



Examination of Terminal Land Requirements for Hydrogen Delivery

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A Variety of Terminal Configurations May Exist for Various Hydrogen Delivery Pathways

- **Gaseous Tube Trailer Pathway**
 - Receive hydrogen from production plant
 - Store low volumes of gaseous hydrogen for operational stability
 - Compress hydrogen for storage and/or charging tube trailers
 - Charge tube trailers in loading bays

- Options for production outages and summer demand surges (each less than 5% of annual demand)
 - **Geologic storage**
 - Compressor
 - **Liquid storage**
 - Liquefier
 - Liquid Pumps
 - Liquid Storage Tanks
 - Vaporizer
 - Compressor

Terminals for Various Pathways (Cont)

- **Liquid Hydrogen Tanker Truck Delivery Pathway**
 - Receive hydrogen from production plant
 - Liquify hydrogen
 - Pump liquid hydrogen for low-volume storage tanks and/or to charging bays
 - Charge tanker trucks in bays

- Options for production outages and summer demand surges (each less than 5% of annual demand)
 - ***Geologic storage***
 - Compressor
 - ***Liquid storage***
 - Liquefier
 - Liquid Pumps
 - Liquid Storage Tanks

Terminals for Various Pathways (Cont)

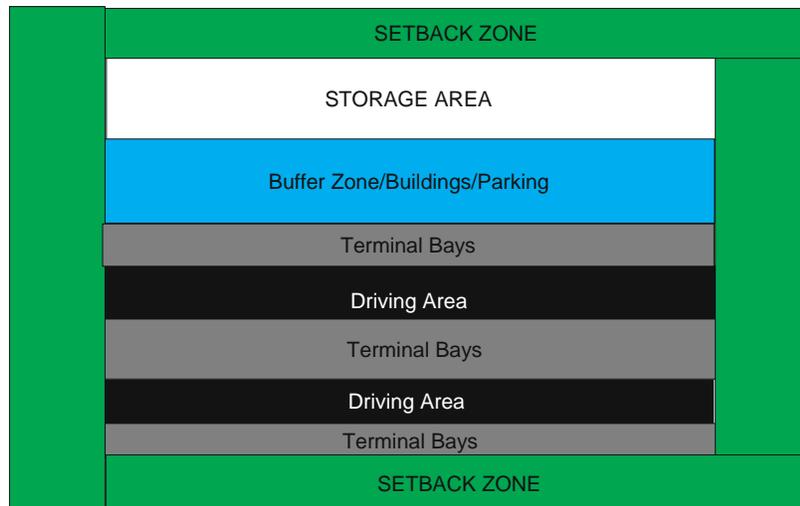
- **Pipeline Delivery Pathway**
 - Compression to pipeline pressures occurs at production plant

- Options for production outages and summer demand surges (each less than 5% of annual demand)
 - ***Geologic storage***
 - Additional Compressors
 - ***Liquid storage***
 - Liquefier
 - Liquid Pumps
 - Liquid Storage Tanks
 - Vaporizer
 - Compressor

Terminal Land Requirements Are Determined by Average Daily Demand, On-Site Storage Needs, and Terminal Layout

- Variables in model include:
 - Hydrogen Demand (kg/d)
 - Storage Capacity (kg)
 - Set-back and Separation Distances
 - Driving Areas (Access/Egress/Maneuvering)
 - Physical Dimensions of Storage Tanks
 - Useful Capacity of Individual Storage Tank (kg)
 - Bay Dimensions

Terminals Must Have Land for Bays, Driving Areas, Buildings, Storage, and Setbacks



Terminal Land Requirements Account for Bays, Truck Maneuvering, Storage, Buildings/Parking, and Setbacks

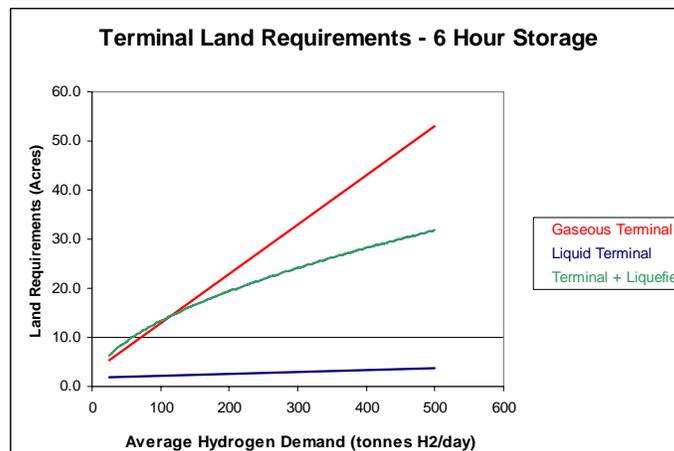
■ Terminal Land Requirement = (Bay Width/Storage Width + Setbacks)

times

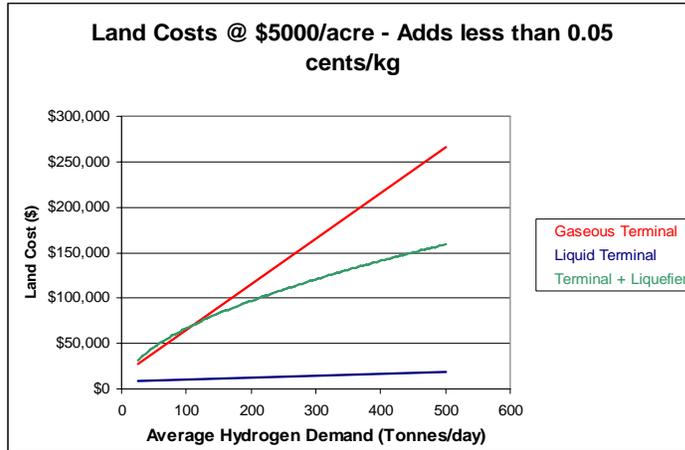
(Bay Depth + Driveways + Building/Parking + Storage + Setbacks)

In some pathways, liquefiers would also be located at terminals. At present, however, their land requirements are included in liquefier cost estimates.

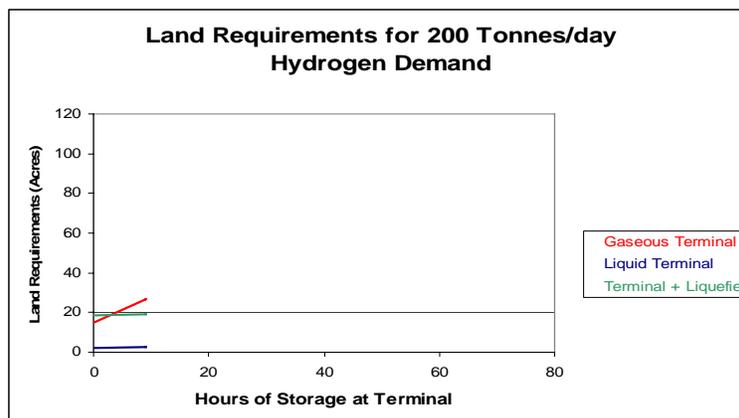
Gaseous Terminals Require Significantly More Land Than Liquid Terminals – But Liquefiers Close Much of That Gap



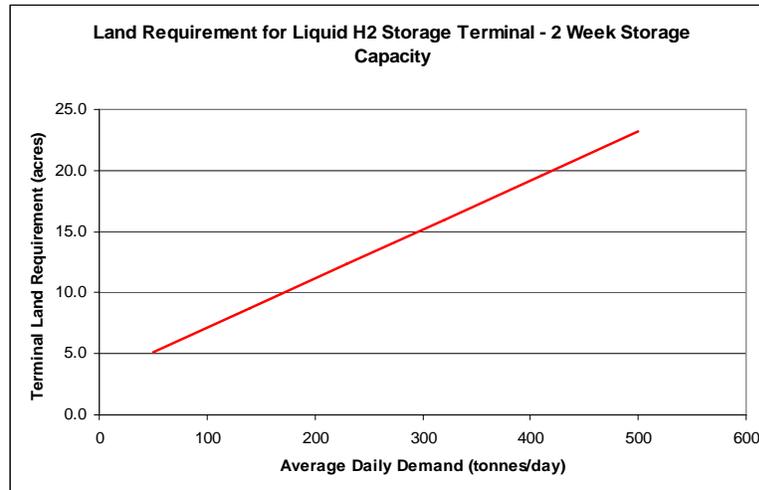
At \$5000/Acre, Land Could Add \$100,000's to the Cost of Gaseous Terminals, But < \$0.01/kg to Delivered H2 Cost



Storage Greatly Increases Land Requirements for Gaseous Terminals But Not Liquid Terminals



Land Requirement to Address Summer Peak/Production Outage in Pipeline Pathway is Comparable to Truck Pathways with Low-Volume Storage



Summary

- Liquid delivery pathway land requirements are dominated by liquefier
- Gaseous delivery pathway necessitates many bays and associated maneuvering areas which increase land requirement
- Gaseous delivery land requirements increase rapidly with storage requirements
- Liquid hydrogen storage land areas for summer peak and production outage in pipeline pathway are comparable to that of truck delivery pathways with low-volume storage
- At \$5000/acre, terminal land costs add little to cost of delivered hydrogen
- Land requirements may limit site selection