Unveiling the potential of liquid hydrogen: Market insights and innovative solutions

Green Hydrogen with Plug

Fuel Cell Markets

The catalyst for Plug's growth

Green Hydrogen at Work™

The most operational experience in emerging hydrogen markets

1+ billion
Hours of operation

60,000+
Systems in service

25 years
Of innovation

99%+
Hydrogen availability

200+
Private fueling stations

40+ tons
Hydrogen dispensed daily

Retail Distribution

amazon
Walmart
The Home Depot
Lowe's
NIKE
IKEA
ACE Hardware
Burlington

Food Distribution

Kroger
Whole Foods Market
Coca-Cola
Wegmans
LIPARI
ASDA
colruyt

Logistics

FedEx
DHL
FM Logistic
ULINE
United States Postal Service
CSX
BNSF Railway
Prelocentre
FreezPak Logistics
MULAG

Automotive

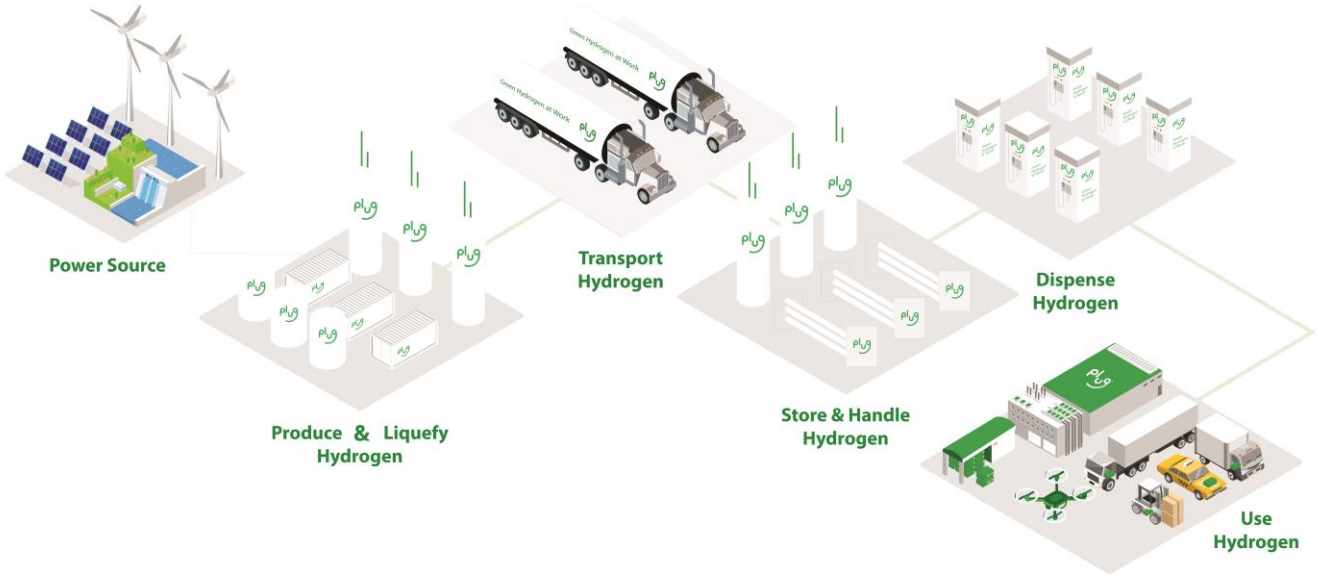
BMW
GM
HONDA
MICHELIN
Mercedes-Benz

Comms

AT&T
Southern Company
PG&E
T-Mobile
verizon

Source: Plug internal analysis (2023)

Plug Hydrogen Solutions



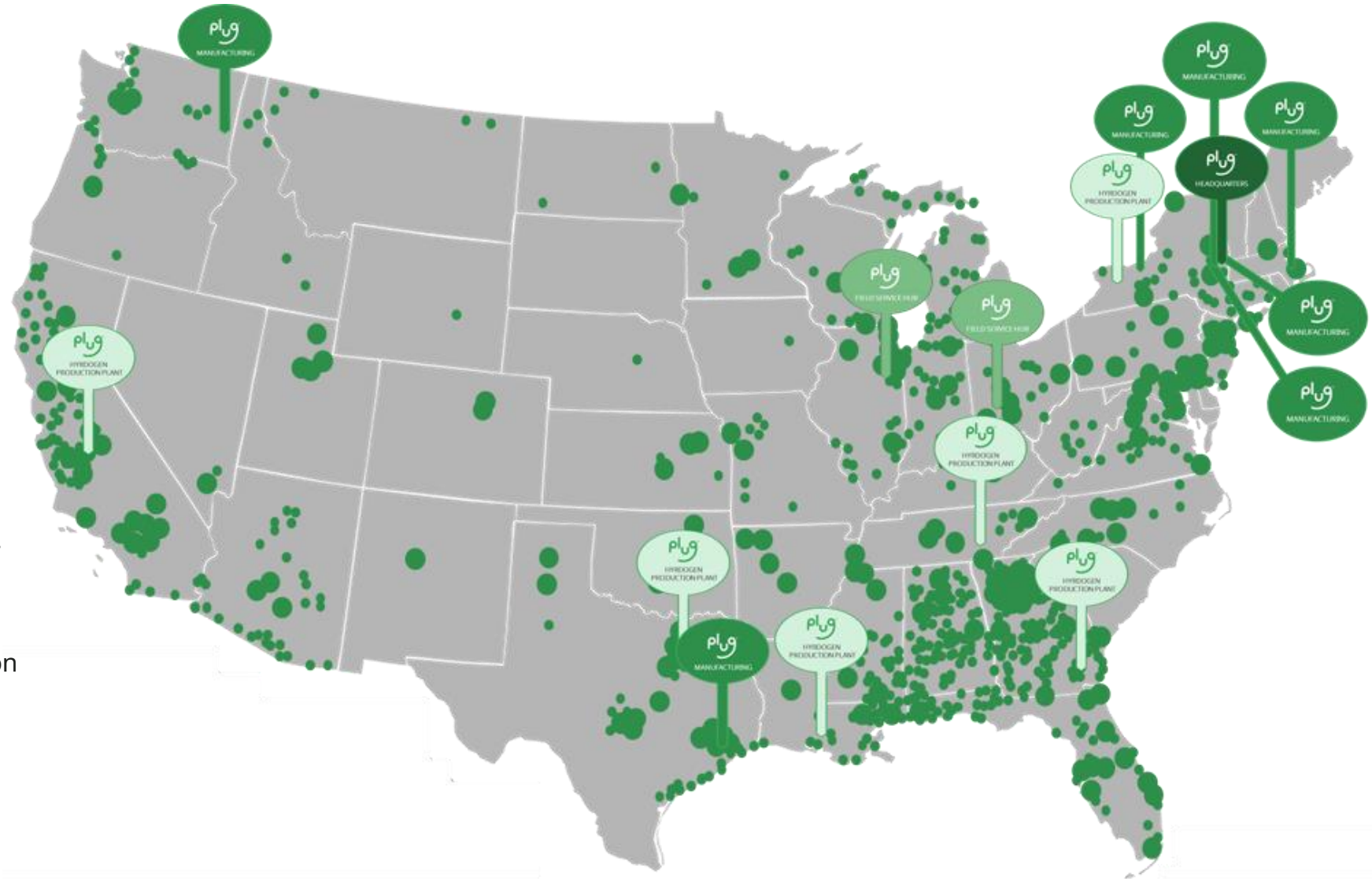
Plug is building an end-to-end green hydrogen ecosystem, from production, storage and delivery to energy generation, to help its customers meet their business goals and decarbonize the economy.

Plug hydrogen generation network

Meeting your hydrogen needs

North American Network
1000 TPD by 2028

- Force majeure resistant network
- Goal of 1000 TPD by 2028
- Announced 35 TPD green hydrogen plant location at Port of Antwerp-Bruges w/15 TPD of liquefaction



Hydrogen Production Plant

Manufacturing

Motive Customer Location

Stationary Power Customer Location

Agenda

Examine liquid hydrogen demand growth forecasts and use cases, how Plug supports this growth with our liquefaction and cryogenic solutions, and the value of our end-to-end offerings

1

Liquid Hydrogen Markets

Applications and demand forecast

2

Leaders in Liquid

A look into what Plug is doing in Green Hydrogen

3

Plug’s Liquid Hydrogen Products

Plug’s suite of liquefaction, storage, transport, and refueling products

4

Complete, integrated solutions

Bringing experience and technology to offer full plant solutions

Liquid Hydrogen Markets

Applications and demand forecast

Why liquid?

Liquid hydrogen provides an ultra-efficient fuel alternative

1. Reduced storage footprint
2. Reduced transportation cost
3. Extended market reach

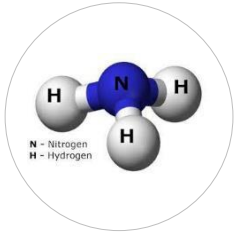
8 gH2 tube trailer deliveries required for every 1 LH2 trailer

GH2 Tube Trailer Capacity = 520 kg

Fewer deliveries | **Smaller footprint** | **Lower CAPEX and OPEX**

LH2 Tanker Capacity = 4900 kg

Options for Hydrogen Transportation



	GAS TRUCK	LIQUID TRUCK	GAS PIPELINE	AMMONIA	LIQUID SHIP
Total Capital Costs	Low	Medium	High	High	Medium
Operating Costs	High	Medium	Low	High	Medium
Transport Cost per kg	High	Low	Low	Low	Medium
Transport Distances	Local ~100 miles	Regional ~ 500 miles	Continental ~ 1,000 miles	Intercontinental > 1,000 miles	Intercontinental > 1,000 miles
Applicable Scale	1 to 10 TPD	10 to 500 TPD	100+ TPD	100 + TPD	100+ TPD

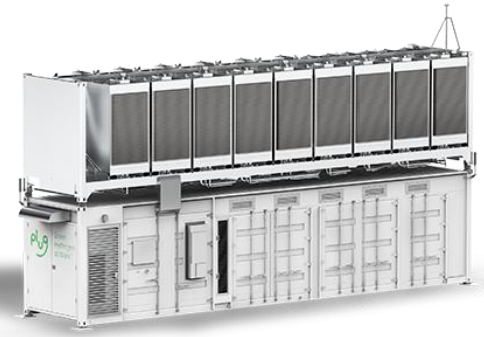
Liquid Hydrogen Markets

Material Handling

Utilizing liquid hydrogen minimizes transportation and infrastructure costs at the end use locations. Increase productivity of equipment.

Stationary Power

Liquid hydrogen reduces storage costs per kg for stationary power applications.



Transportation

Commercial transportation depends on hydrogen to decarbonize. Liquid hydrogen minimizes infrastructure and fueling costs for fleet operations and long-haul trucks.

Heavy Duty Industries

Mining, aviation, and other industrial processes are all looking towards liquid hydrogen to move their industries to zero emissions.

Poll Question

How much faster is it to refuel a hydrogen fuel cell powered Class 8 truck compared to a battery electric Class 8 truck?

a. 25% faster

b. 50% faster

c. 75% faster

d. 98% faster

Long range, high payload transportation

Vehicle Type	Distance	Weight	Charge/Refuel Time
Diesel	500 mile	45,000lb Payload 35,000lb Unloaded	5 Minutes
Battery	500 mile	34,600lb Payload 45,400lb Unloaded	11 Hours
Fuel Cell	500 mile	42,600lb Payload 37,400lb Unloaded	15 Minutes

Truckers are excited about hydrogen because of the minimal impact to operations as compared to batteries

25%

increased payload capacity at 500 miles

98%

reduced refuel time at 500 miles

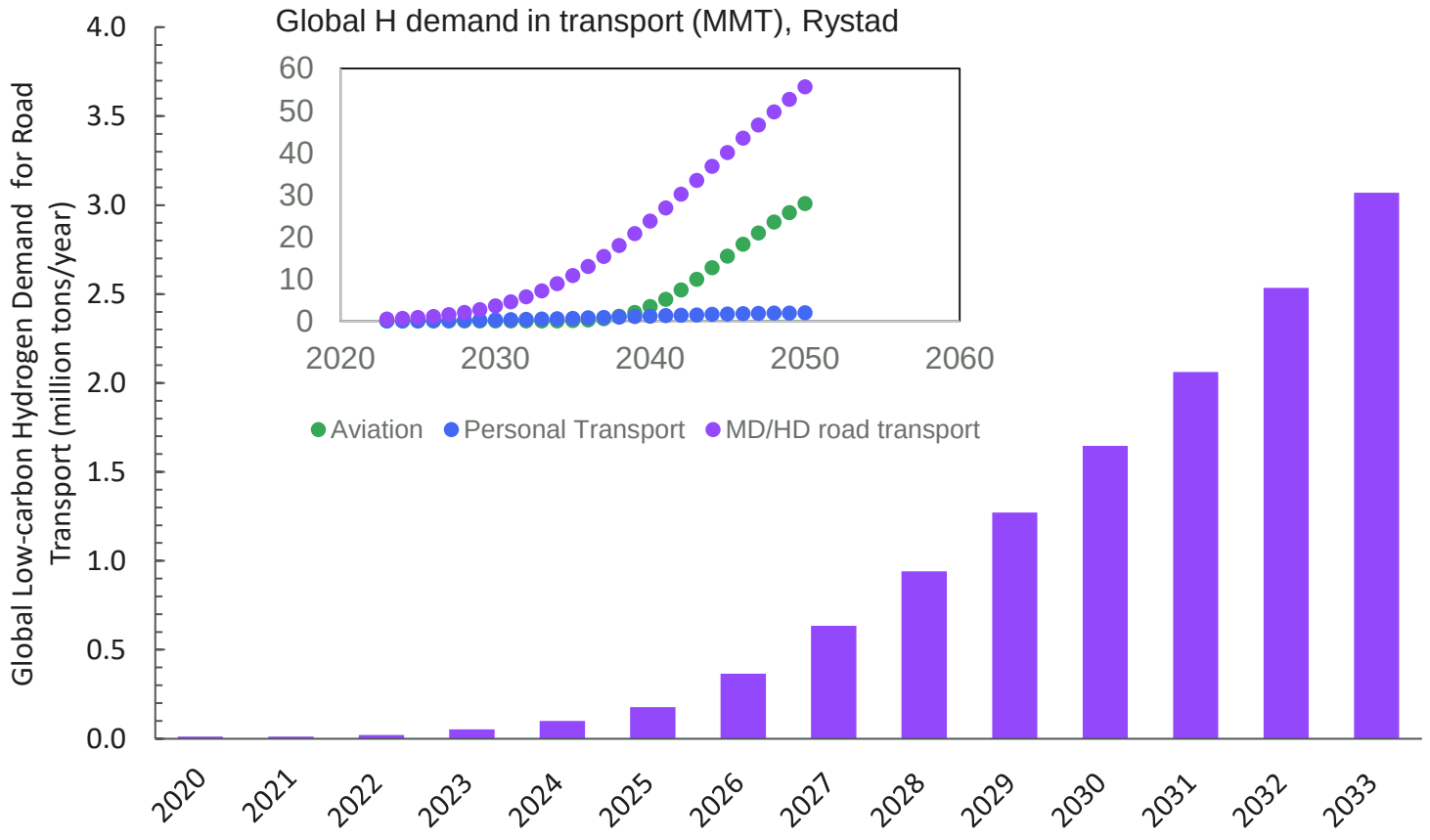
The Future of Liquid Hydrogen: Mobility

H_2 Market Demand For Liquid In the US	Data
Zero Emission Mandate for US Transit Buses	Year: 2030
25% Market Share of FCEV in Transit Buses	~300 TPD
Expected to See Class 8 Vehicles Commercial Sales	2030
1% Market Share of Class 8 Vehicles	150 TPD
10 million passenger flights	Today
Every 0.5 % of flights in H_2 tonnes	833 TPD
Estimated Commercial Dates	2030 - 2035

- High energy density → higher range
- BEVs not suitable for heavy duty applications
- H2 cost compared to batteries offset by operational efficiency gains

Global liquid hydrogen market growth

Demand for low-carbon H_2 for road transport will be **~8,500 TPD** by 2033
Large portion of FCEV road transport expected to be via liquid hydrogen



Note: 1 million tons/year = ~2700 TPD

Growth drivers

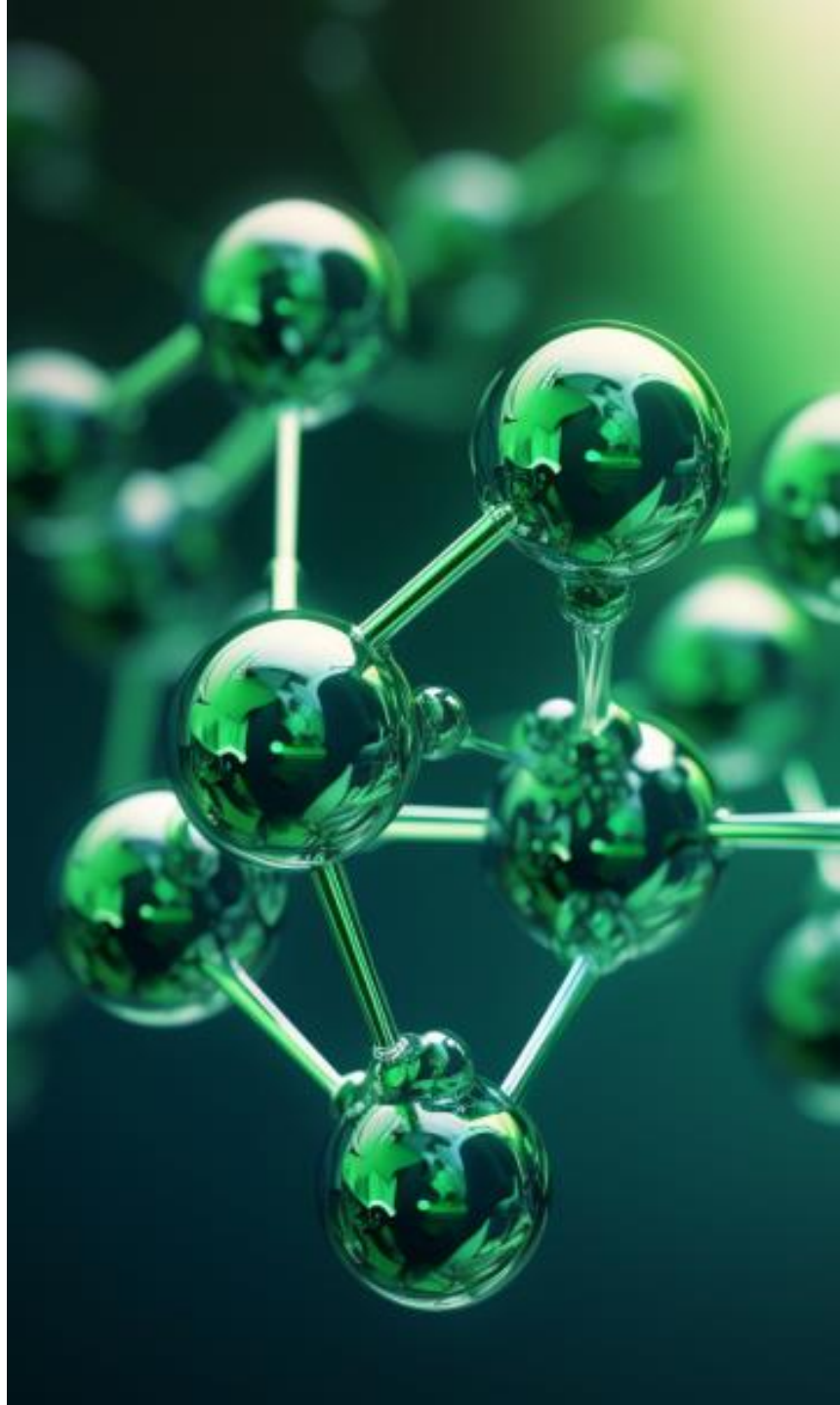
- Government incentives
- Regulatory policy
- Cost reduction
- Deployment of new applications
- Availability of fuel

Poll Question

For countries looking to import hydrogen for use in mobility/transportation sectors, which imported carrier molecule results in the lowest cost at the pump?

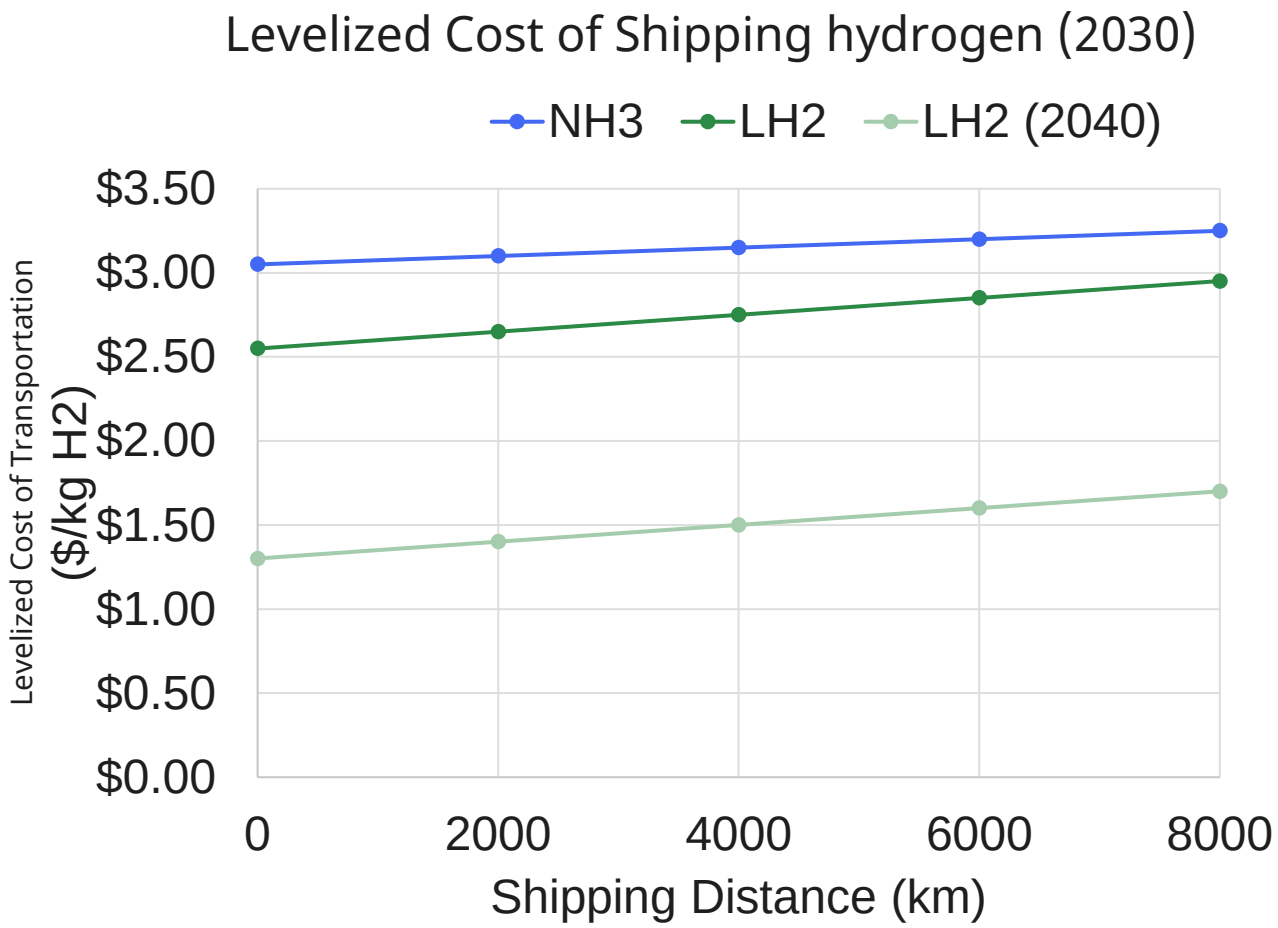
A. Ammonia

B. Liquid hydrogen



Export potential

Exporting liquid hydrogen is economically more viable than ammonia **when targeting liquid mobility applications**



Scenario:

Costs for liquid hydrogen include:

- Liquefaction
- Shipping liquid hydrogen
- Storage tanks (and losses)

Costs for shipping ammonia include:

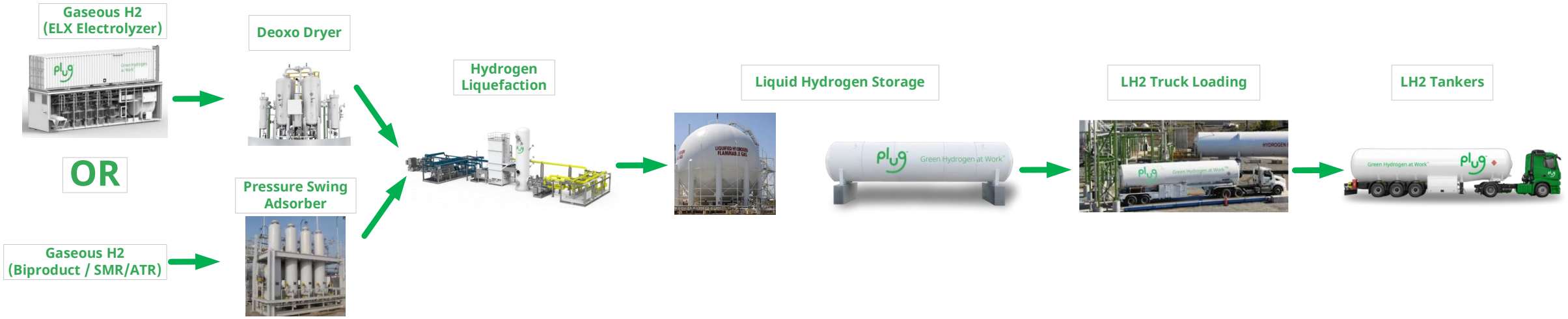
- Ammonia synthesis
- Shipping ammonia
- Storage tanks
- Reconversion of ammonia to hydrogen
- Purification of hydrogen to inlet of liquefaction
- Liquefaction of hydrogen

Sources: Plug analysis, IEA: Energy Technology Perspectives 2023
Potential cost reductions for liquid hydrogen (LH2 Europe) at port terminals via improvement in storage and shipping tanks (up to $1/kg) and improvement in liquefaction technology (up to $0.25/kg) included in LH2 (2040) cost estimations

Leaders in Liquid

Plug is building and offering our solutions to the market

Hydrogen Production Facilities



Design and Engineering

Plug is a leader in building green liquid hydrogen plants

Scalable and customizable

Plug and Plug's customers are building liquid plants from 15 TPD to >400 TPD

Streamlined Procurement

Plug is a one-stop-shop for all the major components of a liquid plant

Standardization drives down cost and schedule

Time & money savings

Plug's end-to-end solution has been optimized and integrated to enable the lowest levelized cost of hydrogen possible

Plug’s Liquefiers

- ✓ Designed for flexible operations and fast turn down
- ✓ All equipment designed for highest reliability
- ✓ Integrated control system for ease of operation
- ✓ 15 liquefiers already being built for Plug and our customers

	LX-15T	LX-30T
Liquefaction Capacity	15,000 kg/day	30,000 kg/day
Specific Energy Consumption	< 11 kWh/kg	
Turndown	Up to 50%	
Liquefaction Cycle	Pre-Cooling: Gaseous Nitrogen Liquefaction: Gaseous Hydrogen	

Liquefier System

- ✓ Modular setup with skid-mounted equipment reduces CAPEX and installation costs
- ✓ Gaseous nitrogen Turbo-Brayton precooling, and gaseous refrigeration reduces required equipment
- ✓ Integrated control system optimizes performance and prevents failures

Peachtree Green Hydrogen Plant - Camden County, Georgia

- 15 TPD LH_2 (Future expansion to 30 TPD underway)
- Design optimization and EPC benefit for other plants
- Construction timeline of about 12 months vs. industry standard of 36-48 months

Global liquid hydrogen projects in construction

Camden County, GA

- **Phase 1 - 17 TPD** green hydrogen capacity
  - **15 TPD** of liquefaction
  - **45 MW** Plug PEM electrolyzers

Port of Antwerp-Bruges, Europe

- **35 TPD** green hydrogen capacity for Europe
  - **15 TPD** of liquefaction
  - **100 MW** Plug PEM electrolyzers
- One of Europe's largest green hydrogen plants

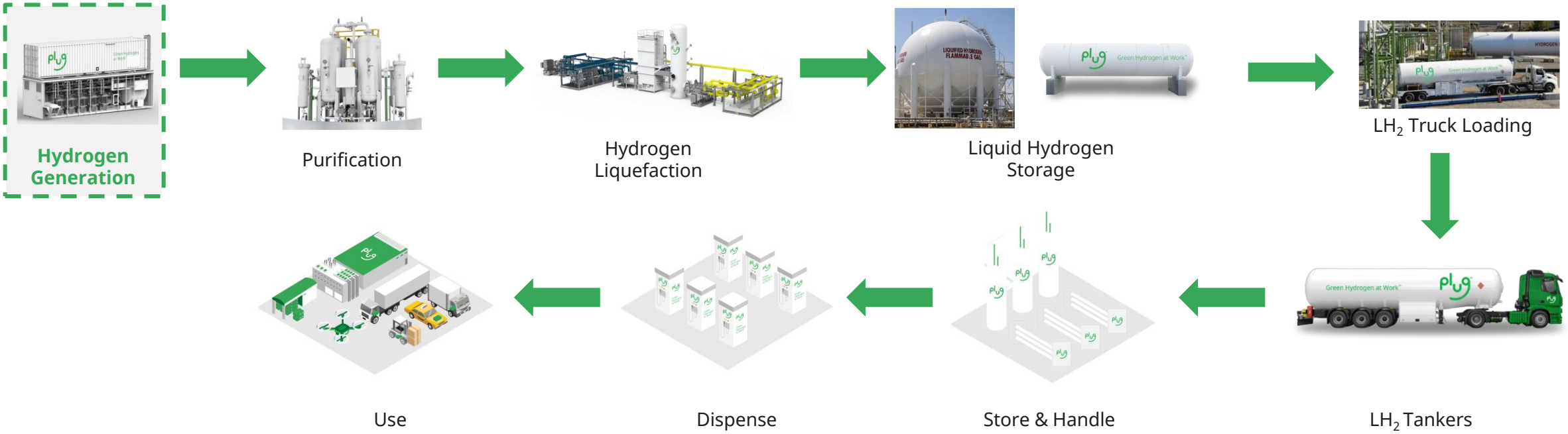
Genesee County, NY

- **75 TPD** green hydrogen liquefaction capacity
  - **200 MW** Plug PEM electrolyzers
- North America's largest green hydrogen production facility

Facility Solutions

Plug’s hydrogen products work hand in hand

Plug’s Green Hydrogen Ecosystem



Plug's Solution Electrolyzers

2 Ton per Day System	4 Ton per Day Array
Up to **5 MW** input	Up to **10 MW** input
Includes full BoP for turnkey simplicity	BoP custom-engineered to meet client requirements
Containerized solution for rapid deployment at scale	Scalable for high volume hydrogen production

Plug’s Green Hydrogen Ecosystem

Hydrogen Generation

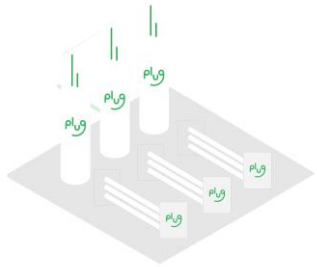
Purification

Hydrogen Liquefaction

Liquid Hydrogen Storage

LH_2 Truck Loading

LH_2 Tankers



Store & Handle Hydrogen

Dispense Hydrogen

Use Hydrogen

Plug's Solution Liquefiers

- ✓ Flexible operations
- ✓ Designed for highest reliability
- ✓ Skid mounted for ease of installation

	LX-15T	LX-30T
Liquefaction Capacity	15,000 kg/day	30,000 kg/day
Specific Energy Consumption	<11 kWh/kg	
LH_2 Purity	99.999%	
Turndown	Up to 50%	

Plug's Green Hydrogen Ecosystem

Hydrogen Generation

Purification

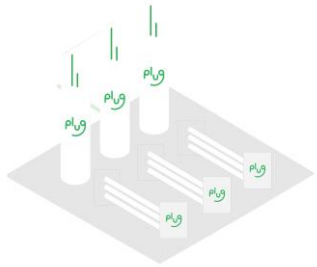
Hydrogen Liquefaction

Liquid Hydrogen Storage

LH_2 Truck Loading

Use Hydrogen

Dispense Hydrogen



Store & Handle Hydrogen

LH_2 Tankers

Plug's Solution LH_2 Tanks and Trailers

As the leading manufacturer, Plug's liquid H_2 tanks and trailers provide the highest level of performance, safety, thermal efficiency, and product longevity

	TL-5000K
Volumetric Capacity	18,200 gal
Payload	10,000 lb

Plug's Green Hydrogen Ecosystem

Hydrogen Generation

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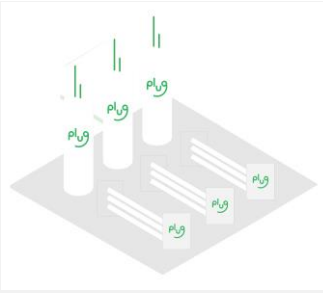
LH_2 Truck Loading

LH_2 Tankers



Store & Handle Hydrogen

Dispense Hydrogen

Use Hydrogen

Plug's Solution
Hydrogen Refueling Systems

Plug Hydrogen Refueling Systems

- >200 stations operational around the world
- Capacities and configurations to meet any use case
- Powering 60,000+ fuel cell powered forklifts each day

Plug’s Portable Refueler

HL-450D-P Portable Refueler Specification		
Dispensing Pressure	700 Bar	350 Bar
Storage Medium	Liquid Hydrogen	
Standard Storage	6,500 USG	

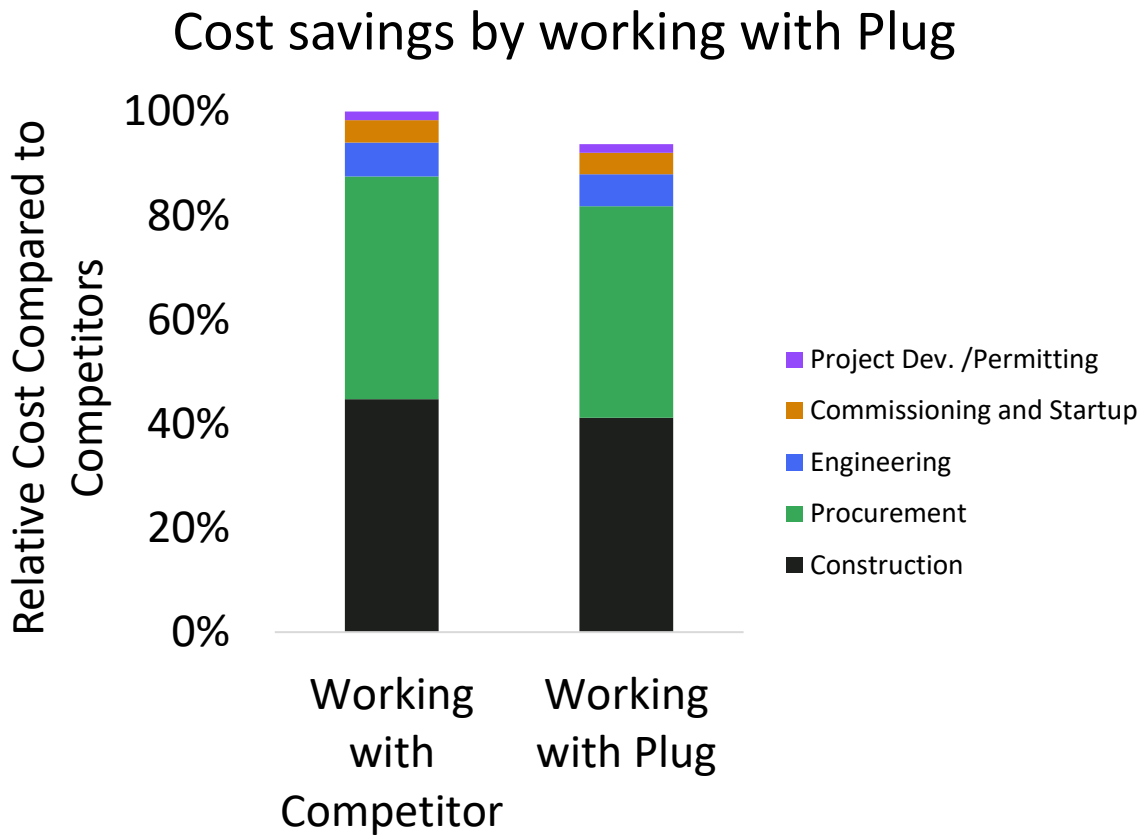
- **Low infrastructure cost:** Significant savings over fixed CapEx infrastructure
- **Speed to market:** Can be placed on site and operational within days
- **High storage capacity:** Improved option over gaseous tube trailers
- **High fueling capacity:** Delivers gaseous fuel at 3.6 kg/min. at 700 or 350 bar with J2601 compliance

Only With Plug: The Complete Ecosystem

From generation to consumption

Cost Savings for Building a Liquid Hydrogen Plant

Working with Plug simplifies your liquid hydrogen plant buildout while also enabling significant cost savings



Key values by working with Plug:

1) Simplified integration
2) Benefit from Plug's lessons learned from buildout of plants
3) Economics/savings and overall customer experience working with "one-stop-shop"
4) Value increases more with full production and distribution scope

Only With Plug

Unmatched support from start to finish

Plug is the only company offering complete, integrated hydrogen solutions from generation and liquefaction through distribution and dispensing

- Experience and technology – Owner and operator of multiple 3rd party liquefiers
- Hands-on experience designing and operating hydrogen generation and liquefaction facilities
- Unparalleled service and customer experience
- End-to-End solution optimizes energy efficiency
- Product standardization enables speed-to-market and cost savings

https://www.plugpower.com/contact-us-liquefaction/

https://www.plugpower.com/contact-us-cryogenics/

Green Hydrogen at Work™