Transition to Hydrogen Fuel Cell Fishing Vessels in Digby, Nova Scotia

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Question

The Municipality of Digby wants to determine the technoeconomic feasibility of local green hydrogen production and storage to supply their fishing vessel fleet and transition the vessels to hydrogen-electric hybrid systems.

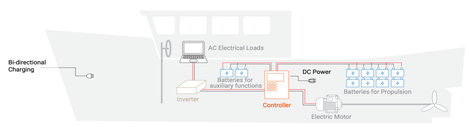
Motivation

- The shipping industry produces about 3% of global emissions annually and it is estimated that marine fishing vessels are responsible for more than 200 million tons of CO_2 emissions every year (Oceans North, 2023).
- Nova Scotia is the largest contributor to Canada's fishing sector and accounts for 30% of all national fishing exports and the fishing industry was responsible for 13.5% of the province's total GDP in 2018 (Nova Scotia Department of Fisheries, 2016; Government of Canada, 2021).
- The province of Nova Scotia has committed to reaching net-zero by 2050.
- 3,278 diesel-powered lobster fishing vessels will need to be transitioned to decarbonized solutions by 2050 (Oceans North, 2023).

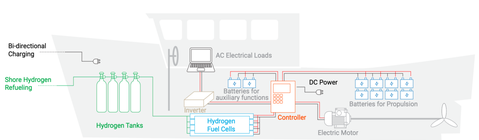
Objective and Scope

- Determine energy requirements of all fishing vessels currently at the Digby wharf for their lobster fishing season
  - Digby is in Lobster Fishing Area 34 and the season runs from the last Monday in November to May 31st
- Calculate the wind turbine requirements to produce hydrogen supply for all fishing vessels
- Calculate emissions savings from switching from diesel to hydrogen-battery hybrid systems
- Calculate 20-year lifecycle cost of hydrogen-battery hybrid vessel versus diesel fuel vessel

Battery-Electric Vessel

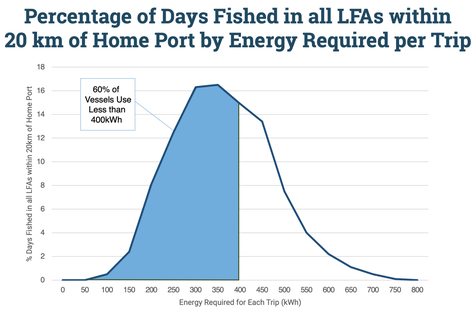


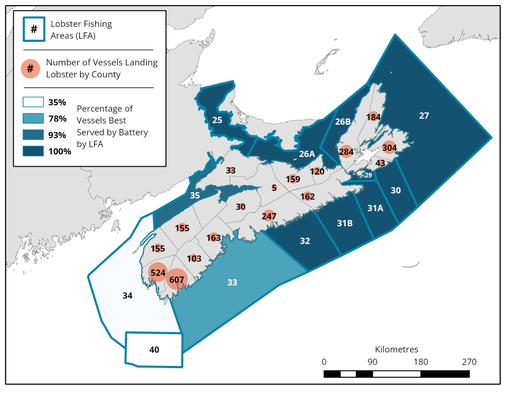
Battery-Hydrogen Hybrid Vessel



Oceans North *Lobster Fleet Electrification Assessment*

- The *Nova Scotia Lobster Fleet Electrification Assessment* by Oceans North (2023) analyzed potential electrification options for fishing vessels in the province.
- Report found that 60% of all lobster fishing vessels in the province could operate with only a 400-kWh battery, because their max travel distance is 20km from their home wharf.
- Digby's Lobster Fishing Area (LFA) is 34 and has the lowest adoption of battery only vessels, making it a good candidate for battery-hydrogen hybrid options.





- The 20-year-lifecycle operating cost for each type of lobster vessel is shown below.
- The cost of hydrogen was assumed to be $12.50/kg with 1,406kg being purchased annually (Oceans North, 2023).
- Lowering the cost through local production would make it more economical for fisherman to make the switch.
- The entire lobster fishing fleet in Nova Scotia is currently estimated to produce 83 million kg of CO2e annually, which is equivalent to 35,000 cars. The fleet energy assessment shows that 60% of these emissions could be eliminated if all vessels that require 600kWh or less switch to a battery or battery-hydrogen hybrid solution.

	Diesel Propulsion System	Battery-electric Propulsion System	Hybrid (Fuel Cell) Electric Propulsion System
Capital Costs	$70,000	$169,550	$192,860
Operating Costs	$209,000	$51,452	$351,520
Maintenance Costs	$70,000	$33,910	$115,716
Total Costs	**$349,040**	**$254,912**	**$660,096**

Methodology

- Four case studies based on two hydrogen electrolysers and two different fleet sizes.
- Calculations for each case study:
  - Daily hydrogen requirements
  - Wind energy output requirements
  - Annual emissions savings
  - Annual water usage
  - Levelized cost of hydrogen
  - 20-year cost comparison to diesel
- Digby currently has an 800kW Enercon E48 wind turbine, so this model is used for all wind calculations

Results

- Daily hydrogen requirement per boat is 9kg to supply 150-kWh of additional power to the 400-kWh battery
- Levelized cost of hydrogen is consistent across all case studies
  - Ranges from $5.26 – 8.01 CAD/kg H_2
  - Dependent on electrolyzer operational hours and cost of electricity
- 20-year operating cost ranges from $456,459 – 533,830 CAD
  - Compared to $349,040 for diesel

	60kg H_2/day	200kg H_2/day	837kg H_2/day	1030kg H_2/day
# of boats served	6.67	22.22	93	Half the fuel for all vessels at the wharf
Wind Energy Requirement	150kW	500kW	2MW	2.5MW
# of wind turbines	1	2-3	9	12
Annual emissions savings	181 tonnes CO_2eq/year	603 tonnes CO_2eq/year	2,523 tonnes CO_2eq/year	2,675 tonnes CO_2eq/year
Annual water usage	197,100 L/year	657,000 L/year	2,749,545 L/year	3,383,550 L/year

Future Recommendations

- Pilot project to construct a hydrogen fuel cell – battery hybrid fishing vessel tested with fishermen to determine if it works for their needs.
- Further financial analysis to understand subsidies available to Digby and municipalities budget.
- Regulations will need to be created with Transport Canada to determine the storage of hydrogen on fishing vessels.

References

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