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HDSAM 2.0: Expanded Capabilities, Enhanced Results in Hydrogen Delivery Modeling

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Presentation Outline

- Enhancements in Version 2.0 vs. Version 1.0
  - Pathway representation
  - Data
  - Modeling
- Demand profile and component sizing
- Results
- Conclusions and next steps

HDSAM 2.0

- Incorporates common building blocks from DOE's H2A models:
  - Delivery Components and Forecourt (Refueling Station) models
  - Discounted cash flow analysis
  - Common financial assumptions and fuel properties
- Flexible, easy to use tool:
  - Programmed as series of Microsoft EXCEL spreadsheets
  - Runs with either H2A defaults or user inputs
  - User-friendly interface to quickly and easily define scenarios of interest
  - Posted on USDOE website (www.hydrogen.energy.gov) with Users' Guide
  - Technical support by EERE help desk
- Automatically links and sizes components into **optimized** pathways
- Provides structure for efficiently examining new technologies, delivery pathways, operating targets and packaging options

Provides "snap shot" of delivery cost resulting from input assumptions. ***Not a transition model****.*

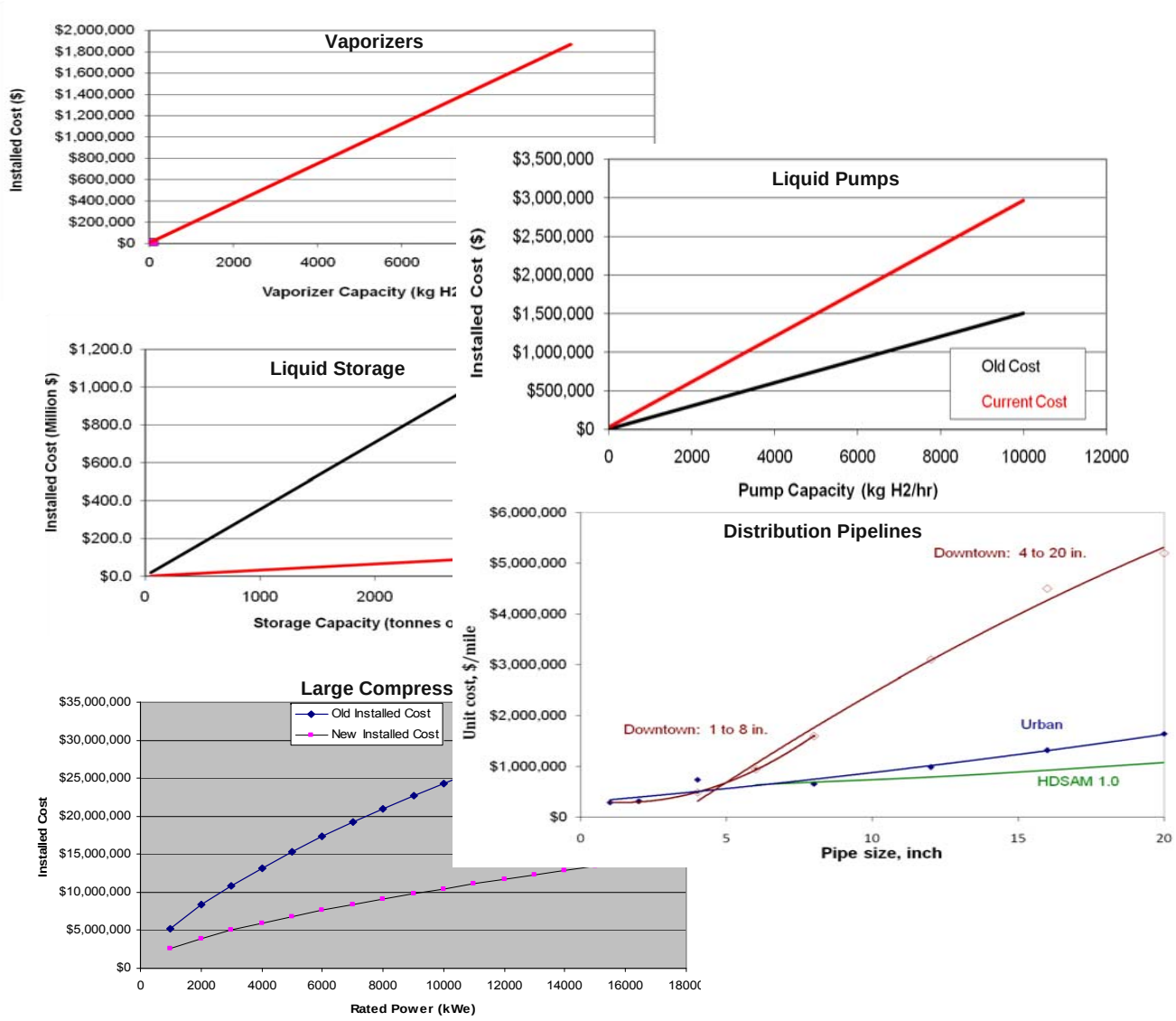
Enhancements in HDSAM 2.0: Better Pathway Representation

- Components sized to meet refueling demand profile (replaces capacity factor set for entire pathway).
- Pathway storage optimized for peak demand (plant outage, summer peak, Friday peak, hourly peak, HOF peak).
- Variable capacity refueling stations (50 – 6000 kg/day).
- Additional pathways (mixed-mode deliveries, handling of plant outage/summer peak).

Enhancements in HDSAM 2.0: Better Data

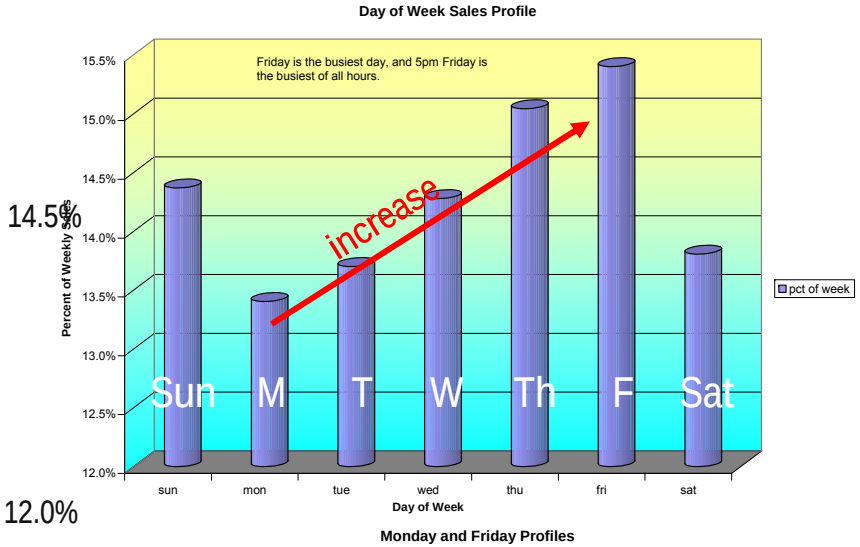
- Improved cost data (liquid handling, pipelines, compressors, storage, labor, indirect capital, O&M) and installation factors.
- Revised cost equations (compressors, pipelines, liquefiers, storage tubes).
- Revised fuel demand profiles (hourly, daily, seasonally).

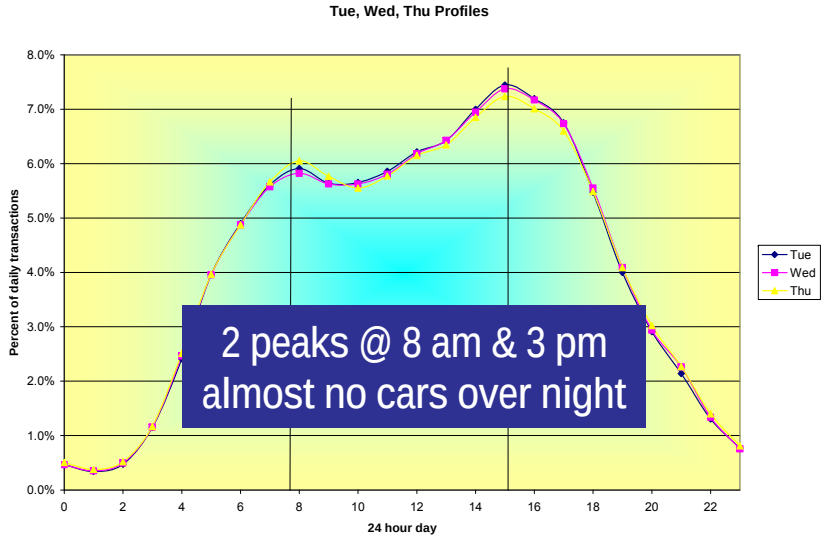
V 2.0 Equations Increase Some Costs, Decrease Others

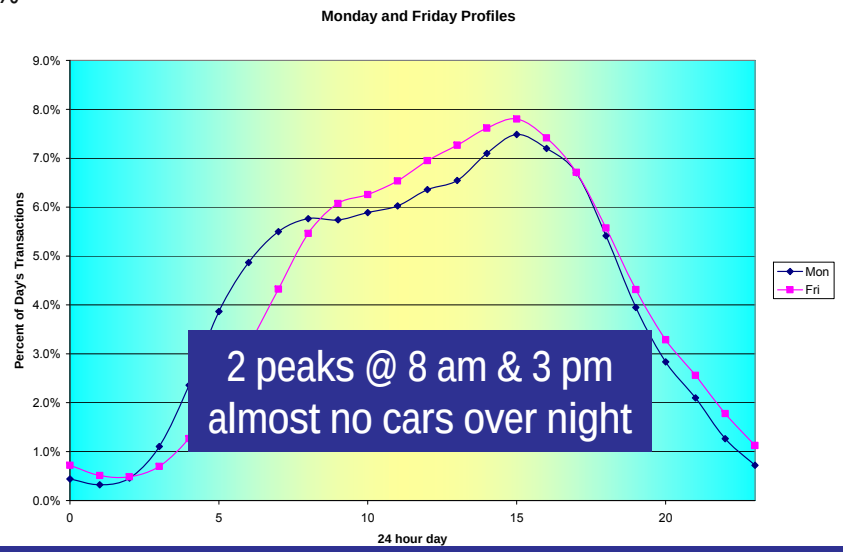


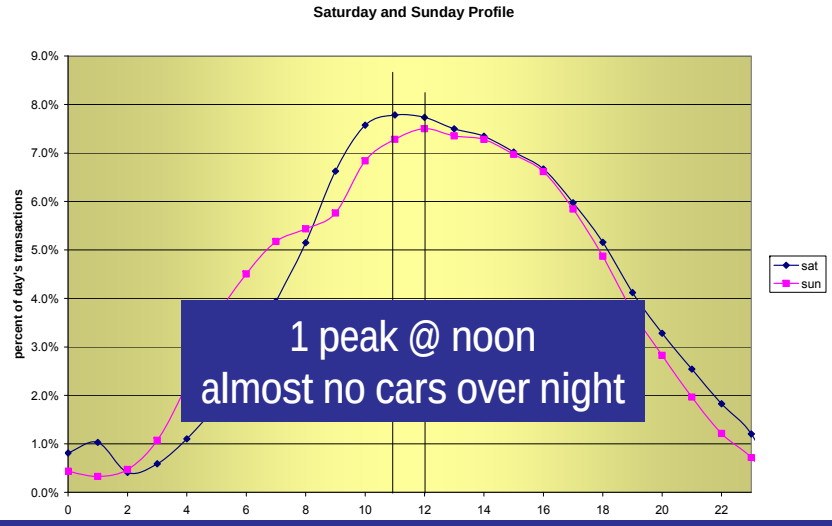
- Vaporizer costs now cover a range of capacities (vs. two refueling-station sizes).
- Liquid storage now reflects large vessels (vs. refueling station-sizes).
- Liquid pump costs now are double HDSAM 1.0.
- Central pipeline compressors now reflect greater scale economies.
- Distribution pipeline costs now vary by location as well as diameter.

V 2.0 Refueling Station Demand Profile Anchors Optimization of Component Capacity & Storage Throughout Pathway







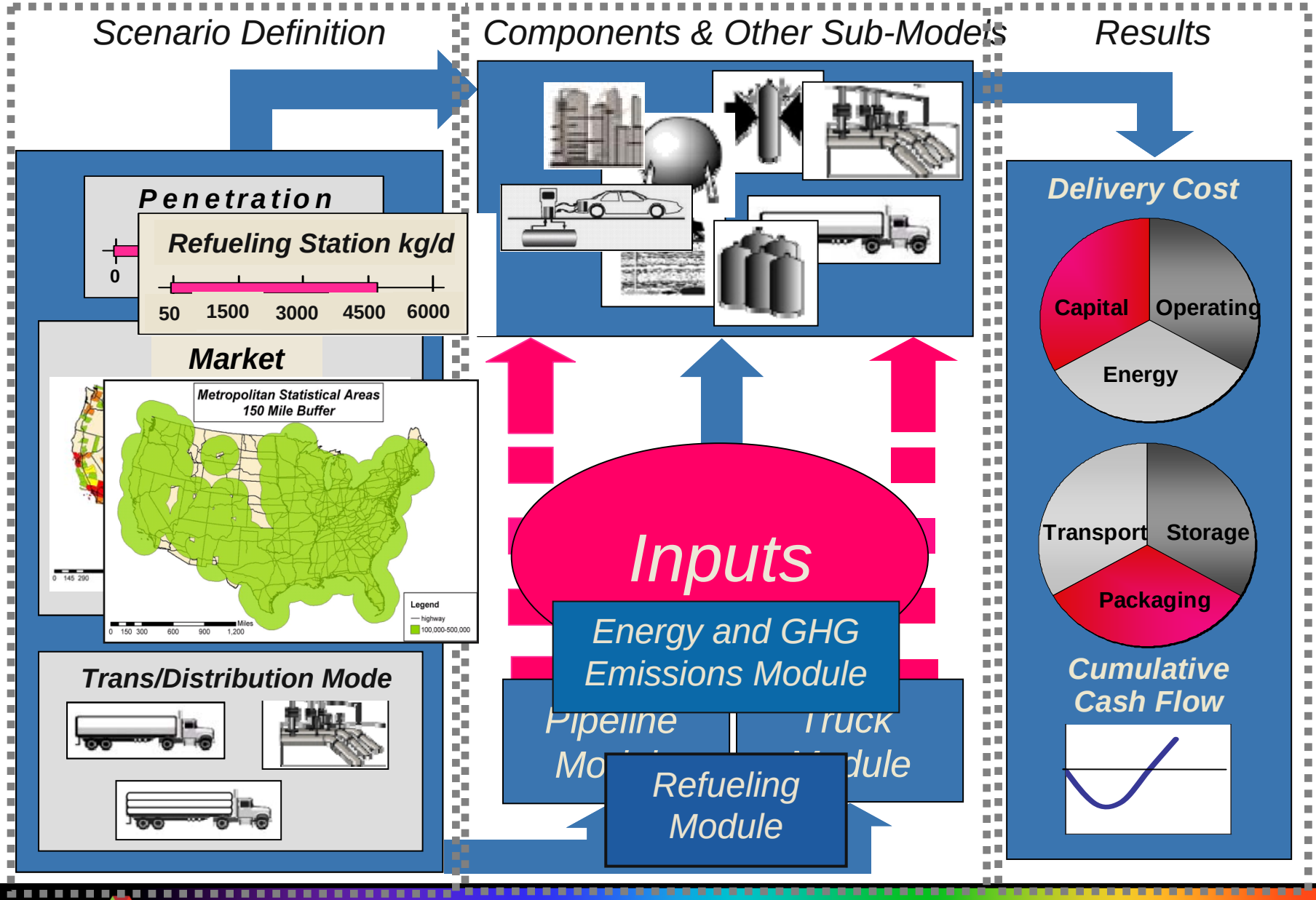


Also seasonal variation! Winter need is 70% and 90% of summer in the US North and South, respectively.

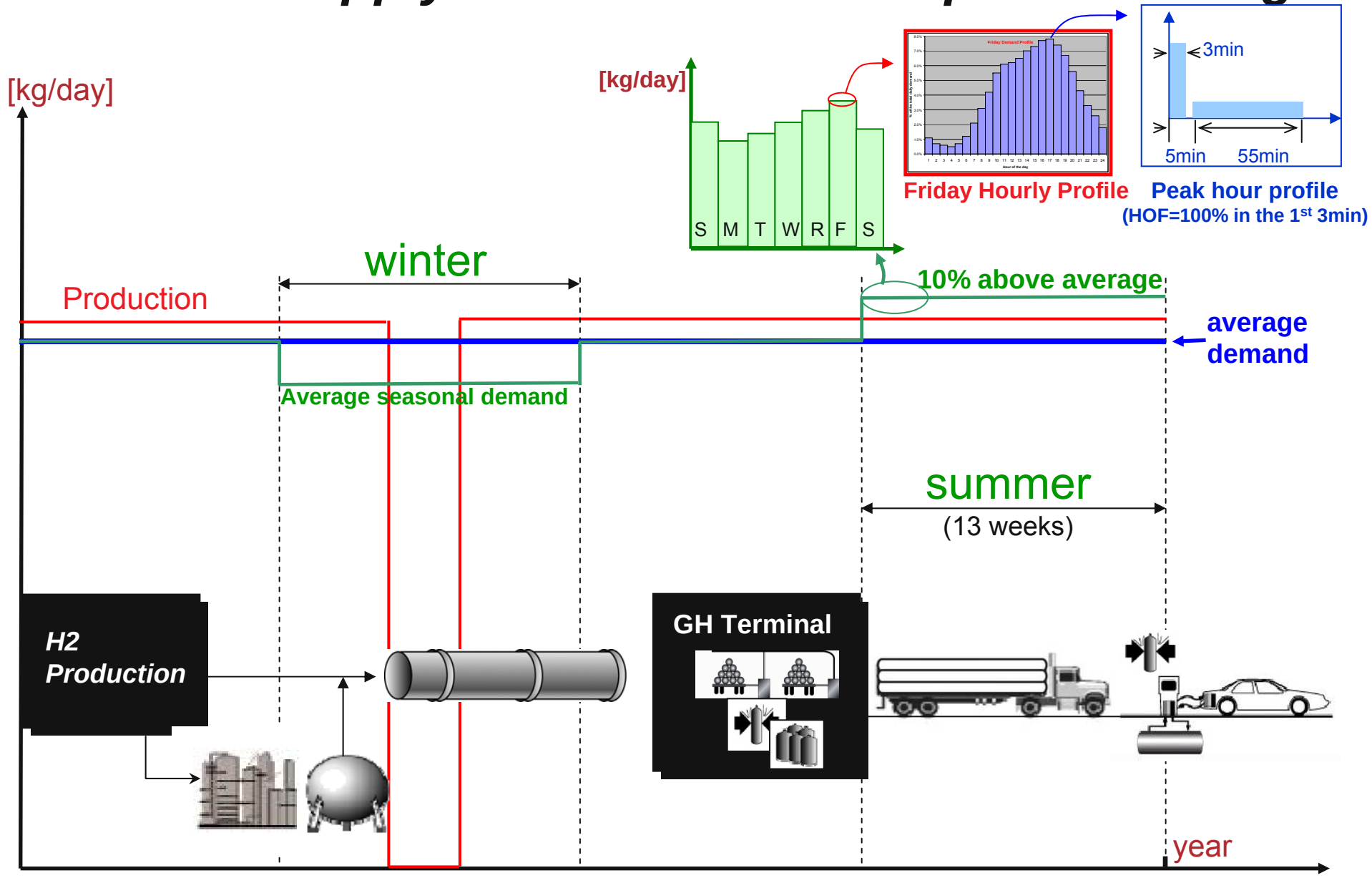
Enhancements in HDSAM 2.0: Better Modeling

- Refueling station (e.g., cascade vs. low-pressure storage, compressor/electrical, evaporator/pump, boil-off recovery).
- Refueling station optimization (both GH2 and LH2, based on total refueling station cost).
- Pipeline geometry (4-ring capability, separate downtown calculations.)
- Practical limitation on size of components (e.g., liquefier, compressors).
- Land area calculations (refueling station, terminals).
- Additional user options (energy use, CO_2 emissions.)

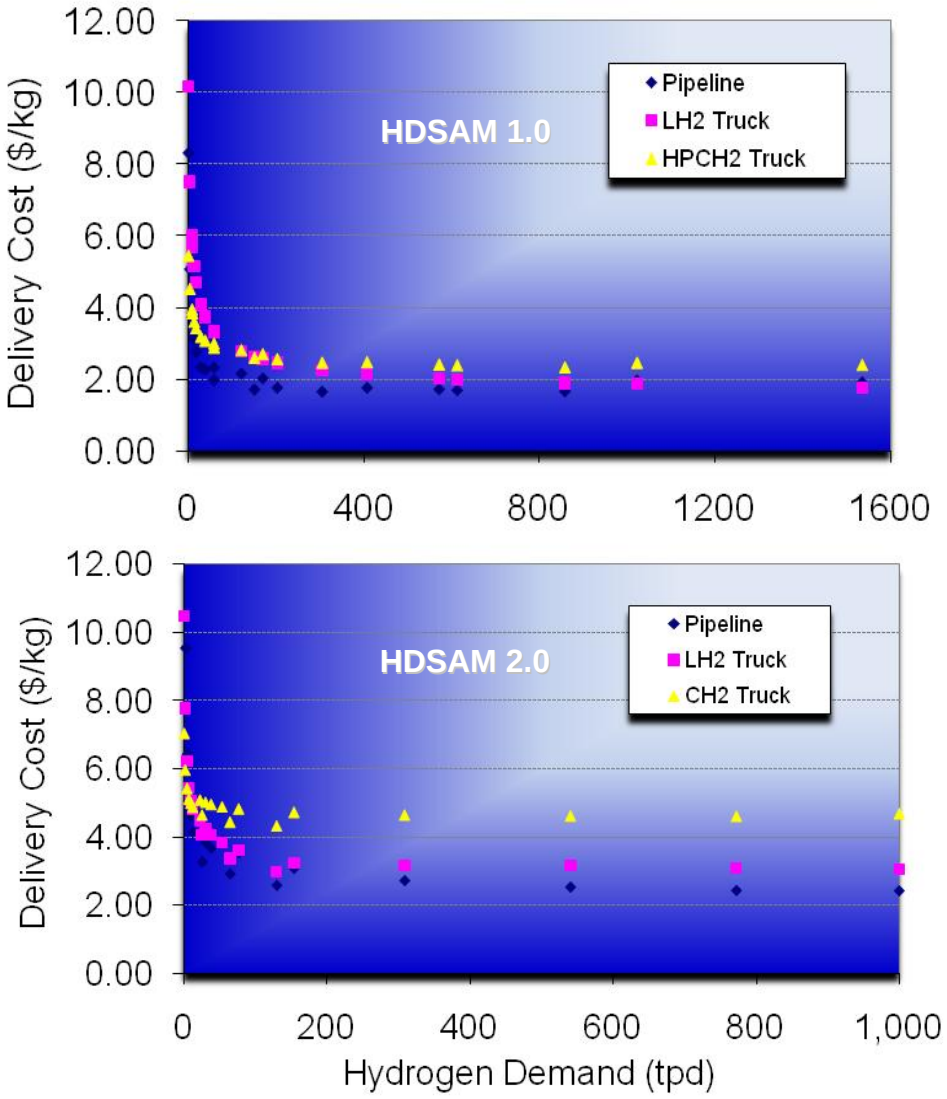
Overview of HDSAM



Demand/Supply Profiles Drive Component Sizing



Results Show Sensitivity to Demand



Cost drops rapidly with increasing demand, up to about 100 tpd.

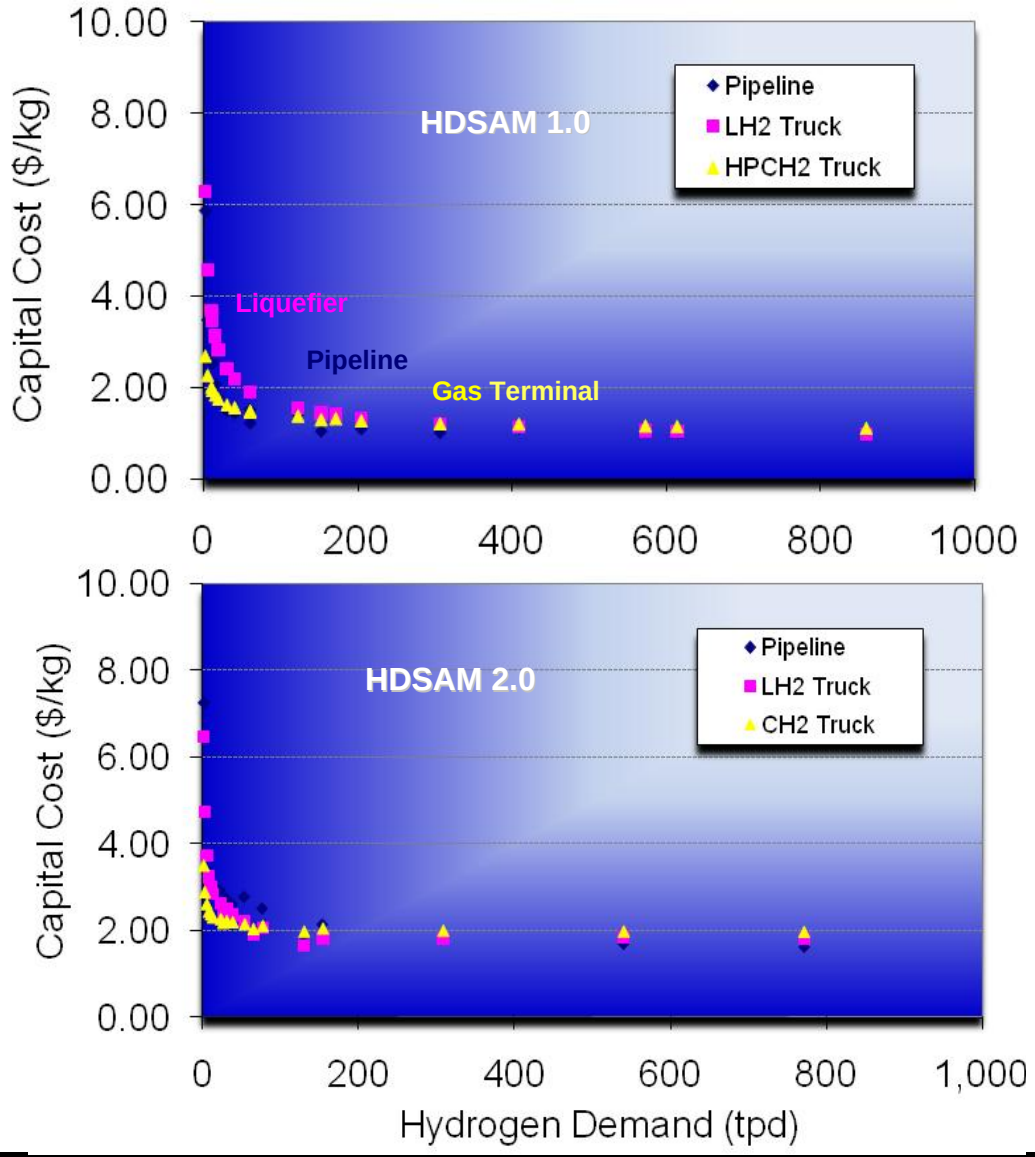
Scale matters for pipeline and liquid delivery, less so for compressed gas truck.

High pressure gaseous truck may be attractive at low demand, despite uncertain characterization.

V 2.0 reflects same pattern, although all estimates are higher.

Cost of LH2 delivery is higher in V 2.0 due to 200 tpd size limit.

Because Delivery Is Capital Intensive



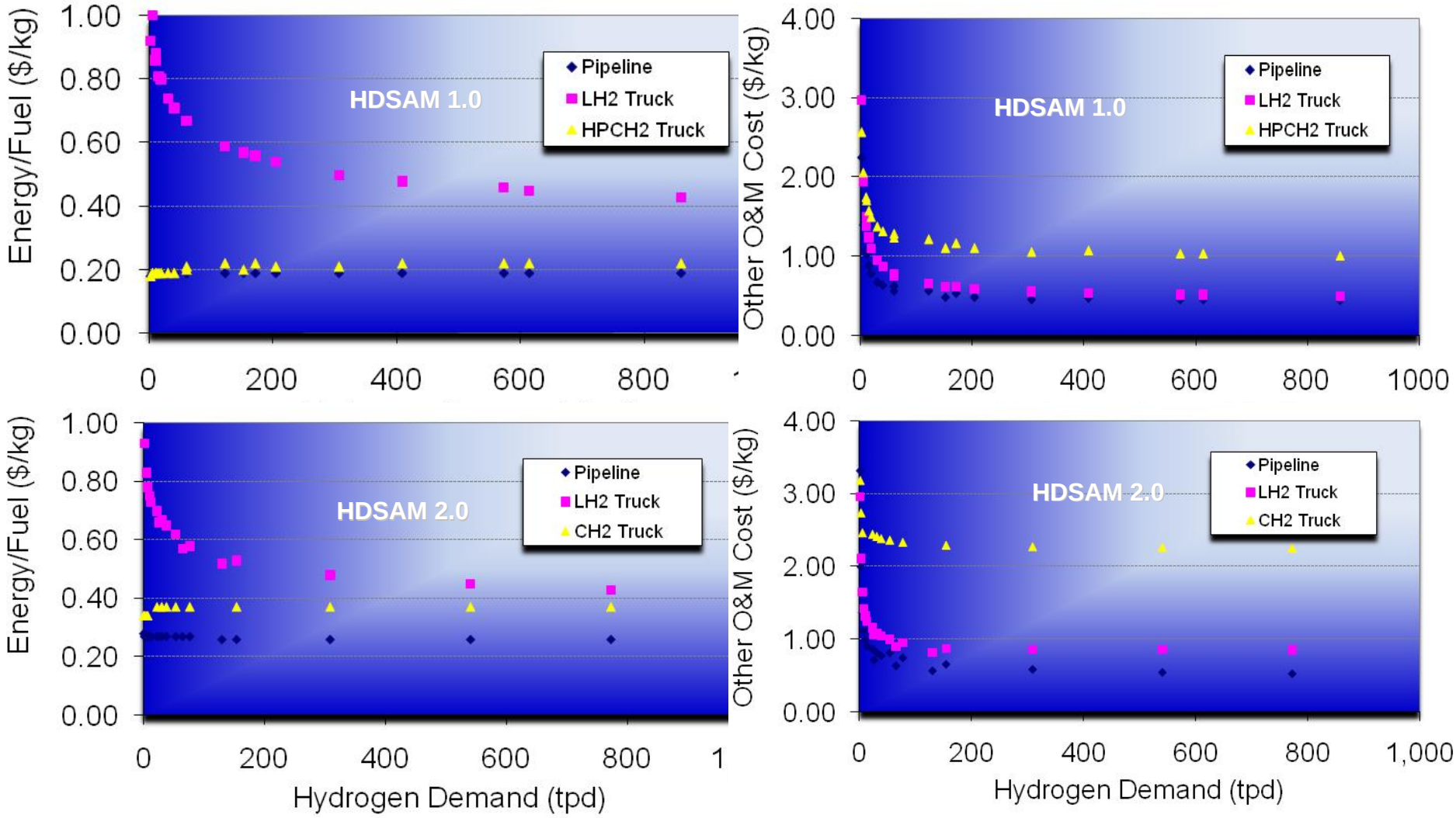
High pressure gas truck is somewhat less capital intensive at low demand.

Capital cost of all delivery modes are comparable at high demand.

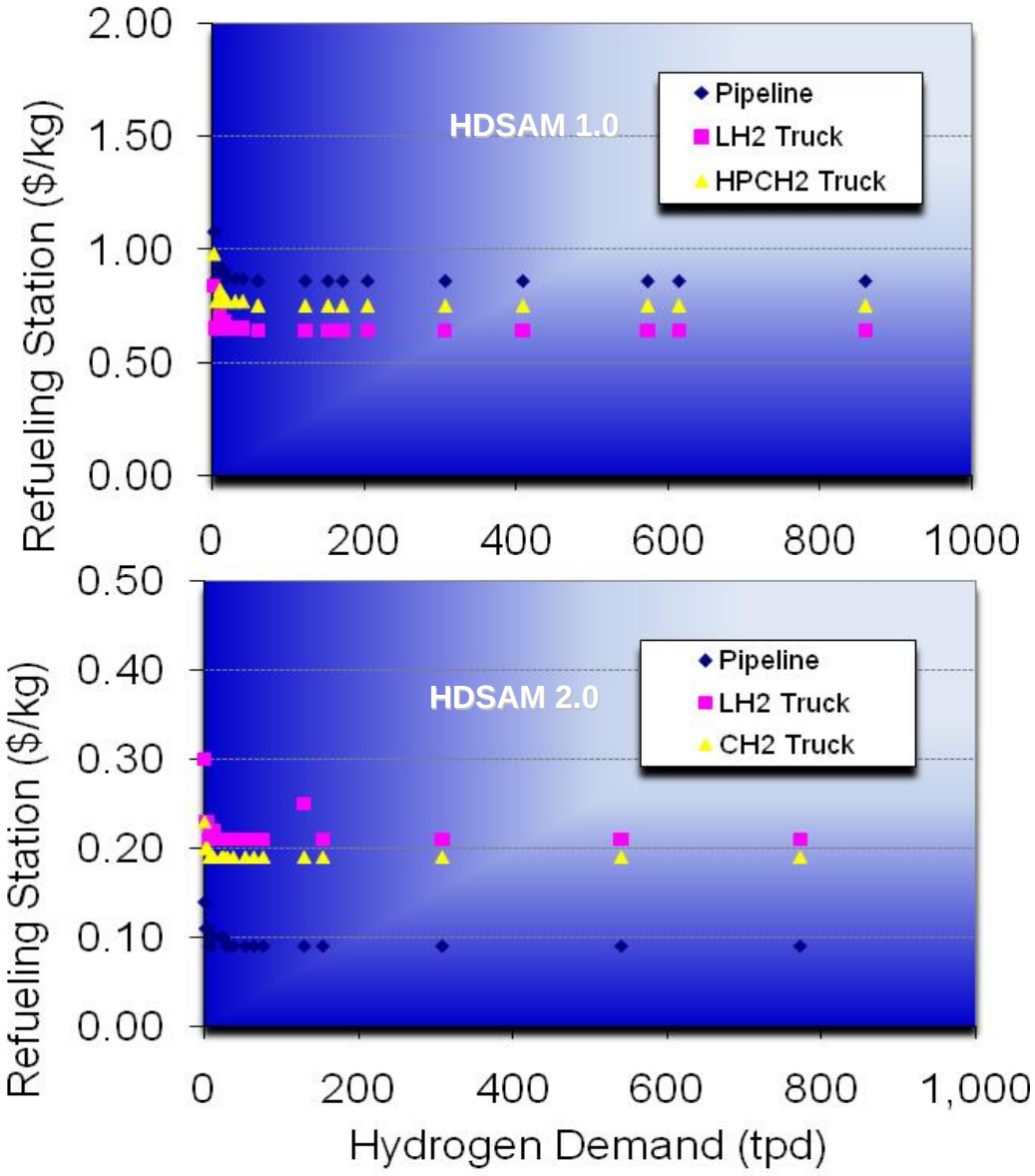
V 2.0 shows same pattern. Again, unit capital cost tends to flatten beyond 100 tpd.

Each mode has a major capital cost challenge, particularly at low demand.

Energy and O&M Are Smaller But Significant for All Modes and Generally Higher in V2.0



With a Single Size, Refueling Station Costs Are Flat

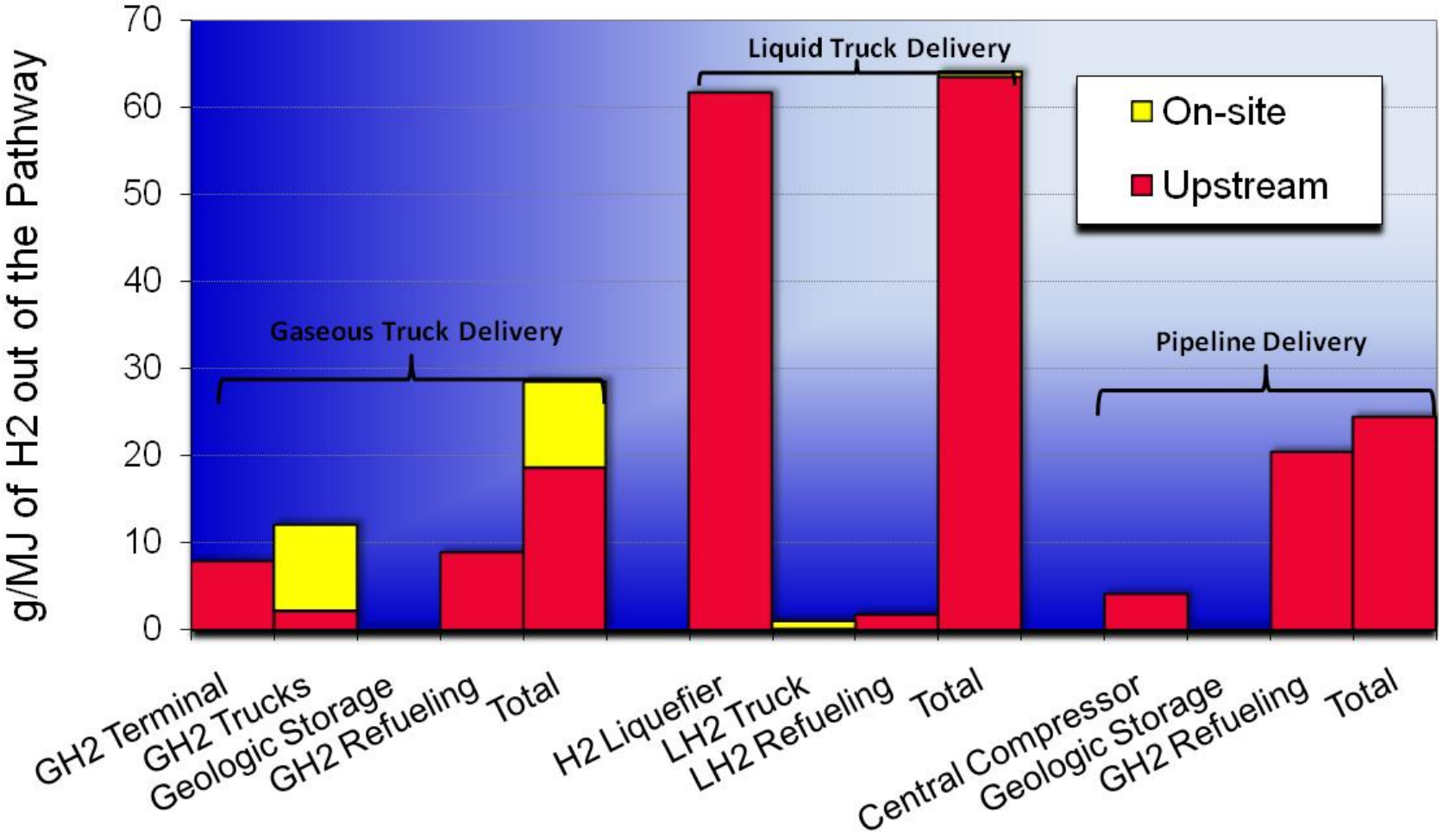


Refueling station capacity is a user input – 100 or 1500 kg/d in V 1.0; 50-6000 kg/d in V 2.0. (All stations are assumed same size).

Optimization in V 2.0 results in 24/7 operation of lower-capacity components to meet average demand. Storage accommodates demand peaks and supply shortfalls.

Due to Liquefaction's Energy Intensity, LHT Delivery Emits More GHGs Than GHT or Pipeline Pathways

Indianapolis, 20% market penetration, 2700 psi tube trailer, 400 kg/d refueling, 62 mi from city



Conclusions

- At low demand, compressed gas delivery appears most economic. High pressure tube trailers may be promising, although characterization and cost inputs are uncertain.
- At higher demand, pipeline delivery is least costly.
- Distance from central plant to city gate may change relative costs (all results shown assume 100 km).
- Pipeline costs may be reduced with system “rationalization”, primarily reductions in service mileage.
- Refueling station costs may be reduced with larger stations.
- Liquefier and pipeline capital costs are a hurdle, particularly at low demand.

Next Steps

- HDSAM 2.0 is now available on the USDOE website (www.hydrogen.energy.gov) with technical support from the EERE help desk.
- V 2.0 Users' Guide will be available by June '08. Full documentation will be available by end FY08.
- V 2.5 will be completed by end 2008. V 2.5 will incorporate:
  - Additional data (refueling station setbacks, separation distances and operating procedures, terminal size limits)
  - Revised models (delivery infrastructure to serve multiple urban areas, hydrogen carriers)

Thanks to other members of H2A/Nexant project team, USDOE Delivery Tech Team, Fuel Pathway Integration Tech Team, and OFCHIT.

Questions?

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