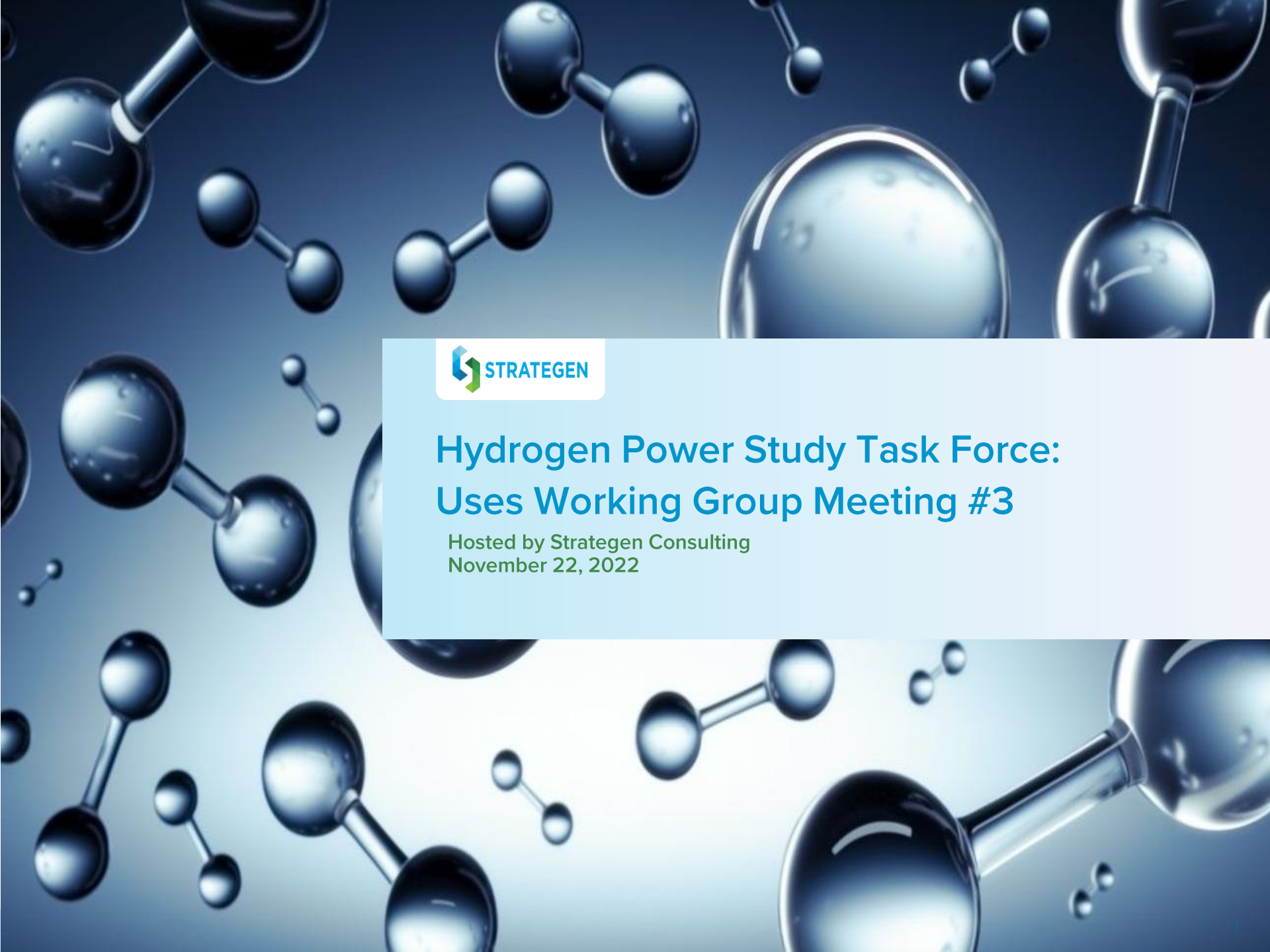


Hydrogen Power Study Task Force: Uses Working Group Meeting #3

Hosted by Strategen Consulting
November 22, 2022

Meeting Logistics

- Mute Microphone – in order to prevent background noise that disturbs the meeting, if you aren't talking, please mute your microphone or phone.

- Chat Box – if you aren't being heard, please use the chat box or raise your hand to ask a question. Please try to limit comments in the chat as these may not be officially captured in the record.

- Recording Meeting – we will record and post the meetings at www.ctgreenbank.com/hydrogentaskforce and you can also access meeting dates and dial-in information through Secretary of State.

- State Your Name – for those talking, please state your name for the record.

Agenda

- Welcome and Introductions – 10 minutes
- Review of Hydrogen End Use Evaluation – 10 minutes
- Review of Preliminary End Use Demand Assessment – 20 minutes
- Discussion and Next Steps – 20 minutes

Reminder: Strategen's Role

- The Strategen team will handle meeting logistics including scheduling and recording meeting minutes.
- The Strategen team will coordinate with Working Group Co-Chairs to develop meeting agendas which will be provided to participants in advance of Working Group meetings.
- The Strategen team will provide technical assistance (including research), where appropriate, for the Working Group.
- It is expected that this working group will meet on a monthly cadence. Meeting recordings and meeting minutes will be publicly available.

Introductions

Please share your name, title, and organization

Working Group Meeting Schedule

	September	October	November	December
Funding	9/27 4-5pm	10/26 10:30am-12 pm	11/18 10:30am-12 pm	12/15 10:30am-12:00 pm
Infrastructure	9/28 2-3pm	10/24 2-3pm	11/17 3-4pm	12/19 3-4pm
Policy & Workforce Development	9/26 3-4pm	10/20 12-1pm	11/29 12-1pm	12/15 12-1pm
Sources	9/27 1-2pm	10/25 2-3:30pm	11/17 11am-12pm	12/20 1-2:30pm
Uses	9/27 12-1pm		11/22 12-1pm	

End Use Prioritization

Review and Discussion

Review of Prioritization "Buckets"

Highest Priority for Additional Investigation

- Focused on end uses that:
  - Are very likely to use hydrogen due to underlying economics
  - Create substantial societal benefits (e.g. GHG reduction, workforce development)
- Proposed end uses include:
  - Critical facilities (24-hour backup need)
  - Aviation (long- and medium-haul)
  - Cargo ships
  - Material handling equipment (w/ long uptimes and charging space constraints)
  - Long-haul heavy duty trucks
  - Fuel cells for peak power generation
  - High heat industrial processes

High Priority for Additional Investigation

- Focused on end uses that:
  - Have a strong financial case for hydrogen use
  - Create societal benefit, but on a smaller scale due to size of industry
- Proposed end uses include:
  - Long-distance bus routes
  - Ferries
  - Freight rail
  - Fleet vehicles with long uptimes and specific refueling locations
  - Hydrogen blending in natural gas pipelines for non-core customer (i.e. power generation and industrial heat)

Other Valuable Applications

- Focused on end uses that:
  - Can be kept "in view" as economics of hydrogen vs. alternatives develop
  - Could provide additional opportunities for market development
- Proposed end uses include:
  - Hydrogen blending for commercial and residential customers
  - Commuter buses
  - Heavy duty trucks with lower daily driving ranges
  - Privately-owned light-duty vehicles
  - Low heat industrial processes
  - Short-haul aviation

Highest Priority Use Cases for Additional Investigation

Types of End Uses

+ **Ends uses that are very likely to use hydrogen because:**
  1. Alternative routes to decarbonization are economically/technically infeasible
  2. Underlying economics are driving hydrogen use in these sectors today

  - Aviation*
  - Marine Shipping**
  - Critical Facilities*
  - Material Handling*

+ **End uses where scale can drive significant societal benefits (e.g. GHG reductions, workforce development), and where hydrogen economics are particularly strong**

  - Long-Haul Trucking**
  - Power Generation*
  - High-Heat Industrial Processes*

*Could be addressed with state-specific policy support
**Would likely require regional/international cooperation

Potential opportunities for directed policy support and market development efforts

High Priority Use Cases for Additional Investigation

Types of End Uses

+ **Ends uses in smaller-scale industries with a strong financial case for hydrogen due to parameters of operation**
  - Long-Distance Buses**
  - Ferries**
  - Freight Rail**
  - Fleet Vehicles with long uptimes and specific fueling locations*

+ **End uses where evidence suggests hydrogen could be an economic decarbonization option, but where technical demonstrations are needed**
  - Hydrogen blending in natural gas pipelines for non-core customers (i.e. power generation and industrial heat)*

*Could be addressed with state-specific policy support
**Would likely require regional/international cooperation

Potential opportunities for state-supported pilots and demonstration projects

Other Valuable Applications

Types of End Uses

+ **Ends uses where hydrogen has value as a decarbonization tool, but where economics do not clearly support hydrogen at this time**

+ **Should be kept "in view" by policymakers but not prioritized unless systems-level analysis determines hydrogen is the lowest-cost option**

- Hydrogen blending for commercial and residential customers
- Commuter buses (i.e. urban transit and other short-range uses)
- Heavy-duty trucks with lower daily driving ranges
- Privately-owned light-duty vehicles
- Low-heat industrial processes

Potential opportunities for technology-neutral policy support and additional study

Deep Dive on Hydrogen Blending

- **End uses for hydrogen blending (i.e. core vs. non-core customers) describe areas of focus for blending efforts, not necessarily the customers that will be receiving hydrogen**
- **Blending for non-core customers can be achieved in two ways:**
  - On-site blending into pipelines/infrastructure directly feeding these customers but isolated from the main gas network
  - Blending into statewide pipeline network upstream of these customers
- **If blended into statewide pipeline network, hydrogen would be used by core customers (i.e. residential and commercial) as well**
  - Would require studies to ensure that distribution network and customer appliances could accept hydrogen blend without significant safety or pollution concerns
  - Likely reduces interconnection costs, but may also reduce the level of hydrogen that could be safely blended compared to more directed blending approaches
  - Should be interconnected at points on the system where hydrogen can continue to be provided to non-core customers if large numbers of core customers electrify their heating/cooking systems

STRATEGEN

Hydrogen Demand Analysis

Introduction to Preliminary Results

Demand Assessment Methodologies

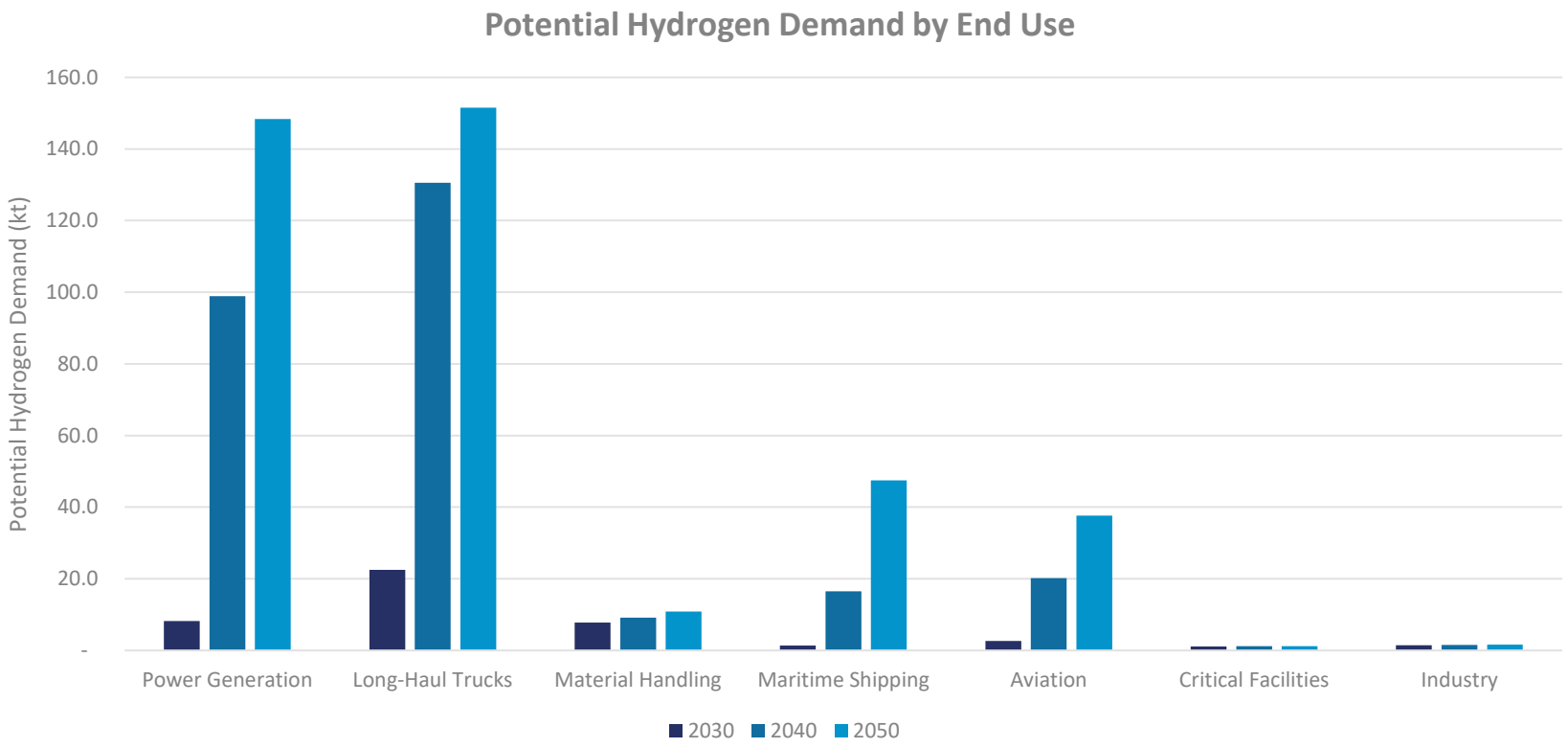
Analysis to date has focused on highest-priority end uses

End Use	Description of Methodology	References
Aviation	Assumed hydrogen use at scale required for sectoral decarbonization, averaged between MPP's "Pragmatic" and "Optimistic" scenarios	Mission Possible Partnership (MPP)
Maritime Shipping	Assumed hydrogen use at scale forecasted by ABS "Zero Carbon Outlook" report	American Bureau of Shipping (ABS)
Critical Facilities	Assumed fuel cell backup at data centers, hospitals, telecom towers, and facilities with behind-the-meter generation assets greater than 100 kW	S&P, various sources
Material Handling	Assumed fuel cell forklift sales in CT reach ~40% of all forklift sales	Various sources
Long-Haul Trucking	Assumed sales of long-haul fuel cell trucks begin in 2028 and scale up to reach 90% of sales over 10 years	MJ Bradley, various sources
Power Generation	Assumed thermal generation in 2050 in line with E3's "Net Zero New England" report, with CT's generation in line with its share of ISO-NE energy demand	E3, EIA
High-Heat Industry	Based on high-heat industrial processes' share of 2020 industrial gas demand, scaled up according to industrial energy growth rate from 2010-2019	EIA, various sources

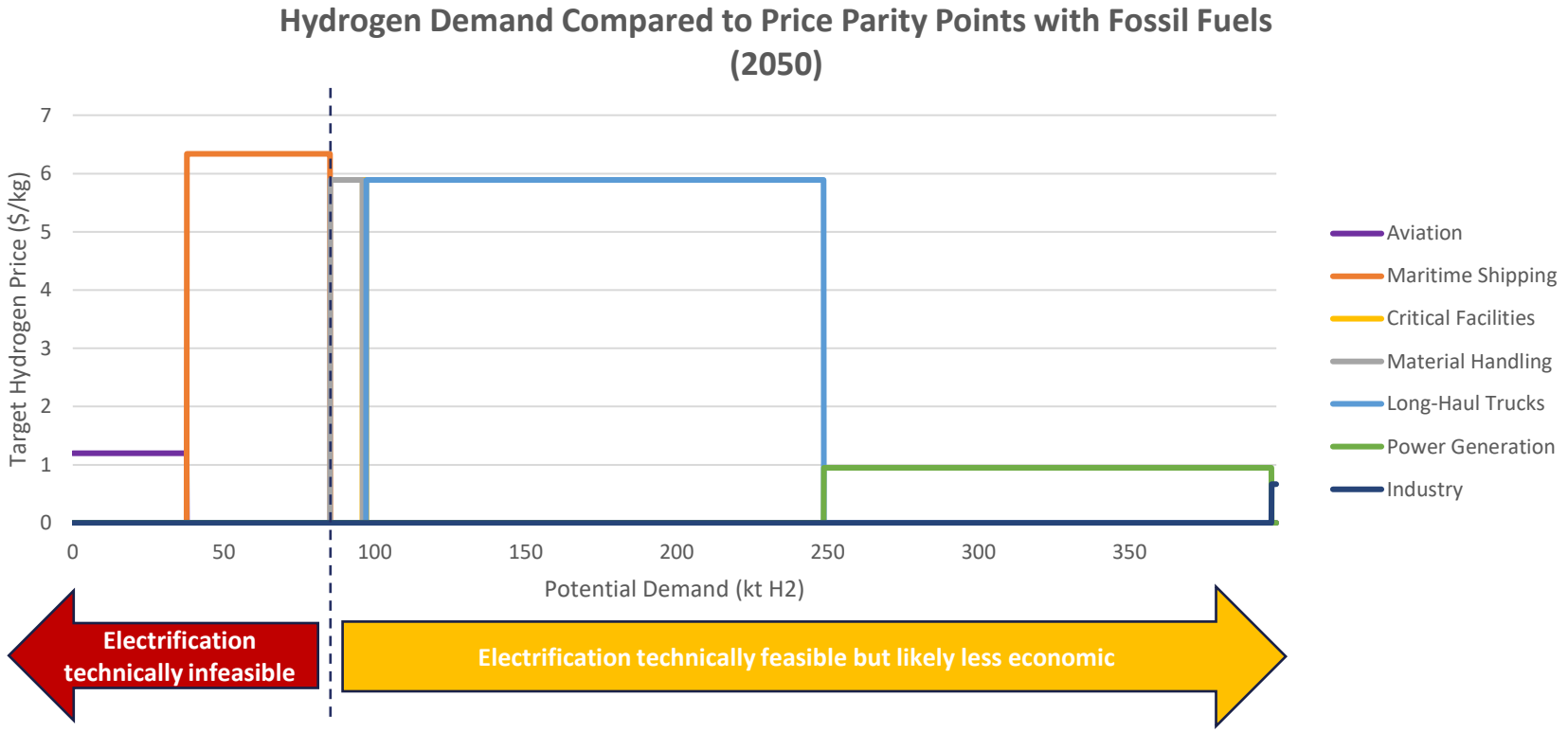
Demand analysis is preliminary and intended to provide only directional insights into potential orders of magnitude

Hydrogen Demand Assessment

Demand stays relatively low in 2030 but has potential to scale up quickly in 2040 and 2050, particularly for long-haul trucking and power generation



Hydrogen Demand Curve



Initial Takeaways:

- Adoption in aviation sector likely to be driven by policy/industry targets due to challenging economics
- Economics are strongest in end uses where hydrogen replaces bunker fuel and diesel, provided costs of ancillary infrastructure can be kept down
- Price points for hydrogen to replace natural gas (e.g. power generation, industry) are more difficult to hit, although hydrogen may still be lower-cost than the next-best decarbonization option

Next Steps and Discussion

Next Steps	Discussion Questions
+ Refine demand analysis based on stakeholder interviews + Assess demand for fuel cells as well as overall hydrogen demand + Include demand analysis for high priority end uses + Integrate with supply curves from and cost impacts of connecting infrastructure (from Sources and Infrastructure Working Groups respectively)	+ Are there any questions or suggestions on the methodologies described? + Are there any other factors or scenarios that should be considered in this analysis? + Is it helpful/important to distinguish between end uses with “technical” and “economic” barriers to electrification? + Are there any outstanding questions on the prioritization framework or descriptions of different end uses?