MCSC | MIT Climate & Sustainability Consortium

Powertrain and system for LOHC-powered long-haul trucking

Project Overview

How can we make hydrogen a more promising option as an alternative fuel for long-haul trucking?


William Green

Long-distance, heavy duty freight transport is a major contributor to GHG emissions, comprising almost 3% of total emissions. Electrification presents a pathway for smaller freight vehicles and shorter routes as reliable charging infrastructure is being deployed. However, battery-powered long-haul trucks are not economically competitive because they require large, heavy and expensive batteries to achieve the required range. Fueling trucks with hydrogen, transported either as compressed gas or as cryogenic liquid, has been discussed as an alternative for some time. However, its adoption in heavy-duty trucks faces challenges due to high transportation and refueling costs, along with the need for refueling infrastructure build-out. This team, led by Professor William Green (Chemical Engineering), has been pursuing an alternative strategy for long-haul trucks: Liquid Organic Hydrogen Carriers (LOHCs), room-temperature liquids that can store and release gaseous hydrogen fuel. The proposed decarbonization concept for trucking and some shipping applications has the potential for broad implementation, supporting needed GHG emission reductions in the transport sector.

The project aligns closely with the MCSC's Transportation pathway.

Findings & Outcomes

This group developed a new powertrain concept with onboard hydrogen release and integrated waste heat recovery from engine exhaust.

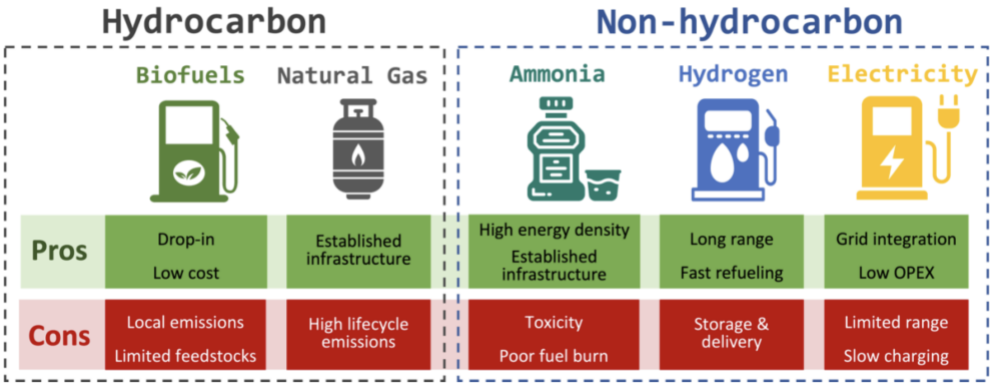
Professor Green and his team have been exploring a cost-effective way to transport and store hydrogen using LOHCs, which require minimal changes to the existing fuel infrastructure. The team has been developing a disruptive technology that allows LOHCs to not only deliver the hydrogen to the trucks, but also store the hydrogen onboard. To implement such a design, the team aims to modify the truck's powertrain (the system inside a vehicle that produces the energy to propel it forward) to allow

onboard hydrogen release from the LOHCs, using waste heat from the engine exhaust to power the "dehydrogenation" process.

Journal Publication: *Energy & Fuels*

The team's findings were published in *Energy & Fuels*, a peer-reviewed journal of the American Chemical Society, in a paper titled "Perspective on Decarbonizing Long-Haul Trucks Using Onboard Dehydrogenation of Liquid Organic Hydrogen Carriers." Their analysis shows the potential of LOHC trucks to reach cost parity with diesel at a hydrogen production cost of $1.6/kg, which is within the price range of blue hydrogen.

Related White Paper: *Alternative Fuels and Powertrains to Decarbonize Heavy Duty Trucking*



The white paper was informed by perspectives from industry members of the MCSC, and insights shared by invited experts from academia and industry during a study panel hosted by the MCSC. Danika MacDonell, MCSC Impact Fellow, one of the contributors to the white paper, has played a critical role in facilitating these connections across academia and industry to support quick decision-making and scalability. The paper identifies near-term priorities to support industry stakeholders in overcoming decision paralysis, navigating the valley of death, and positioning trucking fleets to thrive as the industry transitions to alternative fuels and powertrains.

Related Workshops

The MCSC has hosted a series of workshops to identify critical drivers, pain points, and decision support opportunities to transition trucking fleets to low-carbon energy carriers. Key learnings from these workshops:

1. Total cost of ownership for alternative energy carriers - particularly battery electric - is nearing parity with conventional diesel for some operating profiles, yet transition challenges around up-front costs, infrastructure availability, and fleet performance remain.
2. Different low-carbon energy carriers will be best-suited for different operating profiles – there is unlikely to be a one-size-fits-all solution across the entire industry.

Geospatial Decision Support Tool (Outcome Workshop), June 2024

Logistics Electrification Planning (Outcome Workshop), March 2024

Alternative Fuels and Powertrains for Heavy Duty Trucking (Study Group), June 2023

Electrified Trucking (Outcome Workshop), April 2023

3. Fleets lack dedicated resources to support identification and development of fleet decarbonization opportunities – the MCSC is developing a geospatial decision support tool to help fill this gap.
4. Fleets and shippers are interested in pooled purchase and use of alternative infrastructure, but significant coordination is needed – the MCSC is working to align members around high-level thought leadership to address these coordination challenges, while developing a detailed analytical framework to support the planning and implementation of pooled investment initiatives.

Opportunities for Implementation

Research

- The team's perspective paper highlighted need for dedicated studies and further development of core components for on board hydrogen release with efficient heat integration geared towards trucking applications.
- Study the details of setting up a robust LOHC supply chain to support trucking applications (including co-locating hydrogenation with hydrogen production facilities).

Implementation

- Identify OEMs who would be interested in scaling up the prototype to a full-sized truck. This should also involve other stakeholders in the ecosystem willing to signal interest (see next point). The research team would dig deeper into what would be needed to realize a pilot (actionable enough and at the right scale).
- Identify shippers, carriers and infrastructure providers who would be interested in participating in a pilot, or at least providing perspectives on critical factors (technology readiness, infrastructure availability, etc.) that would impact their decision to pilot/adopt the concept.