Low- and zero-carbon energy solutions in Norwegian coastal maritime transport: a technological innovation system analysis

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Outline

• Low- and zero-carbon maritime energy solutions
• Norwegian Coastal Shipping
• Technological Innovation Systems (TIS) Analysis
• Main findings
• Policy recommendations
• Conclusions
Low- and Zero Carbon Technologies

- Battery-Electric
- Hydrogen
- Liquifed Biogas (LBG)
- Biodiesel

Foiling battery powered speed ferry (sketch). Source: Flying Foil

Hydrogen powered speed ferry (sketch). Source: Brødrene Aa
Norwegian Coastal Shipping

10 % of total GHG emissions

Domestic shipping and fishing
Domestic aviation
Railway
Machinery etc.
Road transport
Technological Innovation Systems Analysis

• Innovation System?

1. Strucural Analysis: actors, networks and institutions
2. Functional Analysis
   • 7 indicators
3. Identification of system strengths and weaknesses -> policy recommendations
# Summary of Functional Analysis

<table>
<thead>
<tr>
<th></th>
<th>Knowledge Development and Diffusion</th>
<th>Direction of Search</th>
<th>Entrepreneurial Experimentation</th>
<th>Market Formation</th>
<th>Legitimation</th>
<th>Resource Mobilisation</th>
<th>Positive Externalities</th>
</tr>
</thead>
<tbody>
<tr>
<td>LBG</td>
<td>Red</td>
<td>Yellow</td>
<td>Red</td>
<td>Red</td>
<td>Yellow</td>
<td>Red</td>
<td>Yellow</td>
</tr>
<tr>
<td>Battery-electric</td>
<td>Red</td>
<td>Yellow</td>
<td>Red</td>
<td>Red</td>
<td>Yellow</td>
<td>Red</td>
<td>Yellow</td>
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<td>Hydrogen</td>
<td>Red</td>
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<td>Red</td>
<td>Yellow</td>
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</tbody>
</table>

- **Strong**
- **Intermediate**
- **Weak**
Direction of Search

Indicates the route for the development of the TIS and is determined by the strategic choices that are made by actors involved in the TIS.

+ Clear political climate and emission reduction goals
+ Public procurement specifications
+ State initiated “development contracts”

- Battery-Electric & Hydrogen: Lack of standards and regulations
- LBG: Little attention on maritime use of LBG
“I think that at least within the road ferry segment it is very much controlled by the government’s decision that there should be zero emissions for ferry connections. Battery-electric seems to be the most requested alternative where it is possible, and they are starting to think about hydrogen too.” (Ship-yard 2, 2018)
Legitimation

The process of gaining regulative legitimacy and social acceptance for the new technology.

+ Success rate of pilot testing & existing ships
+ Investments from important actors

- LBG & Hydrogen: Uncertainties regarding fuel availability
- BE: Uncertainties around battery life length & power grid capacity

<table>
<thead>
<tr>
<th>LBG</th>
<th>Weak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery-Electric</td>
<td>Strong</td>
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<td>Hydrogen</td>
<td>Intermediate</td>
</tr>
</tbody>
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**Legitimation: Battery-Electric**

“I think that what was done at Lavik-Oppedal [M/V Ampere] opened up the door for the rest of us to follow” (Public Administration 4, 2017)

<table>
<thead>
<tr>
<th>Vessel Type</th>
<th>In operation</th>
<th>Under construction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car/passenger ferries</td>
<td>59</td>
<td></td>
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<tr>
<td>Cruise ships</td>
<td>16</td>
<td></td>
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<tr>
<td>Fishing vessels</td>
<td>15</td>
<td></td>
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<tr>
<td>Offshore supply vessels</td>
<td>19</td>
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<tr>
<td>Other offshore vessels</td>
<td>27</td>
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<tr>
<td>Ro-Ro cargo vessels</td>
<td>10</td>
<td></td>
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<tr>
<td>Tugs</td>
<td>9</td>
<td></td>
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<tr>
<td>Other</td>
<td>32</td>
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</tr>
</tbody>
</table>

Number of vessels with batteries by vessel type. Data adapted from DNV-GL’s Alternative Fuels Insight (AFI) platform.
Policy Recommendations

• Increase the cost of fossil fuels
• Maintain clear direction
• Make choices: different technology suitable for different ships
• R&D Support
• Financial support to shipping industry
• Support variety
• Provide support-seeking assistance
• Cluster and networking support
• Increase number of development contracts
• Public procurement as a tool
• Differentiated harbour fees
• Licenses to operate
Policy Recommendations

**SYSTEM STRENGTHS**
- Maintain clear direction
- Public procurement specifications

**DIRECTION OF SEARCH**

**SYSTEM WEAKNESSES**
- Lack of standards and regulations
- Uncertainties around battery life length

**POLICY MEASURE**
- Increase number of development contracts
- Increase R&D Support

**LEGITIMATION**
Conclusions

1. Norway is world-leading within sustainable shipping
2. Clear climate and emission reduction policies drive innovation
3. Development contracts major driver of technology development
4. Success rate very important for legitimation
5. All technologies in need of further R&D support
Thank you for listening!

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