



# Hydrogen as a Transportation Solution

Fleet Sustainability Technology

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# North American Council for Freight Efficiency



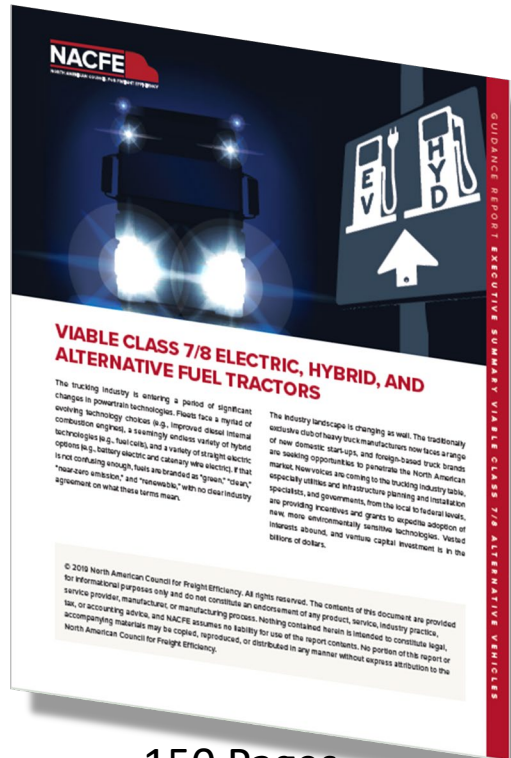
[www.NACFE.org](http://www.NACFE.org)

- Unbiased, non-profit
- Mission to double freight efficiency
- All stakeholders
- Scale available technologies, guide future change and Run on Less demonstrations.
- Primary focus: Tractor-trailers



# Guidance on Hydrogen

## Making Sense of Heavy Duty Hydrogen Fuel Cell Tractors



150 Pages

222 References

August 2022



143 Pages

235 References

## Viable Class 7/8 Electric, Hybrid, and Alternative Fuel Tractors

<https://www.nacfe.org>

# Many Bridges to the Future

## PRESENT

Technology immature  
Many unknowns  
& challenges

## “MESSY MIDDLE”

Many optimized solutions  
Growing infrastructure  
Multi fuel choices

Innovation & maturation  
Facts replace estimates  
Learning curves

## FUTURE 2050

Fast charging everywhere  
Long life, low cost batteries  
Acceptable weights



Legacy Diesels  
Natural Gas

Diesel Advancements  
Natural Gas  
Hybrids

Battery Electric  
Hydrogen Fuel Cells  
Renewable Natural Gas & Diesel

CBEV & FCEV from  
Clean Energy

# The Hill Climb To Zero Emission

## NA Trucks in Commercial Use

- 2.8M Tractors
- 8.8M Single Unit Trucks

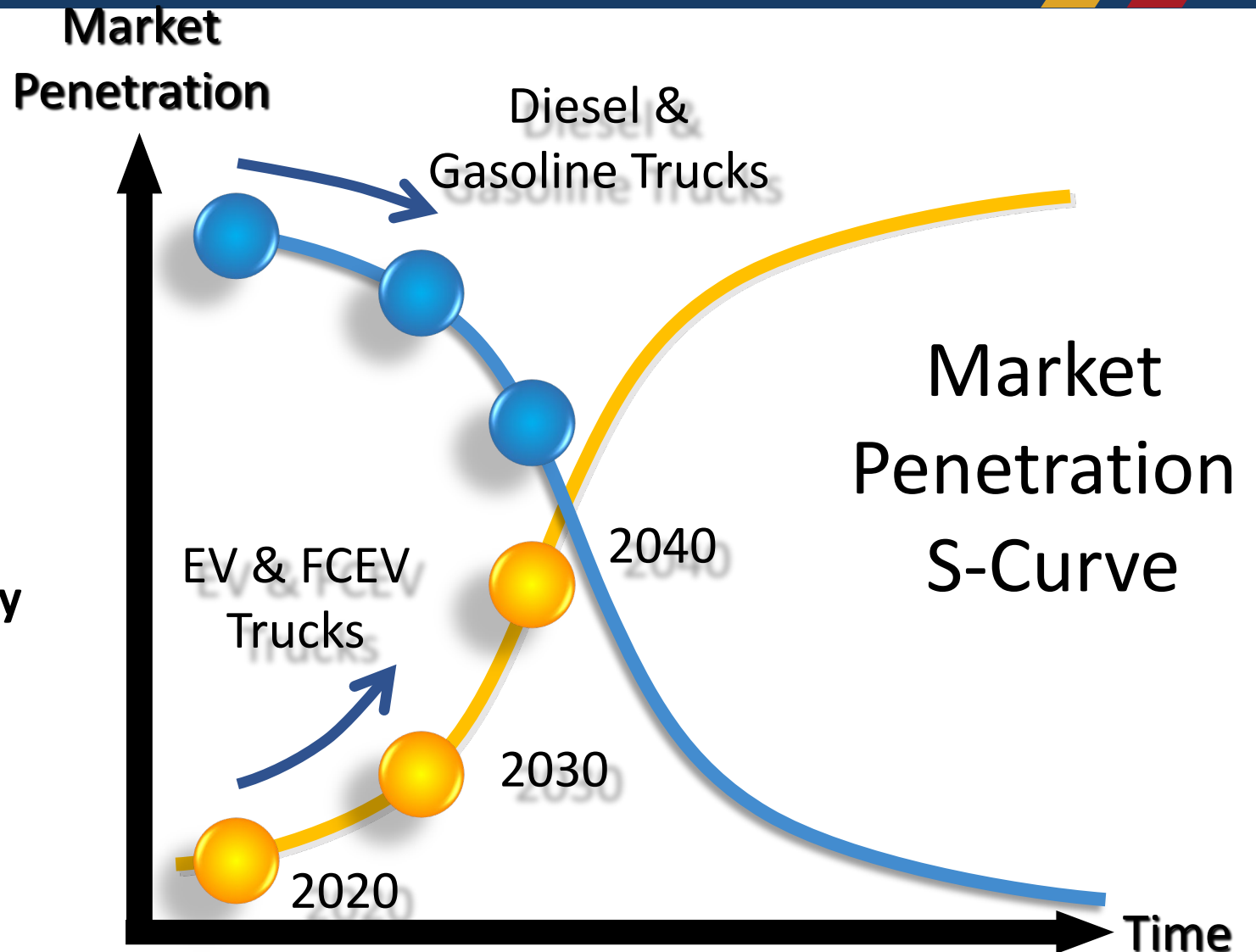
## NA Annual Production Capacity

- ~320k HD Truck/Tractors
- ~350k MD Trucks

## NA Production EV/FCEV Trucks Today

- < 100 HD
- < 5,000 MD

NA = North America



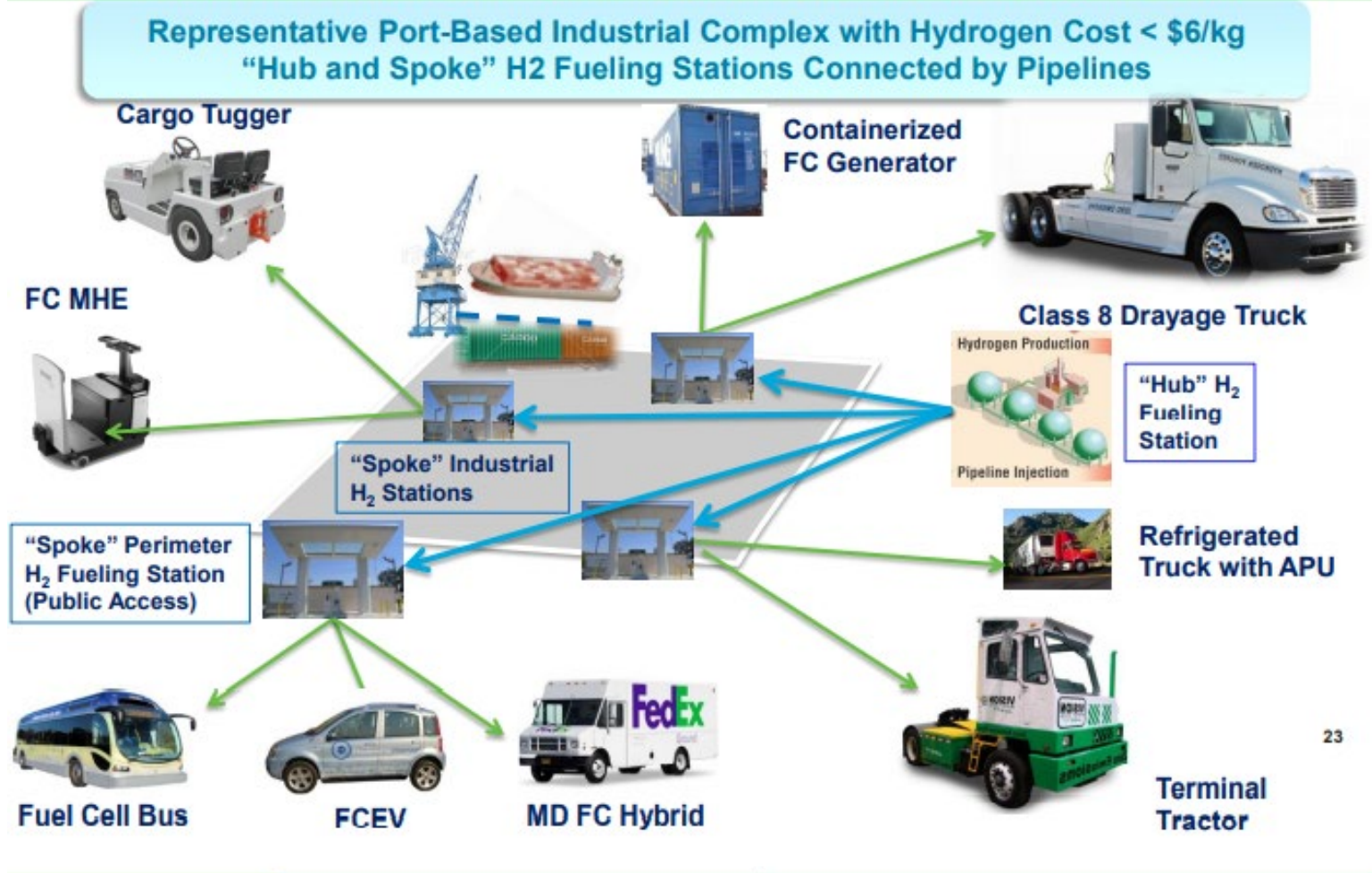


# Hydrogen is Complicated

- A regional decision
- More than just trucking
- More than just debating efficiency
- More than debating fill times
- Its not H<sub>2</sub> vs EV
- Requires innovation
- Green hydrogen requires green electricity

# Scaling is Regional

## “Clustering” FCEVs Can Drive H2 Demand in Port-Based Distribution Complexes

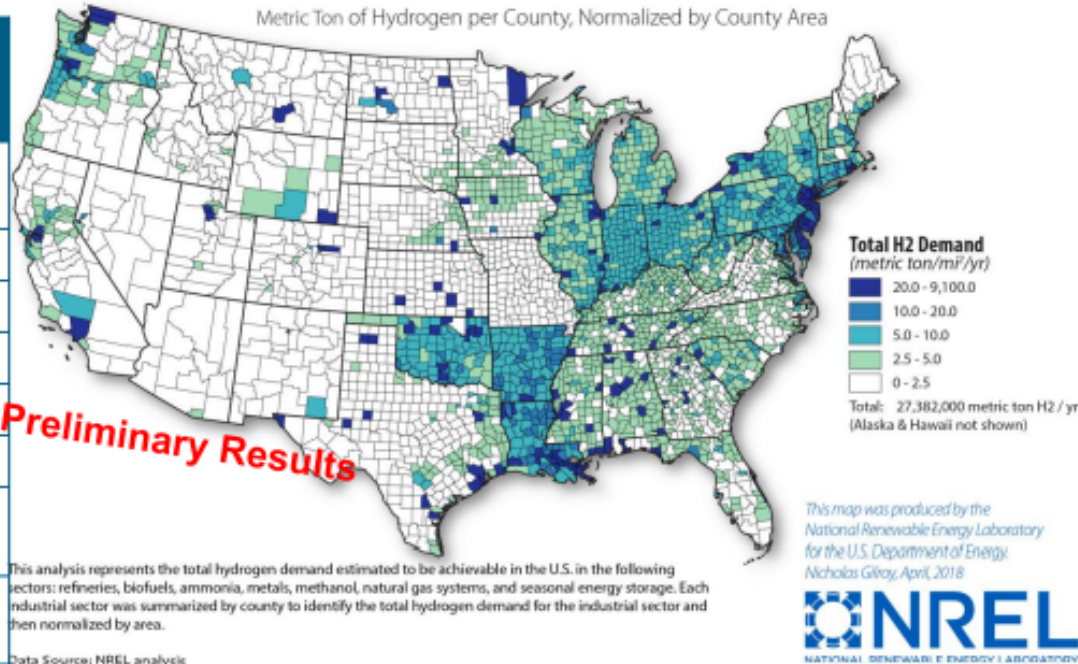


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# Scaling is not just Trucks

## H2@Scale Analysis: Estimated Technical Potential Hydrogen Demand

Demand	Technical potential (MMT* / year)
Refineries & CPI <sup>§</sup>	8
Metals	6
Ammonia	5
Methanol	1
Biofuels	1
Natural Gas	7
Light Duty Vehicles	28
Other Transport	3
Electricity Storage	28
<b>Total</b>	<b>87</b>



This analysis represents the total hydrogen demand estimated to be achievable in the U.S. in the following sectors: refineries, biofuels, ammonia, metals, methanol, natural gas systems, and seasonal energy storage. Each industrial sector was summarized by county to identify the total hydrogen demand for the industrial sector and then normalized by area.

Data Source: NREL analysis

**Technical Potential Demand: 87 MMT/yr**  
**Current U.S. market: ≈ 13 MMT/yr**  
**Including captive generation for ammonia and refining**

\* MMT: Million metric tonnes

§ CPI: Chemical Processing Industry not including metals, ammonia, methanol, or biofuels

Light duty vehicle calculation basis: 190,000,000 light-duty FCEVs from <http://www.nap.edu/catalog/18264/transitions-to-alternative-vehicles-and-fuels>



# Hydrogen Success Factors

## Factors for Hydrogen Success in Trucking



### Plant Size

H<sub>2</sub> production plants need to achieve economies of scale.



### Market Penetration

Industries must demonstrate new demand for hydrogen.



### Distribution Network

Hydrogen must be distributed from production facilities to end users.



### Delivery Technology

Technology to quickly deliver high pressure fuel in volume to the vehicle needs development.



### Storage Technology

Technology must develop to safely and efficiently store hydrogen – both for distribution/fueling and onboard the vehicle.



### Reliability

Hydrogen technologies must prove reliable in real-world use.



### Electricity Cost

Cheap electricity must be readily available for electrolysis.



### Battery Costs

Battery cell costs must come down as energy density increases.



### Safety Acceptance

Technicians, drivers and emergency personnel must be properly trained.



### Sustainability

A sufficient supply of green hydrogen must be available and affordable.

# Hydrogen Fuel Cell Trucks

- Several in fleet test
- OEM development
- Production plans
- Compressed & Liquid Hydrogen





# Hydrogen Opportunities

## Consider Hydrogen Fuel Cell Trucks for your Duty Cycle if:



Zero-emission  
at the tailpipe  
is important



Tractor tare weight  
is critical to  
maximizing payload



Long distance  
routes over 500  
miles are common



Winter conditions  
are significant to  
operations



Green or blue  
hydrogen is  
readily available



Regions have  
incentivized  
hydrogen use



Less  
mountainous  
regions

# Hydrogen Fuel Cell Conclusions

- Hydrogen fuel cell trucks are just starting to see real-world use and their adoption is being driven by regional or national considerations that are much bigger than what exists for trucking fleets.
- Battery electric trucks should be the baseline for hydrogen fuel cell electric vehicle (HFCEV) comparisons, rather than any internal combustion engine alternative.
- As for all alternatives, fleets should optimize the specifications of FCEVs for the job they should perform while expecting that the trade cycles will lengthen.
- The future acceleration of FCEVs is likely not about the vehicles or the fueling but more about the creation and distribution of the hydrogen itself.
- Finally, the potential for autonomous fuel cell trucks to operate 24 hours a day adds significant opportunity for making sense of capital and operational investment in hydrogen.



The logo for NACFE features the acronym "NACFE" in a bold, red, sans-serif font. The letters are positioned between two horizontal dark blue lines. To the right of the acronym is a dark blue graphic element consisting of a rounded, irregular shape that resembles a stylized map of North America or a similar abstract form.

**NACFE**

**NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY**

**THANK YOU**

<https://www.NACFE.org>