



Hydrogen

For Heavy-Duty Long Haul

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May 11, 2023



North American Council for Freight Efficiency

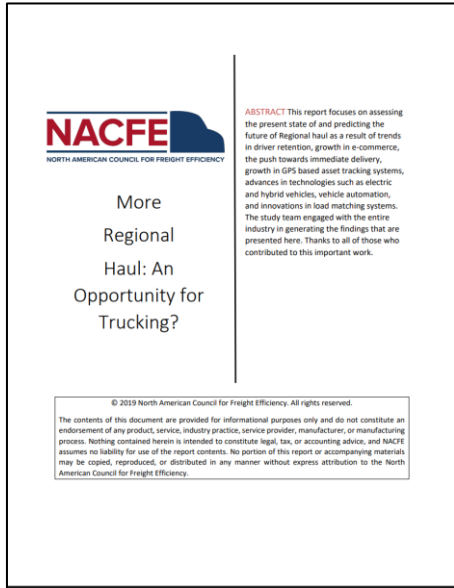


- Unbiased, fuel agnostic, non-profit
- Mission to double freight efficiency
- All stakeholders
- Scale available technologies, guide emerging change and Run on Less demonstrations.

www.NACFE.org
www.RunOnLess.com

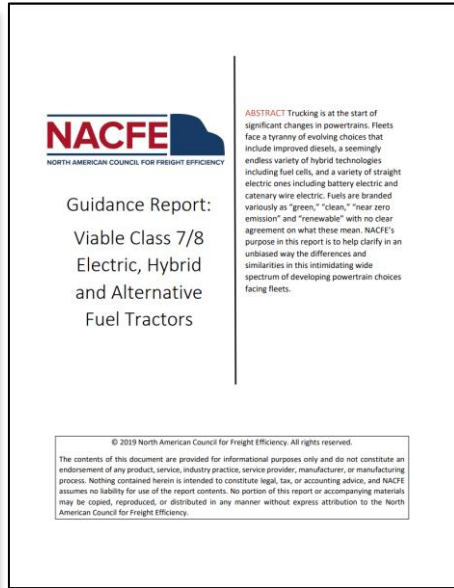


NACFE Hydrogen Reporting



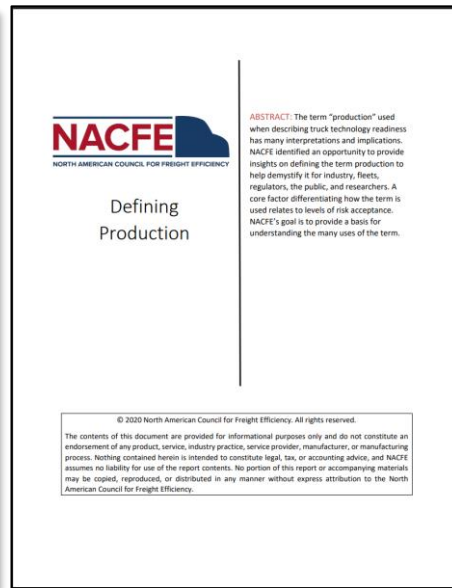
[More Regional Haul: An Opportunity for Trucking?](#)

Apr 2019



[Viable Class 7/8 Electric, Hybrid and Alternative Fuel Tractors](#)

Dec 2019



[Defining Production](#)

Jan 2020



[Making Sense of Heavy-Duty Hydrogen Fuel Cell Tractors](#)

Dec 2020

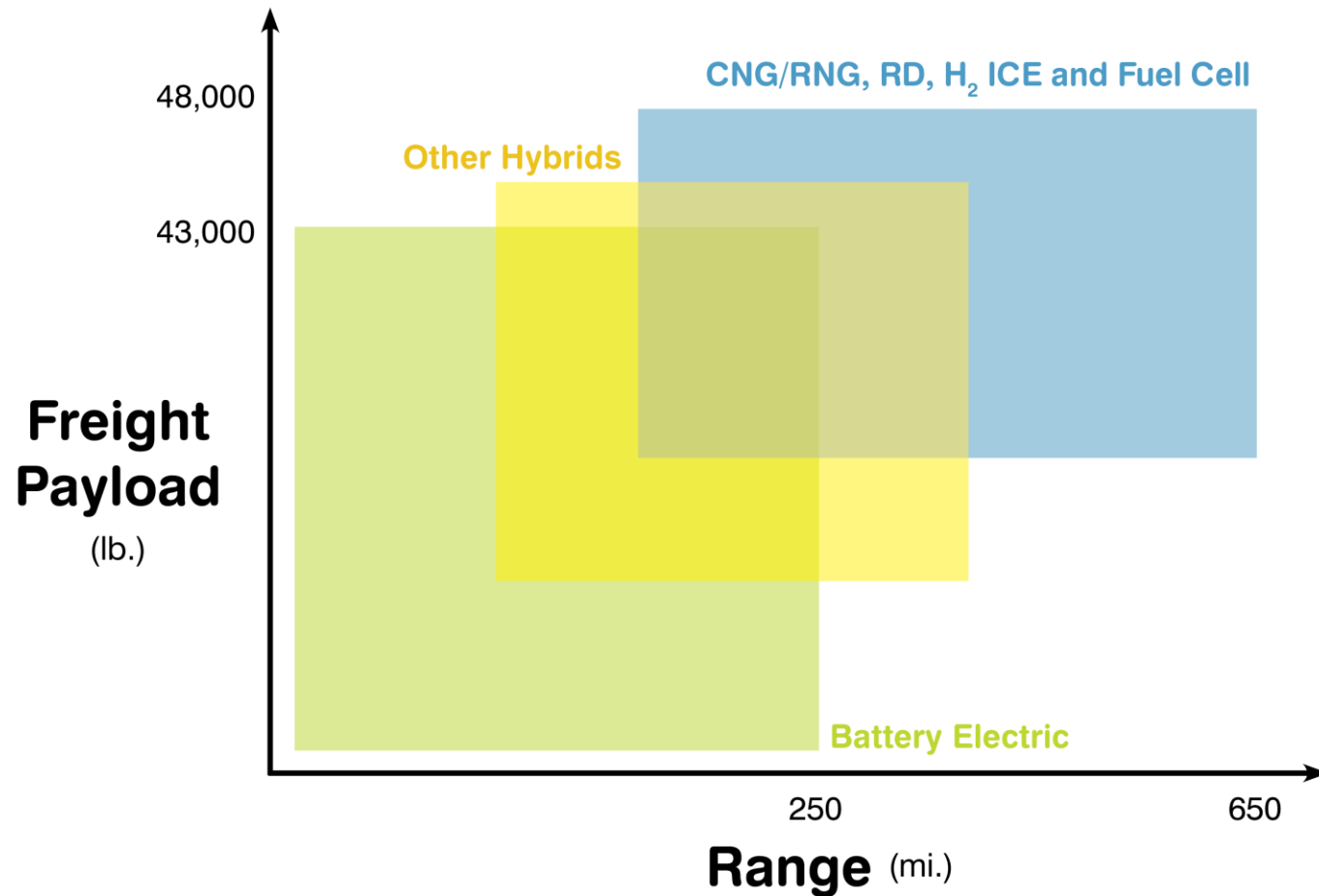


[Hydrogen Trucks: Long-Hauls Future?](#)

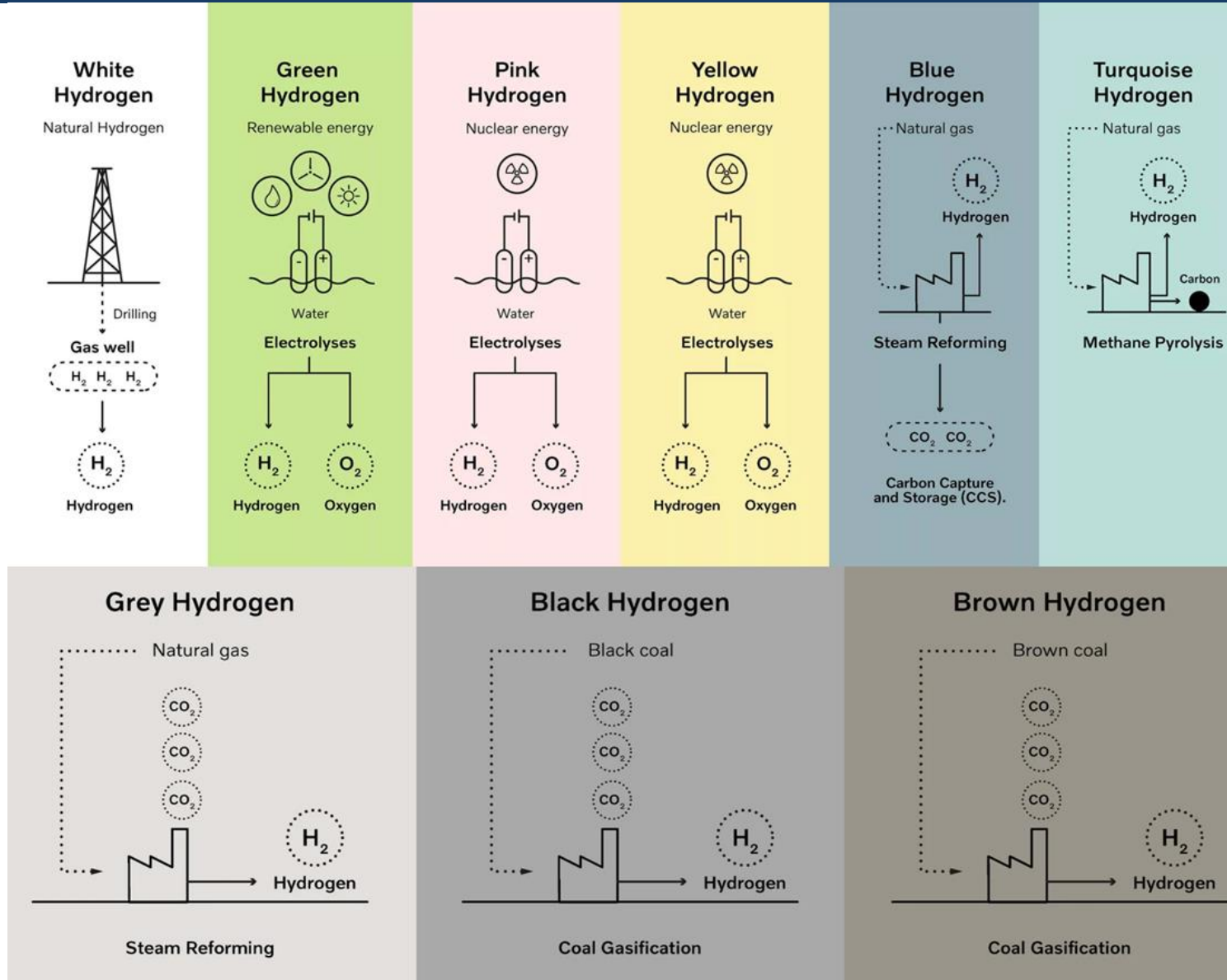
Apr 2023

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Optimum Duty Cycle Sweet Spot



Colors and Carbon Intensity



Blueprint to Zero Emissions

	 BATTERY/ELECTRIC	 HYDROGEN	 SUSTAINABLE LIQUID FUELS
Light Duty Vehicles (49%)*		—	TBD
Medium, Short-Haul Heavy Trucks & Buses (~14%)			
Long-Haul Heavy Trucks (~7%)			
Off-road (10%)			
Rail (2%)			
Maritime (3%)			
Aviation (11%)			
Pipelines (4%)		TBD	TBD
Additional Opportunities	<ul style="list-style-type: none"> • Stationary battery use • Grid support (managed EV charging) 	<ul style="list-style-type: none"> • Heavy industries • Grid support • Feedstock for chemicals and fuels 	<ul style="list-style-type: none"> • Decarbonize plastics/chemicals • Bio-products
RD&D Priorities	<ul style="list-style-type: none"> • National battery strategy • Charging infrastructure • Grid integration • Battery recycling 	<ul style="list-style-type: none"> • Electrolyzer costs • Fuel cell durability and cost • Clean hydrogen infrastructure 	<ul style="list-style-type: none"> • Multiple cost-effective drop-in sustainable fuels • Reduce ethanol carbon intensity • Bioenergy scale-up

* All emissions shares are for 2019

† Includes hydrogen for ammonia and methanol

What NACFE Got Right And Wrong

In NACFE's 2020 [Making Sense off Heavy-Duty Hydrogen Fuel Cell Tractors](#) report had five major findings

- Hydrogen adoption is being driven by regional and national considerations
- Battery electric is baseline not diesel
- Optimize specifications for duty cycle
- Creation and distribution of the hydrogen
- Autonomous fuel cell 24/7 operations

Original Report Other Findings

- Hydrogen colors vs. carbon intensity
- Trends in state and federal regulations
- Hydrogen economy cannot be built solely on the shoulders of long-haul trucking
- Standardization is critical
- Spectrum of designs for fuel cell powertrain
- Hydrogen burning diesel-based engines not originally forecasted

New Report Findings

1. Hydrogen powered freight is required for a zero-emission freight future
2. Significant amount of hydrogen funding
3. The cost of hydrogen production, transportation storage and dispensing needs subsidies
4. Managing the actual retail cost of hydrogen more important than reducing the production cost
5. Hydrogen is closely tied to electricity.
6. Hydrogen is a significant factor in federal, state and local planning and regulations
7. Purpose-built hydrogen trucks optimized for specific duty cycles may not be valued well in the second market
8. Hydrogen costs decrease as the scale of the hydrogen plants increase
9. Hydrogen used for creating alternative fuels like renewable diesel will reduce net emissions but at the cost of delaying adoption of zero-emission alternatives
10. All the answers do not need to be known on day one of hydrogen.
11. Hydrogen and electricity supply are inherently resilient

New Report Conclusions

- Hydrogen and battery electric are not an “either/or” but an “and” for the zero-emission freight future.
- Hydrogen fuel cell tractors are the only zero emission solution for many duty cycles for heavy duty tractors.
- Alternative fuels like RNG, renewable diesel, and hydrogen used in internal combustion engines will be required
- Industry agreement is needed on gaseous or liquid hydrogen.

Contact Information



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