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Research article

The roles of scientific research and stakeholder engagement for evidence-based policy formulation on shipping emissions control in Hong Kong

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ABSTRACT

Shipping emissions control is critical to air quality management and improved public health for coastal port cities and regions with heavy marine traffic. However, Asian port cities have been slow in introducing regulations on marine fuels for two main reasons – firstly, due to a lack of information and therefore appreciation on the air quality and public health benefits that could be derived; and secondly, due to sensitivity as to whether there may be negative impacts on port competitiveness and trade opposition. Hong Kong, one of the top-ten international container ports in the world, has been proactive in reducing shipping emissions in the past decade. The *Ocean Going Vessels Fuel at Berth* regulation, enforced since July 2015 in Hong Kong, is the first marine fuel control regulation for ocean going vessels in Asia. This regulation has been adopted nationally by China for its coastal ports, followed by the establishment of domestic emission control areas in its coastal waters that will come into force in 2019. This paper describes the decade-long journey where scientific research led to evidence-based policy changes. New insights and understanding arising from the research enabled cross-sectoral engagement and dialogue among the key stakeholders in government, industry and civil society, which resulted in the political consensus needed for a change in policy and legislation. Similar evidence-based policy formulation, together with public-private sectors dialogue could be useful to other jurisdictions in pursuing a "win-win" path to improve environmental protection and public health through regulating shipping emissions. The same combination of science-to-engagement-to-policy approach could also become part of a knowledge-and-consensus-building process for other environmental policy areas as well.

1. Introduction

Air pollutant emissions from marine vessels (hereinafter referred to as shipping emissions) are harmful to both the natural environment and public health. It has been estimated that air pollution from ocean going vessels (OGVs) are responsible for around 60,000 cardiopulmonary and lung cancer deaths per year around the world and about 15,000–20,000 deaths in East Asia (Corbett et al., 2008; Liu et al., 2016; Molloy, 2016). Where shipping activities are in close proximity to dense population, the risk of exposure to shipping emissions naturally affect many more people. Shipping emissions control should therefore be an important component of air quality management of port cities and coastal areas.

Globally, shipping emissions is regulated by the International Maritime Organization (IMO), the United Nations specialized agency that regulates international shipping, whose responsibility includes protection of the environment through prevention of pollution caused by ships. The IMO establishes emissions control regulations through the International Convention for the Prevention of Marine Pollution from Ships (MARPOL). The current global cap for sulphur oxides (SO_x) content in marine fuel was set in 2012 at 3.5%; and it will be reduced to 0.5% by 2020 (IMO, 2017b). The IMO provides for the establishment of Emission Control Areas (ECAs) to control SO_x, where countries may establish more stringent controls within their jurisdictions. There are currently four IMO-designated ECAs, namely the Baltic Sea and North Sea in Europe, the North American ECA covering most of the United States and Canada, and the United States Caribbean Sea. The SO_x limit for marine fuel used by OGVs within ECAs was progressively lowed by the IMO from 1.5% maximum starting from 2000 to 1.0% from 2010 and to 0.1% from 2015(IMO, 2017b). In Asia, prior to 2015, there had been no local regulation on mandating OGVs to use low-sulphur fuel (IMO, 2017a; World Shipping Council, 2017a).

The control of shipping emissions for OGVs has been slow for

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individual jurisdictions, not only because the public health and environmental benefits were not fully appreciated (see below) but also local authorities that have control of ports remain concerned about the loss of competitiveness and higher cost of regulation. If one port tightens regulations, which would increase cost for the shipping companies, the concern is that the ships could use another port without such regulations.

Hong Kong has been one of the busiest container ports in the world since the 1980s (World Shipping Council, 2017b). The terminals at Kwai Chung (KC) are located very close to dense residential and commercial areas. The problem of shipping emissions was not considered significant till 2007, when research started to measure and estimate the contribution of shipping emissions to Hong Kong's total air pollution, as well as the extent to which shipping emissions affected the population. The results of research helped both the shipping industry and the Hong Kong Special Administrative Region (HKSAR) Government to take action that led to public-private sector collaboration and the eventual mandate requiring OGVs to use cleaner fuel while at berth in Hong Kong – the first such regulation in Asia.

This paper presents Hong Kong's experience on shipping emissions control, which started from gaining awareness of the problem that eventually led to policy and legislative change. Moreover, its success also influenced Mainland China's shipping emissions control policy, leading to substantial regulatory reform that is having nationwide and international impact.

In this paper, we use narrative to elucidate the key actors' role, actions and contributions to the evolvement of policy making process on shipping emissions control in Hong Kong (session 2–6); and then we use Advocative Coalition Framework (ACF) to examine the dynamics among the key actors (session 7). The ACF was firstly introduced in 1980s by analyzing the policy process of the clean air action in the United States (Sabatier, 1988). It offers a framework to explore the interactions and learning among major players in the policy change process (Li, 2012; Weible et al., 2011), especially in the case where expert-based information plays an important role (Lodge and Matus, 2014; Weible et al., 2010). Data and evidences in this study are collected from a series of study reports, media records, legislative documents and regulatory statements. The source of knowledge in this paper also includes the experiences and reflections from practitioners who were deeply involved in the whole process of policy change. Engaging practitioners into the research process through narrative inquiry, practitioners become producers of knowledge and help to bridge the gaps between assumptions and actual practices (Ospina and Dodge, 2005). Hong Kong's practice on shipping emissions control can help the development of ACF application.

2. Scientific evidences from research group

The Study on Toxic Air Pollutants (TAPs) – also known as hazardous air pollutants – was seminal in raising Hong Kong's awareness and knowledge of the potential impacts of shipping emissions on public health. TAPs are known or suspected to cause cancer or other serious health, or adverse environmental effects (Lau, 2003). Started in 1997, a TAP monitoring program was carried out by the Hong Kong Environmental Protection Department (HKEPD) in which six TAP groups were routinely measured, including dioxins/furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), carbonyls, volatile organic compounds (VOCs), and elements such as vanadium (V) and nickel (Ni). In addition to the TAP monitoring program, samples for particulate matters (PM_{10}) were collected for chemical analysis from Hong Kong's fourteen general air monitoring stations that made-up the city's Air Quality Monitoring Network (as shown in Fig. 1). The monitoring data pointed to emissions arising from ships: firstly, among all the general stations, the Kwai Chung monitoring station that was nearest the container terminals recorded the high annual elemental carbon (EC) concentration that was associated with the diesel PM level; secondly, compared with the other monitoring stations, elevated levels of Ni and V were shown in Kwai Chung, indicating an emission source local to Kwai Chung, which was most likely from the ships berthed at the container terminals, as the combustion of heavy oil was known to be the major source of Ni and V (Yuan et al., 2006; Huang et al., 2009; Yuan et al., 2013). The findings of the TAP study, published in 2003, suggested the significance of emissions contribution from the residual fuel oil combustion by marine vessels around the container terminals in Hong Kong.

To further understand the role of shipping emissions in Hong Kong's air pollution mix, spatial-temporal analysis and resumption of elemental speciation of PM_{10} at Kwai Chung were suggested. In the subsequent study of *Significant Marine Source for SO_2 Levels in Hong Kong*, published in 2005, the impacts of local shipping emissions were further identified (Lau et al., 2005). SO_2 is a product of fuel combustion mainly from power plants and vessels. Thus, it could be used as an indicator to investigate the environmental impact from fuel combustion. The study used circular pollution wind map (CPWM), principal component analysis (PCA) and singular value decomposition (SVD) to analyze the SO_2 monitoring data. The results found that ground-level SO_2 measured in Hong Kong was primarily produced from marine vessels. However, the official emission inventory at that time indicated that shipping emissions took up less than 6% of total SO_2 emission in Hong Kong and that the major source of SO_2 is from power plants. The concentration at a particular receptor depends on the combined effects of the emission amount, prevailing wind and dispersion conditions, as well as distance between monitoring station and emission source. Compared with the power plants, the ships are emitting much closer to the populated areas and also emitting at a much lower level (where the dispersion is much weaker), and thus their impacts on the populated areas near the port could be higher even though their overall emission amount is lower. This new finding led to technical discussions between the research group and HKEPD, resulting in a follow-up study to examine the variabilities and uncertainties of the emission inventories in Hong Kong.

In the *Study on Analysis of Variability and Uncertainty for Hong Kong Air Pollutant Emission Inventories* (Lau et al., 2010), published in 2010, key emission sectors in the emission inventory were scrutinized. For the shipping emissions inventory, significant systematic differences were found between previous "Point" estimates and the result of the uncertainty study, with SO_2 emission of 3592 tons and 10,053 tons respectively. It was noticed that the fuel assumption and consequent emission factors used in the two studies were different: while previous estimates were only based on marine gas oil (MGO, S% = average 0.5%), the uncertainty study mainly used emission factors of heavy fuel oil (HFO, S% = average 2.7%). It was recognized that in actual ship operation, the fuel consumed by OGVs and river vessels was not limited to MGO, but also residue oil and diesel oil. As the emission factor value of MGO is much lower than HFO, the fuel assumption of MGO in previous estimates would lead to lower values of emission and consequently underestimation of the emissions.

Given the high uncertainty in the old estimation of emission inventory, the HKEPD commissioned a study to develop a new methodology to calculate the shipping emissions inventory. The subsequent *Study on Marine Vessels Emission Inventory* (published in 2012), estimation were based on radar observations and ship information from the Automatic Information System (AIS), using activity-based approach and taking into consideration the fuel types, ship types and time-in modes (Ng et al., 2012). The new estimates were significantly higher than the old emission inventory, which were consistent with the uncertainty analysis. With the updated estimation method, plus the fact that land-based emissions (power plants and vehicles) had decreased due to tighter regulation, shipping emissions turned out to have contributed 50% of total SO_2 emission, 32% of total NO_x and over 37% of total PM emissions of Hong Kong in 2012. In addition, it was estimated that OGVs contributed 79% of SO_2 emission from vessels with the bulk of the emissions emitted during the hoteling mode (not moving, or