MIT Green Group

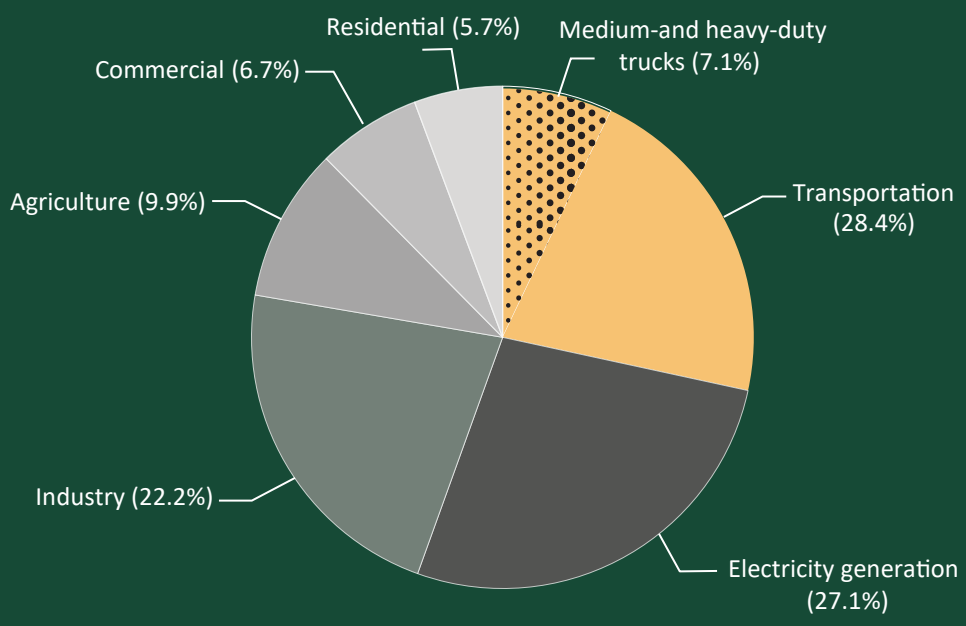
MCSC MIT Climate & Sustainability Consortium

Decarbonizing Long-haul Trucking

Climate change caused due to rising global mean temperatures from greenhouse gas (GHG) emissions is a major problem, plaguing the 21st century. Solving the climate crisis is largely reliant on phasing out fossil fuels and replacing them with renewable energy. Today, medium and heavy duty trucks run exclusively on diesel, and accounts for 7.1% of the total GHG emissions.

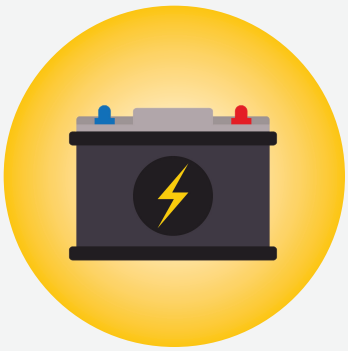
Decarbonization of the trucks is a hard problem. Trucks are an indispensable part of the modern supply-chain, any increase in the cost of trucking is felt universally. Decarbonization solutions need to be both economically viable and practical to implement.

"Medium and heavy duty trucks accounts for 7.1% of the total GHG emissions"



This document summarizes the preliminary findings from studying three decarbonization options for long-haul trucking in the US:

Biofuels



Battery Electric

Hydrogen

Understanding Long-haul

*"Long-haul trucks often **do not return to depots at night**, need to refuel/recharge at many locations"*

Flexible Routes

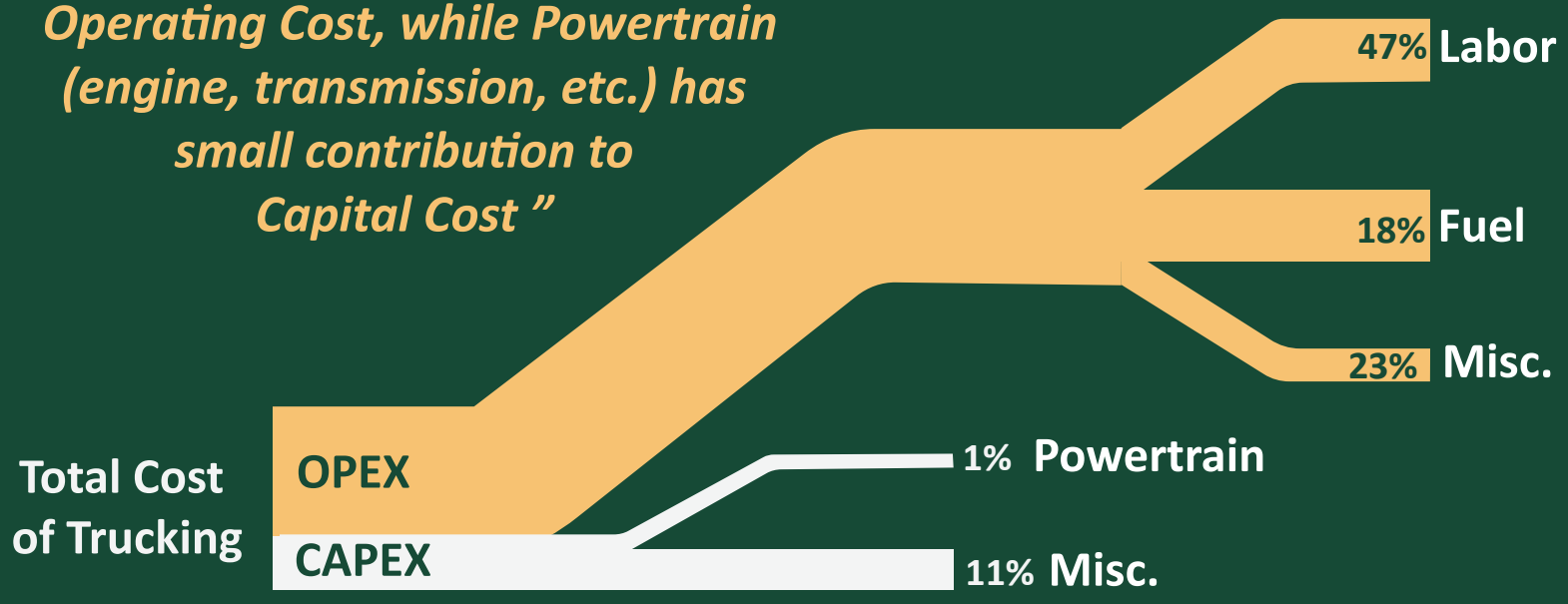
*"**Trucks have high energy demand.** One day of driving consumes 80 gallons of diesel"*

11 hours/day

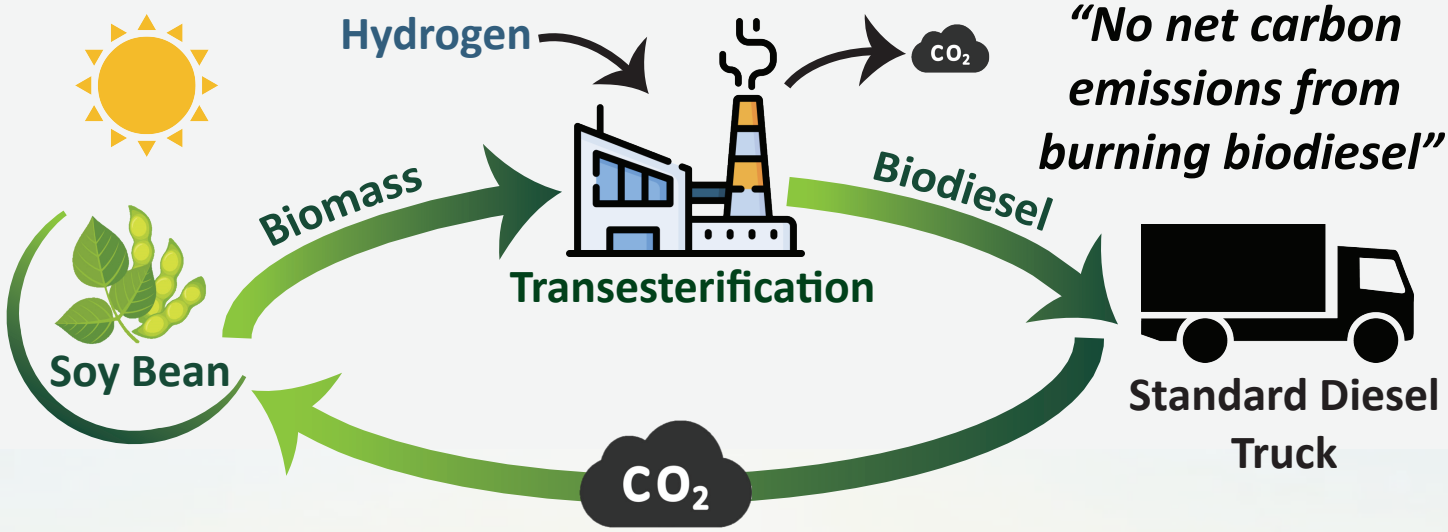
*"**Operating Cost dominates Capital Cost** by a **factor of 5** over the lifetime of the truck"*

600 miles/day

"Labor & Fuel make up majority of Operating Cost, while Powertrain (engine, transmission, etc.) has small contribution to Capital Cost "



Biofuels



"No net carbon emissions from burning biodiesel"

*"**Biodiesel** is functionally equivalent to diesel, thus compatible with standard trucks"*

"Relatively inexpensive"

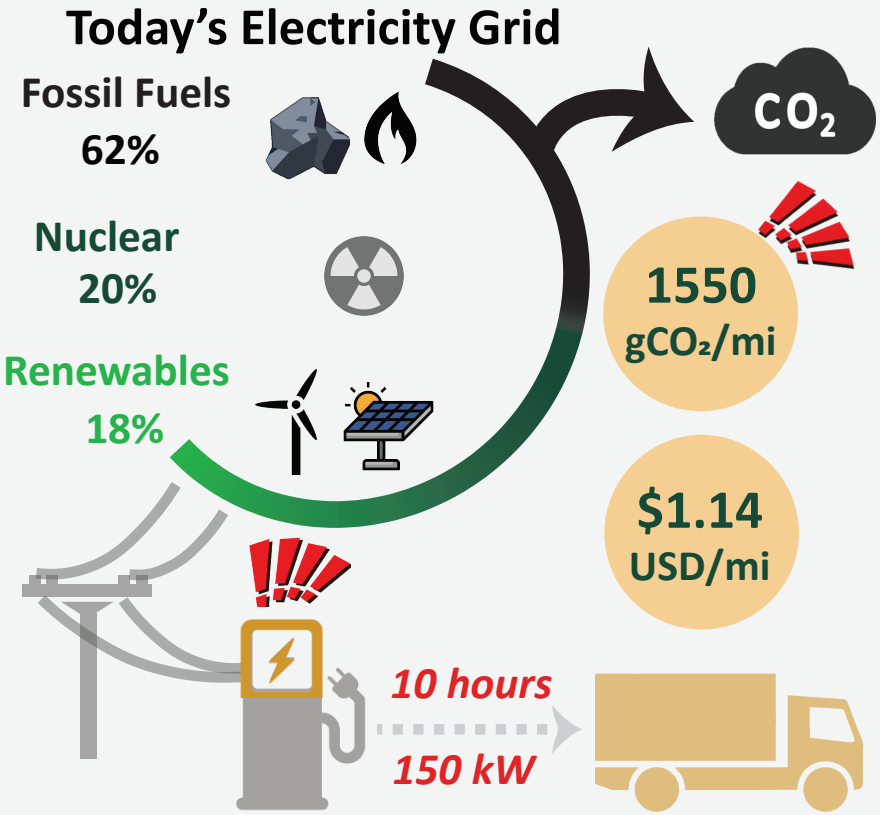
$0.42 USD/mi

157 gCO_2/mi

"89% reduction from diesel"

*"Crops need land and water to grow. Both scarce resources, leading to **scalability concerns**"*

Battery



"CO_2 emissions arise from burning fossil fuels to generate electricity"

"Grid is expected to be cleaner in the future"

*"We need a **1500** kWh battery, weighs ≈ **6** tonnes, costs **$200k**"*

"Batteries are getting cheaper each year"

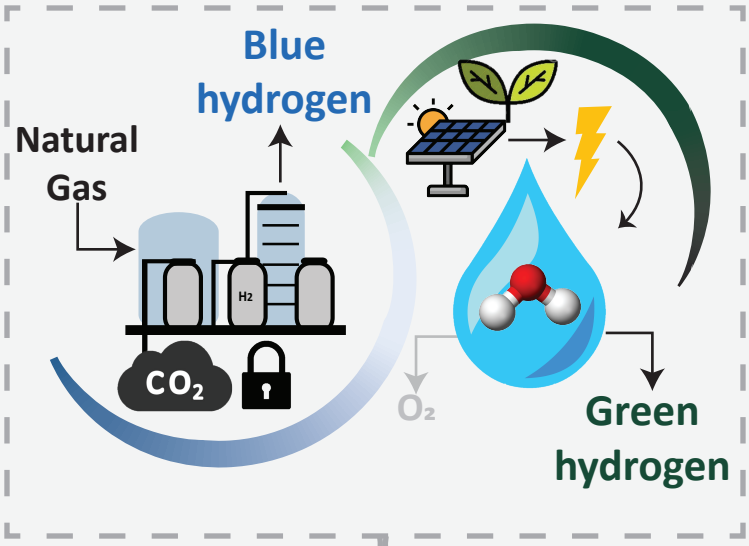
To learn more scan QR code provided on page 6

Hydrogen

$2 USD/kg
3.6 gCO_2/gH_2

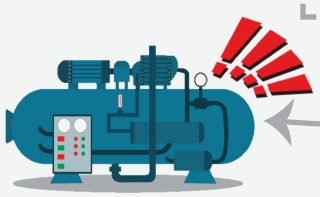
*90% Carbon Capture

"Blue hydrogen is cheap and relatively clean"



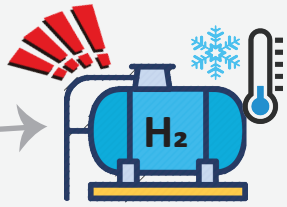
$8 USD/kg
0.6 gCO_2/gH_2

"Green hydrogen is expensive but very clean"



Compressed

Liquified

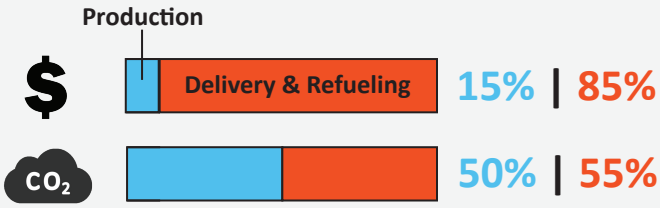


"Hydrogen needs better delivery and refueling methods"

Energy lost - 20 to 30%
Compressor cost > $1MM USD

Boil-off losses
Liquifier is expensive

At gas station



$1.70 USD/mi

1020 gCO_2/mi

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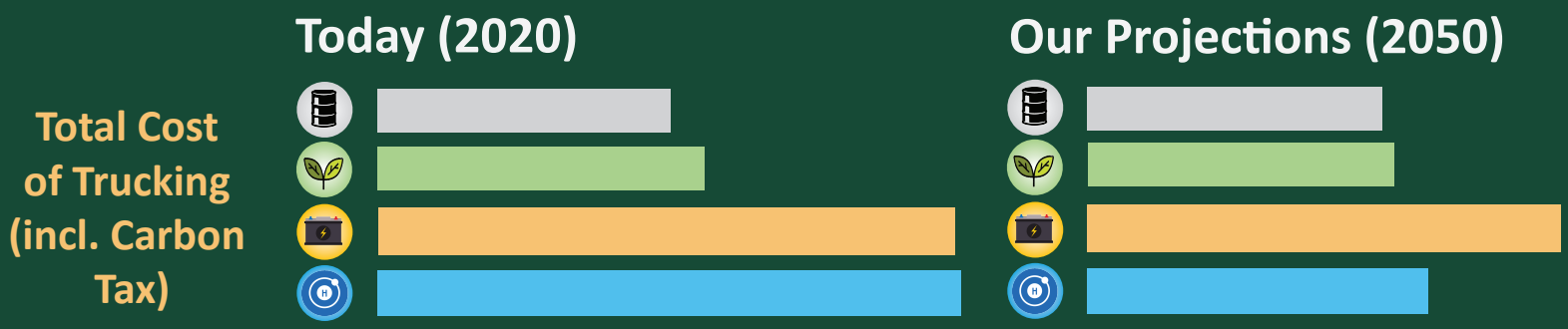
Summary



*"Long-haul trucking remains an **open problem** with no clear winner"*

*"**Hydrogen has practical advantages** for long-hauling such as scalability and fast refueling time. Also, there is a enormous potential to improve delivery and refueling to further reduce H_2 cost"*

Liquid Organic Hydrogen Carriers (LOHCs)

They are organic molecules that can be reversibly **hydrogenated (exothermic)** and **de-hydrogenated (endothermic)** to absorb and release hydrogen as needed

Pros

Liquid fuel - Synergistic with existing fuel infrastructure

High thermo-stability and inert

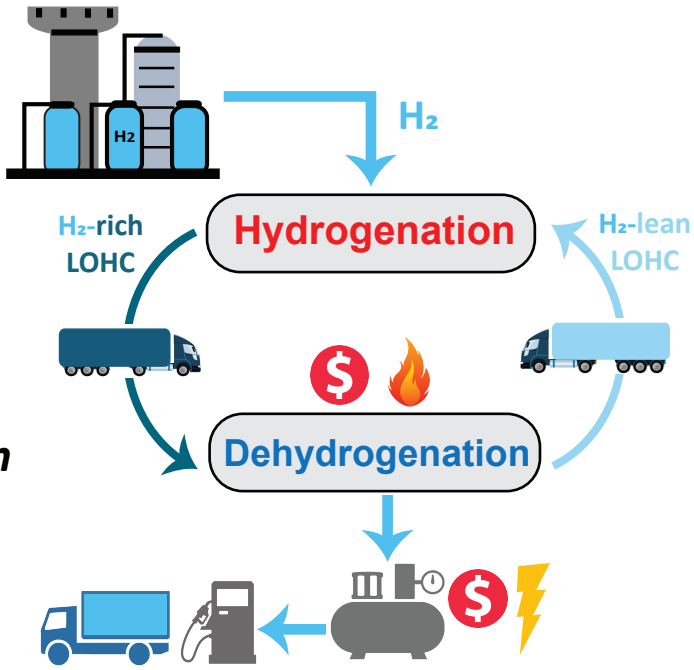
Mature technology can handle fuel demand for long-hauling

Cons

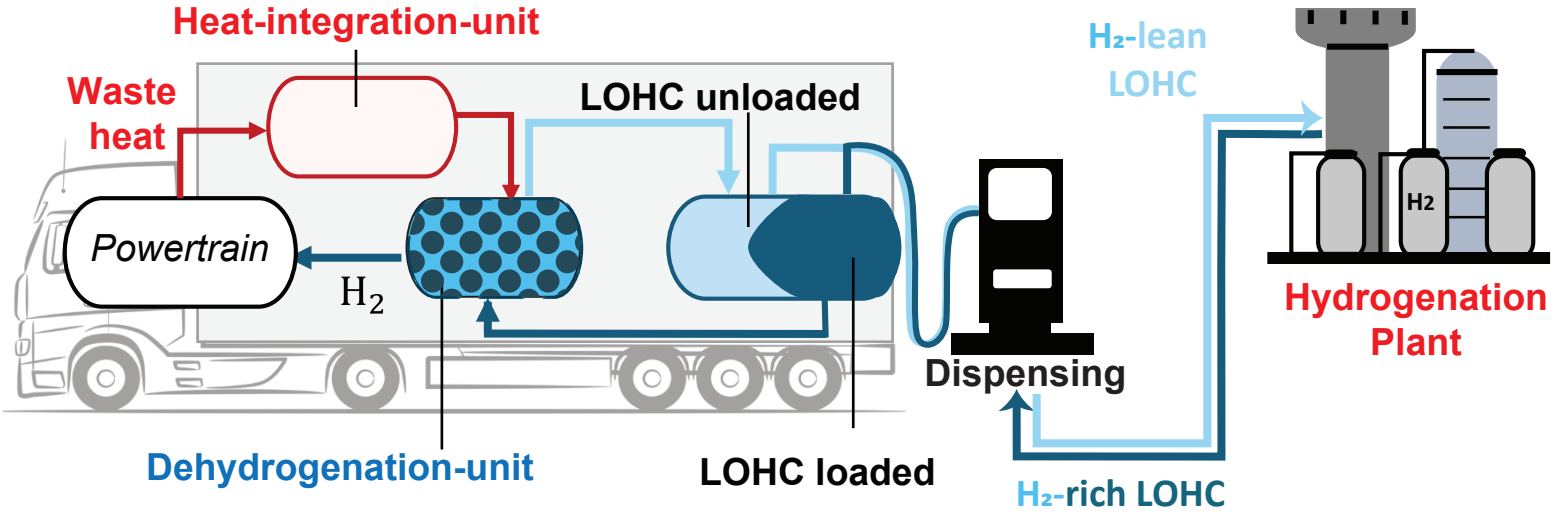
30% energy penalty due to highly endothermic dehydrogenation

Hydrogen still needs compression before using it as a fuel

LOHC Today



Our Idea: On-board Hydrogen Generation



"40% of the fuel's energy is wasted in the exhaust of an internal combustion engine. We will use this to power dehydrogenation"

"No need for compression as we eliminate any need to store hydrogen as a gas"

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