO_x, and 5 tonnes of particulate matter (PM_{10}) emitted by the cruises during their visit at Kai Tak from 2013 to 2014. Thus, there is an urgency of the cruises to commit fuel switching during their berths in Hong Kong.

3. Green port practices

Leading ports over the world have imposed measures on eliminating the emissions from the vessels. Five major areas of green port practices are discussed below to seek for opportunities on the green port development in Hong Kong. These include international regulations, onshore power supply, vessel speed reduction, fuel switching, and technology development. Ng et al. (2013) reviewed green port measures carried out in the ports authorities and government agencies (Table 1).

Region/Port	Measures				
	Engine standards	Onshore Power Supply	Fuel sulphur content	Fuel switching	Vessel Speed Reduction
EU	✓		✓	✓	
US	✓		✓		
California		✓		✓	✓
Hamburg		✓	✓	✓	
Antwerp		✓	✓	✓	
Rotterdam		✓	✓	✓	
Amsterdam		✓	✓	✓	
Singapore				✓	
Taiwan		✓		✓	✓
Yantian / Shekou		✓			
Hong Kong			✓	✓	

Table 1. Green port measures in leading port authorities and government agencies in the regions.

3.1. International Regulations

Government and environmental organizations are drivers on emission control. Annex VI is one of the regulations enforced by IMO. It is one of the important tools set up in the International Convention for the Prevention of Marine Pollution from Ships (MARPOL Convention) to set limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emission of ozone depleting substances. Hong Kong is one of the countries that ratified this regulation. MARPOL Annex VI is adopted in 1997, addressing air pollution from ocean-going vessels. MARPOL Annex VI is revised in 2008 and entered into force in 2010. Under the revised convention, the global cap is reduced to 3.5% in 2012, then progressively to 0.5% in 2020, subject to feasibility review no later than 2018. Limitations on air pollutants are also revised. For example, for NOx emissions from marine diesel engines installed in ships, it is required to comply with the following requirements. Engines installed on or after 1 January 2011 are required to comply with a 'Tier II' emission limit. A more stringent 'Tier III' emission limit on engine operations and installations in the Emission Control Areas (ECAs) will be adopted in January 2016. Marine diesel engines installed on or after 1 January 1990 but not prior to 1 January 2000 are required to comply with 'Tier I' emission limits. The revised regulations are expected to bring benefits to the atmospheric environment and human health.

3.2. Onshore power supply

The on-shore and shoreside power supply enable the replacement of traditional diesel auxiliary engines and power supply. The European Commission recognized shoreside power, known as cold ironing, in 2006. Any vessels at berth should use shoreside electricity in community ports, especially for ports that are near to residential areas. The shoreside power is supplied by wind in Sweden. Hydro power is introduced in leading ports, including the ports in California, port of Gothenburg in Sweden, and the ports of Yantian and Shekou in China. With the shoreside power, the SO_2 in Port of Long Beach (POLB) has saved 283 tonnes per year and nitrogen oxide has saved 580 tonnes per year while in POLA has saved 1 tonne per day. The use of electricity generated on-shore power supply by vessels can replace the onboard-generated power from diesel auxiliary engines. The government of Hong Kong is planning to secure funding to install the on-shore power supply facilities at Kai Tak Cruise Terminal. There are still operational and commercial constraints for Ocean Terminal to install on-shore power supply to improve the air condition along the coastal front. The use of electricity-powered equipment in the terminal replacing the diesel-powered supply greatly reduces the CO_2 emissions. The MTL invested HK$170 million to convert 94 RTGCs into electric-RTGCs and HIT invested HK$140 million on a crane-electrification programme at Kwai Tsing Container port. Similarly, other terminals are converting their fleet of RGCs from diesel to electricity.

3.3. Vessel speed reduction

Vessel speed reduction is important to the environment along coastal harbor front. The reduction of vessel speed lowers the GHG emissions. Leading ports in vessel speed reduction (VSR) programs are POLA, POLB, and the Port of San Diego (POSD). The program aimed to reduce air pollutants and GHG from vessels by slowing down their speeds. POLA and POLB present rewards to ship operators when they meet the requirements of the program. The rewards will be given to vessel operators for slowing down to 12 knots or less within 40 nautical miles (nm). The VSR program 'Green Flag program' in POLB provides incentives for vessel operators who voluntarily reduce the speed of their vessel, for example, reduction in dockage fees. Ships burn less fuel and emit less air pollutants through speed reduction. The number of vessels slowing down in the 20 to 40 nautical mile zone has increased from 40% in 2008 to 75% by March 2009. In 2008, POLB estimated that the program reduced 678 tonnes a year of NOx, 453 tonnes of SOx, 60 tonnes of diesel PM, and more than 26,000 tonnes of CO_2 equivalent (Ross and Associates Environmental Consulting, 2009; POLB, 2009). POSD in San Diego also requested cargo vessel operators entering or leaving San Diego Bay to observe a 12-knot speed limit. For cruise ships, a 15-knot limit is requested. The VSR zone extends 20 nautical miles seaward from Point Loma.

3.4. Fuel switching and Emission Control Area

Burning of bunker fuel in vessels emit heat and GHG. The use of low sulphur fuel oil during vessel berthing and the adoption of ECA come to the attention of port authorities and government. An ECA can be designated for SOx and PM, or NOx, or all three types of emissions from ships, subject to a proposal from a Party to Annex VI discussed in Section 3.1 of the paper. Setting up an ECA allows the address of ship emissions produced outside jurisdictional boundaries, in areas where ship emissions could still impact the local region. Consistent regulations following the MARPOL Annex VI parties enable the control of ship emissions in a broader area with more stringent requirements. These facilitate the elimination of air pollutant and the protection of public health. Fuel switching programs are started to be organized in various regions including Hong Kong. A Fair Winds Charter (FWC) program is introduced in Hong Kong. The FWC is an industry-led, voluntary, at-berth fuel switching programme for OGVs calling at Hong Kong. It is the first initiative of its kind in Asia, and the only shipping-industry led fuel switching initiative in the world. Participating vessels switch to low sulphur fuel (0.5% sulphur content or less) while at berth in Hong Kong. Through the program, shipping associations and organizations urged government to introduce legislation for at berth fuel-switching and collaborate across the Pearl River Delta (PRD) region to regulate in line with international standards.

3.5. Technology development

Various technologies are developed in regions to improve the ship and port operation emission issues. Europe Union (EU) has adopted technologies including seawater exhaust gas scrubbing, low-sulphur residual oil and selective catalytic reduction. Thus, vessels in Europe are started to show improvements in ship emission reductions. With the adoption of scrubbing, the SO_2 has been reduced 90%, NOx has been reduced 3 to 5% and PM has been reduced 50%. Furthermore, starting from 1 January 2010, the European Sulphur Directive required any seagoing vessels to use a maximum of 0.1% sulphur fuel oil when at quay for more than two hours. Ports in Sweden have adopted selective catalytic reactors, also known as the retrofitting equipment. The total emissions including SO_2, NOx and PM have been reduced significantly. In the port of Vancouver in Canada, vessels are encouraged to replace the conventional engine air inter-cooler by the water-injection and humid-air motors. The use of fuel oil can be highly reduced and the seawater can be used with this kind of motors. By replacing the motors, the total emissions can be reduced by 40 to 50%. In the Port of Vancouver, fuel additives are used as to increase the cost efficiency. In other words, there would be less fuel oil consumed during sailing. The NOx has been reduced about 30% and PM has been reduced more than 65%.

4. Conclusion and future development

Hong Kong, being the third largest container port in the world and having the second cruise terminal running into operation, requires the need of comprehensive green port operations and practices to minimize the impact of air pollutant emissions from the shipping and port operations. Current issues in the GHG emissions in the container and cruise terminals are reviewed, especially on the coming needs of cruise fuel switching in the Kai Tak Cruise Terminal. The mandatory vessel speed reduction in designated zone in Hong Kong should be further studied and developed. Latest environmental

measures from the leading ports all over the world are discussed. Five major aspects of green port practices, including international regulations, onshore power supply, vessel speed reduction, and fuel switching are evaluated. Suggestions and future green port development in Hong Kong are discussed.

5. **References – available upon request**