Targeting the reduction of shipping emissions to air: A global review and taxonomy of policies, incentives and measures

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**Shipping:**

- It is essential for the growth of **90% of global trade** and the **least** environmentally damaging mode of long-distance transport (*López-Navarro, 2013; Styhre et al, 2014*).

- However, it represented around **2.2% of the global CO\textsubscript{2} emissions** (*Smith et al, 2014*) and are expected to increase by **50% in 2050** (*UNCTAD, 2016*).
  
  - CO\textsubscript{2} emissions by shipping **are not covered** by the Kyoto Protocol, Copenhagen Accords (*UNCTAD, 2010*) or the Paris Agreement (*UNCTAD, 2015*).
  
  - Demand for shipping is forecast to **increase** in the future (*Smith et al., 2014; UNCTAD, 2016*).

*Ships* → Major source of atmospheric emissions and climate change that can have significant **adverse effects on human health and the environment** (*Cullinane and Cullinane, 2013; Corbett et al., 2007*).

Several actors have initiated **policies, incentives and measures** to reduce maritime air emissions.
This article aims to **identify and classify policies, incentives and measures** that have been implemented across the globe and are related to the **abatement of shipping air emissions**.
Specific types of measures, geographical areas or individual policies implemented worldwide. However, none of them has dealt with air emissions from shipping as a whole.

- Technical and operational measures and cost implementation (Bouman et al., 2017; Miola et al., 2011; Johnson et al., 2013; Smith et al., 2014; Bazari and Longva, 2011; Kontovas and Psaraftis, 2011; Psaraftis, 2018; Eide et al., 2009; Eide et al., 2011) Improvement of the operational efficiency of shipping (Cullinane and Cullinane, 2013; Wang and Cullinane, 2006; Cullinane and Khanna, 1999).

- Inventory of environmental performance indices (Svensson and Andersson, 2012)

- Market-based incentives and policies for innovative technologies or alternative fuels (Shi, 2016; Wan et al, 2018; Psaraftis, 2012; Nikolakaki, 2013; Davidson and Faber, 2012), Slow steaming (Cariou, 2011; Wan et al., 2018) bunker levy schemes (Kosmas and Acciaro, 2017). And specific policies (Franc and Sutto, 2014; Nikopoulou et al., 2012).

- The use of alternative fuels (Bengtsson et al., 2012; Brynolf et al., 2014).

- The potential of individual measures to reduce maritime air emissions at ports (Ahl et al., 2017; Cullinane, 2012; Innes and Monios, 2018; Winnes et al., 2015; Zis et al., 2014)

- Three-layered approach to vessels emissions based on geographical area (Lindstad et al., 2015).
Categorization

Policy instrument / measures → Total 249 case studies

Based on the classification of the Swedish Environmental Protection Agency (SEPA).

a) their ‘nature’, the category and subcategory of measures under which they fall
b) Their geographical level of application,
c) The continent where the organization is located
d) The specific type and sector (public or private) of the organization

After their categorization, the initiatives were analysed using the SPSS Statistics software in order to give some insight into their frequencies and the interrelationships between them.
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a) Their ‘nature’, the category and subcategory of measures under which they fall

Category and subcategory

Administrative
- Legislation
- Norms
- Limit
- Agreement
- Inspection
- Technical req.
- Environ. Class.

Economic
- Fee
- Grant
- Discount
- Tax
- Tax deduction
- Subsidies
- Certificates

Informative
- Eco-labeling
- Training
- Advising

Research
- Research
- Development
- Testing

Infrastructure
- Infrastructure investment
Categorization

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After their categorization, the initiatives were analysed using the SPSS Statistics software in order to give some insight into their frequencies and the interrelationships between them.
b.) Their geographical level of **application**,  
c.) The continent where the **organization** is located

<table>
<thead>
<tr>
<th>Geographical location</th>
<th>Initiatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>International</td>
<td>29</td>
</tr>
<tr>
<td>Regional</td>
<td>26</td>
</tr>
<tr>
<td>National</td>
<td>48</td>
</tr>
<tr>
<td>Local</td>
<td>141</td>
</tr>
</tbody>
</table>

**Sources:** BestFact case studies, GreenPorts, IAPH, OECD, IMO, EU, EPA, World Port ranking list, Port Authorities
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d) **The specific type and sector (public or private) of the organization**

After their categorization, the initiatives were analysed using the SPSS Statistics software in order to give some insight into their frequencies and the interrelationships between them.
d.) The specific type and sector (public or private) of the organization

Several actors have initiated **policies, incentives and measures** to reduce maritime air emissions.

- International Institutions (inter-governamental organizations)
- Regional Institutions
- National Strategies
- Port Authorities
- Private Firms
d.) The specific type and sector (public or private) of the organization

Several actors have initiated policies, incentives and measures to reduce maritime air emissions.

Some examples:
Categorization

Policy instrument / measures → Total 249 case studies

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After their categorization, the initiatives were analysed using the SPSS Statistics software in order to give some insight into their frequencies and the interrelationships between them.
1.) **Organization profile of the institutions** that have adopted measures, policies and incentives with maritime emission reduction potential

![ Continent Distribution](image1.png)  
![ Sector Distribution](image2.png)
1.) **Organization profile of the institutions** that have adopted measures, policies and incentives with maritime emission reduction potential

<table>
<thead>
<tr>
<th>Type of organization</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Port Authority</td>
<td>47.6</td>
</tr>
<tr>
<td>Governamental Agency</td>
<td>22.7</td>
</tr>
<tr>
<td>Inter-governamental organization</td>
<td>9.2</td>
</tr>
<tr>
<td>Private Firm</td>
<td>8.7</td>
</tr>
<tr>
<td>Public-Private Partnership</td>
<td>4.8</td>
</tr>
<tr>
<td>Non-Profit Organization</td>
<td>2.2</td>
</tr>
<tr>
<td>Industry Association</td>
<td>1.7</td>
</tr>
<tr>
<td>Others (research, state; trade org)</td>
<td>1.3</td>
</tr>
<tr>
<td>Environmental NGO</td>
<td>1.3</td>
</tr>
<tr>
<td>International Organization</td>
<td>0.4</td>
</tr>
</tbody>
</table>

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**Results**

**Methodology**

**Literature review**

**Introduction**

**Policies and initiatives**

**Conclusion**

**Relevance**

**Objective**
1.) **Organization profile of the institutions** that have adopted measures, policies and incentives with maritime emission reduction potential
2.) **Identification** of measures, policies and incentives targeting the abatement of maritime air emissions
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<table>
<thead>
<tr>
<th>Administrative</th>
<th>Economic</th>
<th>Informative</th>
<th>Research</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Legislation</td>
<td>6</td>
<td>1</td>
<td>20</td>
<td>2</td>
</tr>
<tr>
<td>Limit</td>
<td>12</td>
<td>1</td>
<td>9</td>
<td>18</td>
</tr>
<tr>
<td>Agreement</td>
<td>2</td>
<td>17</td>
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<tr>
<td>Inspection</td>
<td>4</td>
<td>85</td>
<td></td>
<td></td>
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<tr>
<td>Technical requirements</td>
<td>10</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental classification</td>
<td>4</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Legislation: Fee, Eco-labelling, Development
- Limit: Penalties, Advising
- Agreement: Grant
- Inspection: Discount
- Technical requirements: Tax
- Environmental classification: Tax deduction
- Subsidies
- Reimbursement
- Trade with emission allowances
3.) **Inter-relationships** between **categories** of measures, **geographical** level of **application** and **type** of institutions

Category of measure and type of the organization

![Graph showing distribution of measures by category and type of organization](image-url)
3.) **Inter-relationships** between **categories** of measures, **geographical** level of **application** and **type** of **institutions**
This study aims to identify and analysis all the diverse policies, incentives and measures implemented globally in a comprehensive way and its dealing with the **reduction of shipping air emissions** as a whole. This study permits to evaluate the level of success and identify the best performing of measures.

- **Europe** is the region where the majority of measures, policies and incentives.
- Almost half of the initiatives were implemented by **port administrations**, followed by governmental agencies and inter-governmental organizations.
- **Economic incentives** are the most commonly used initiative and they mainly applied by port authorities in the form of **discounts** (‘environmentally differentiated port dues’).
- **Infrastructure investments** (LNG refuelling points and OPS in ports) represent some popular measures.
- In general, **administrative policies** (regulations and mandatory measures) are mostly implemented by inter-governmental institutions while the ‘Informative’ and ‘research’ measures are implemented by private firms and public-private partnerships.

**Further research:**
- Depth analysis of the ports’ policies for the reduction of maritime air emissions.
- An evaluation of initiatives applied on a large scale to map their emissions reduction for shipping.
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