Feasibility Study of Future Energy Options for Great Lakes Shipping

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Agenda

1. Background
2. Baseline – What fuels are ships currently using? How much are they emitting? What are the major ports?
3. How can GL-SLS shipping decarbonize?
4. What are the regulatory considerations?
5. What are the conclusions and policy recommendations?
Background

The Great Lakes-St. Lawrence Seaway (GL-SLS)

- 3,700 km (2,300 mi)
- 110+ ports
- 136 million tonnes (Mt) of cargo transported in 2022, valued at USD 26 billion.
Baseline – 2021 fuel consumption

510,000 tonnes: ~80% distillate
Baseline – 2021 emissions

1.6 million tonnes CO₂:
Mainly from US and Canadian bulk carriers, chemical tankers, and tugs
Baseline – major ports and their infrastructure
How can GL-SLS shipping decarbonize?
Fuel options to be used in engines, fuel cells (hydrogen), or batteries (electricity)

- **Fossil-based fuels**
  - Methanol
  - Ammonia
  - Hydrogen
  - DME

- **Biofuels**
  - Methanol
  - Diesel
  - Methane
  - DME

- **e-fuels**
  - Methanol
  - Diesel
  - Methane
  - Ammonia
  - Hydrogen

- **Electricity**
  - Batteries
Criteria to determine suitability of different fuel and power options for GL-SLS shipping

- Life-cycle emissions
- **Total cost of ownership**, including CAPEX and OPEX
- **Applicability** to the types of voyages undertaken by GL-SLS ships
- Technological maturity
- **Compatibility** with existing ships/engines
- Feedstock availability
- **Risks**, including safety and environmental hazards
Fossil-based fuels

Main problem: high emissions

Main benefit: inexpensive
Biofuels

Main problems: **ILUC** (soy); **expensive** for advanced biofuels (FT, DME)

Main benefits: some are **drop-in fuels** for the existing GL-SLS fleet; can achieve low emissions
Main problems: **high emissions** when using grid electricity; all are **expensive**; new risks for ammonia (toxicity) and hydrogen (explosion)

Main benefit: **low emissions** using additional renewable electricity

Life-cycle GHG emissions (gCO2e/MJ)
Main problems: **TCO of using electricity is expensive**; mediocre emissions savings using grid electricity

Main benefits: **zero emissions** using additional renewable electricity; can be used to electrify tugs
What are the regulatory considerations?
### Regulations

<table>
<thead>
<tr>
<th>Category</th>
<th>Air pollution</th>
<th>GHGs</th>
<th>Safety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy</td>
<td>Low/no sulfur, low PM, no major challenges for NOx and CO</td>
<td>Requires full life-cycle assessment</td>
<td>Challenging for new fuels</td>
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- GHGs:
  - More complicated
  - Requires full life-cycle assessment

- Safety:
  - Challenging for new fuels
  - Still being developed for hydrogen (explosion risk) and ammonia (acute toxicity)
What are the conclusions and policy recommendations?
Conclusions

Fuels and power options

• Avoid fossil-based fuels.
• Use waste-derived biofuels.
• Use additional renewable electricity for e-fuels and electricity for batteries.
• Use fully-electric tugs/harbor craft and hybrid-electric setups for cargo ships.
• Use hydrogen made from additional renewable electricity in fuel cells to improve efficiency and virtually eliminate life-cycle emissions.

Regulations

• Compliance with air pollution regulations will be straightforward.
• Compliance with GHG regulations, which are still being developed, will be more complicated, requiring full life-cycle analyses.
• Safety regulations for using hydrogen and ammonia as marine fuels are still being developed.
Policy Recommendations

Policy recommendations

• Focus on driving down the cost of producing and using low life-cycle GHG e-fuels, or making fossil fuels more expensive (e.g., carbon pricing), or both.
• Consider adopting a low-carbon fuel standard (LCFS) or a blending mandate.
• Expand shore power for electric tugs/harbor craft and cargo auxiliary power.
• Plan for new fuel storage infrastructure for hydrogen, ammonia, and methanol.
• Promote repowering and replacement of GL-SLS vessels to make them zero-emission vessels.
• Establish a public database of total annual fuel consumption and in-port fuel consumption by each ship in the GL-SLS.
Questions?
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