Plug Power Perspective on Hydrogen Economy Recycling Needs

Briefed by Karen Swider Lyons, Ph.D.
Principal Scientist, Hydrogen Fuel Cells, Chief Technology Office

May 26, 2022

Plug: the green hydrogen ecosystem

25 years
of innovation

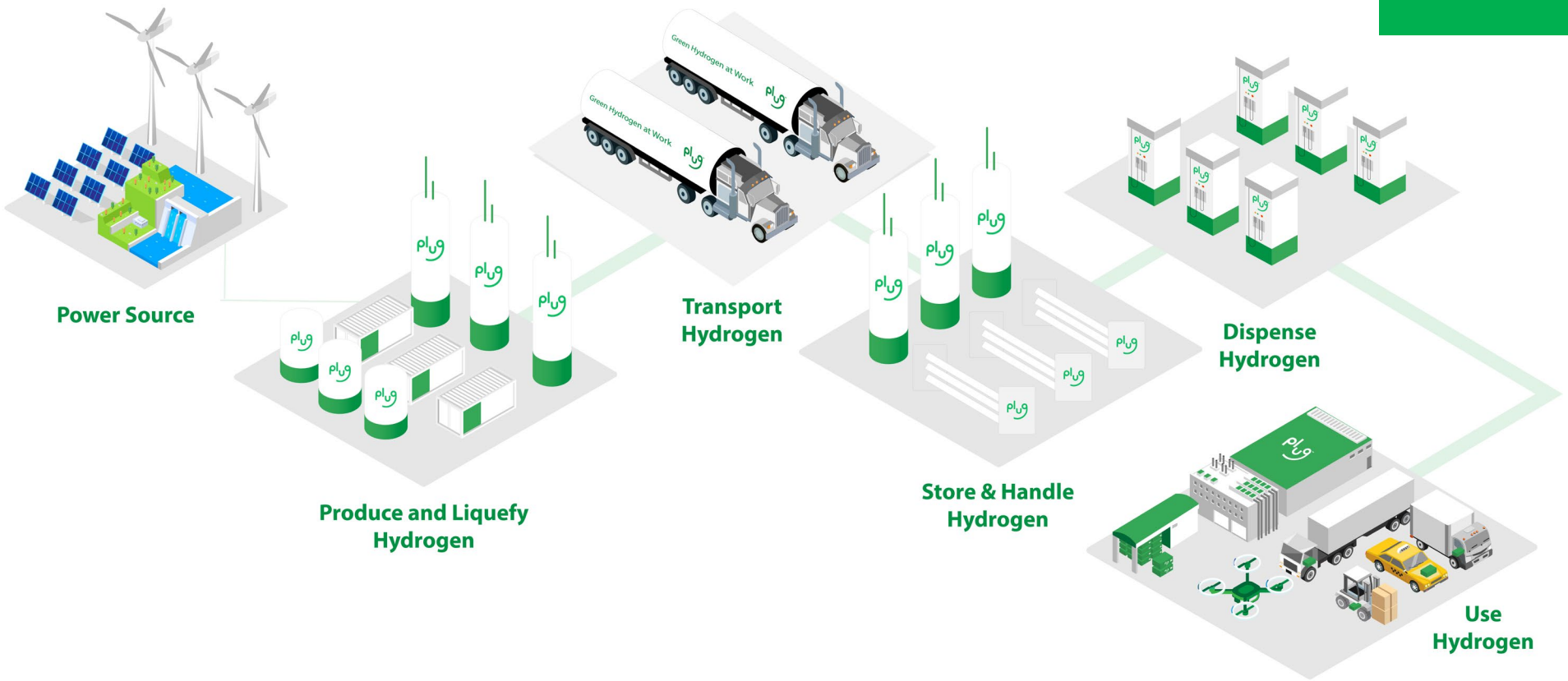
258
granted patents

40+ tons
of hydrogen
consumed daily

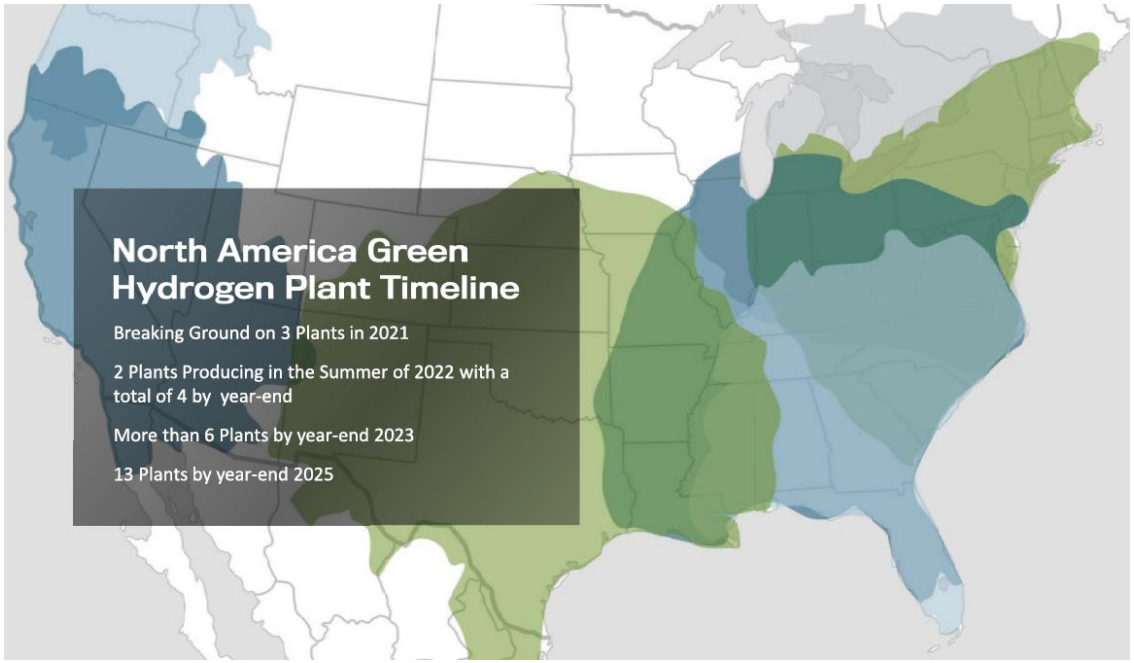
60,000+
systems in service

850+ million
hours of operation

2,800+
employees



Plug Power – Perspective on Green Hydrogen



- Connect RDD&D to Hydrogen Hubs.
- Focus on near term technologies (high TRL and MRL) for near term wins.
- Long-term tax incentives to sustain clean hydrogen. infrastructure toward commercial sustainability.

Plug Power on track for 500 metric tons of green hydrogen per day by 2025

- Direct coupling of PEM electrolysis to renewables.
- >30,000 electrolysis systems to date.

- 50,000 fuel cells presently in use.
- Hydrogen liquification and transportation infrastructure.
- 2,200 regular US employees (2800+ worldwide).
- Domestic manufacturing capability in NY (3 sites), MA, WA. >Gigawatt capability.

Need sustained support from US DOE to grow green hydrogen business

- Invest in cost reductions for materials and manufacturing.
- Attract more manufacturers to the supply chain.
- Large scale hydrogen storage development and demonstrations.
- Convert natural gas infrastructure to hydrogen.

10 MW PEM electrolysis facility in GA

Recycling strategies for a productive hydrogen economy

- Design for low-cost, high-volume manufacturing and recycling (cradle to cradle)
- Technoeconomic analysis methods for cradle-to-cradle ownership
  - High purity metals have higher initial costs, but easier to recycle
- Facilitate the clean/green recycling of metals, carbon fibers, precious metals, and PFAS
  - Free of hazardous chemicals

    C&E News: "*Scientists call for IPCC-like group on chemical pollution"*

    UN Environment Assembly likely to vote in 2022 on whether to form panel
- Adapt automation equipment from automotive and battery industries
  - Automated stack disassembly
- Create secondary markets involved with standardization for reuse
  - Consider standardizing certain aspects of fuel cells and electrolyzers – electronics, hydrogen sensors/valves, and balance of plant components
  - Interoperability of sensors and components across U.S. suppliers
  - Repurpose older electrolyzers for hydrogen generation applications where efficiency less critical (10% usage time)
- Aggressively recycle Iridium
- Develop U.S. supply chain for catalysts, polymers, carbon fiber, electronics.

Decrease the carbon intensity of manufacturing lifecycle

Priority for ESG – *Environmental, Social and Corporate Governance* – for publicly traded companies

SEC mandates on reporting Scope 1, Scope 2 and Scope 3 emissions.

Objective: provide investors with decision-useful information to assess a registrant's exposure to, and management of, climate-related risks, and in particular transition risks.

https://www.sec.gov/news/press-release/2022-46; March 21, 2022

Require a registrant to disclose information about:

Scope 1: its direct greenhouse gas (GHG) emissions.

Scope 2: indirect emissions from purchased electricity or other forms of energy.

Scope 3: emissions from upstream and downstream activities in its value chain.

Some other ideas

- DOE could play an important role by connecting companies working in hydrogen technologies to recycling companies.
- The DOE can also show sustained support for hydrogen technologies, which will incentivize new vendors to participate.
- Develop materials labeling practices to quickly identify which materials can be recycled.
- Identify TEA/TCO of most recyclable materials (e.g., Pt or Pt alloys).
- Develop methods to minimize and recycle packaging.
- Processes should be developed so that manufacturers can re-use parts on hand (instead of using a secondary recycler).
- Design and processes for component refurbishment.

Final thoughts

- ❖ Growth in high volume manufacturing requires parallel growth in high volume recycling.
- ❖ The hydrogen industry needs to be reimagined at scale with designs for re-manufacture, secondary markets, and recycling.
- ✓ Look at all ways to use recycling to simplify supply chain.
- ✓ Fully support ESG goals for clean energy.

Green Hydrogen at Work™