ARGONNE NATIONAL LABORATORY

TRANSPORTATION TECHNOLOGY R&D CENTER

Hydrogen Fuel Infrastructure Options

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ASME International

Hydrogen Infrastructure:

The State of Technology and Standards

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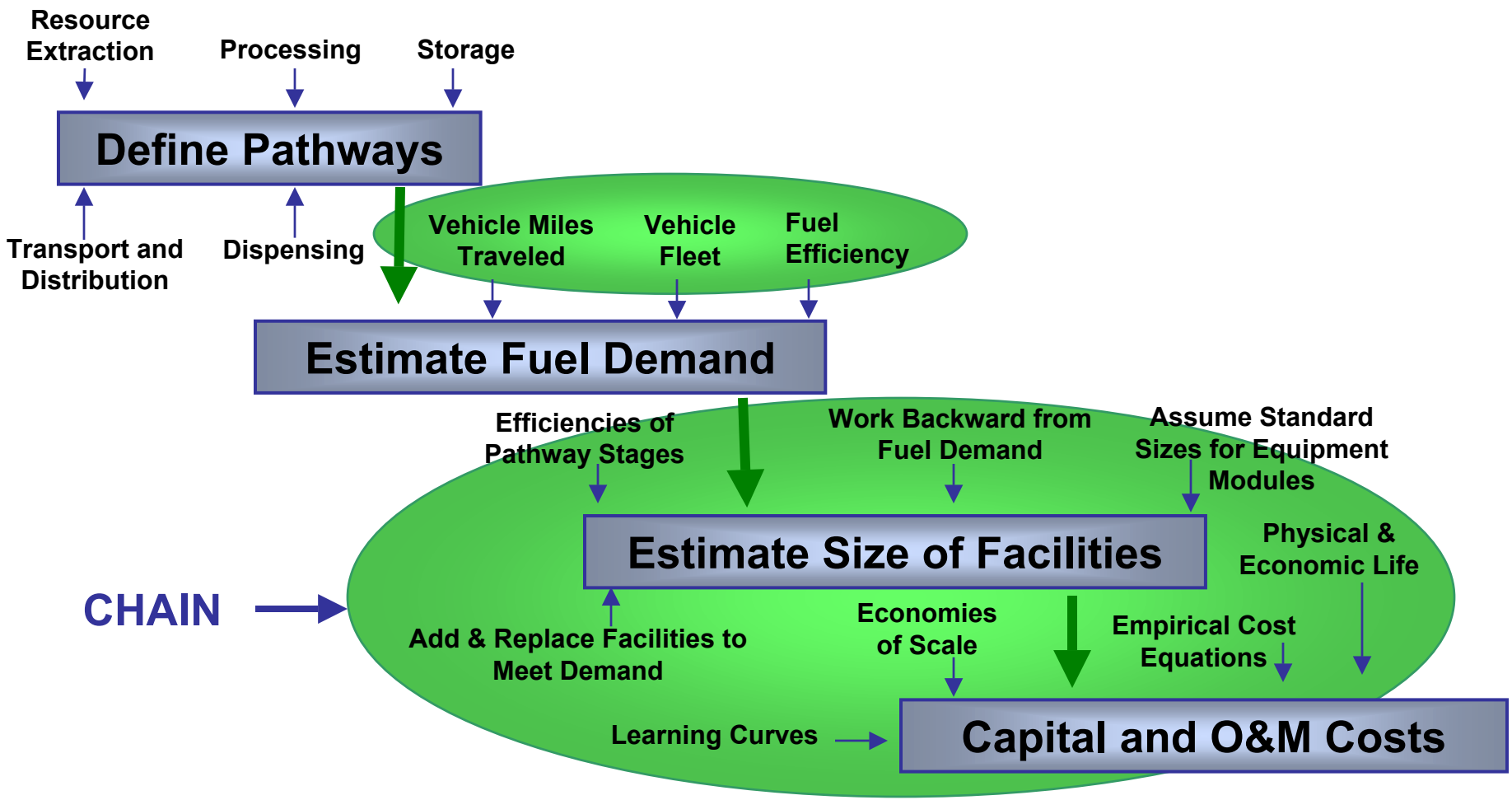
Topics

- Cost modeling process
- "Well-to-pump" pathways
  - Components
  - Arrangement
  - Key assumptions
- Illustrative component cost analyses
- Results

"Well-to-Pump" Pathways Include:

- Feedstock acquisition
  - Crude oil
  - Natural gas
  - Uranium
  - Coal
- Feedstock transport and storage
- Processing
  - Petroleum refining
  - Hydrogen production
  - Coal, natural gas or uranium processing
- Product distribution and storage
  - Pipelines
  - Compressor stations
- Dispensing and retailing

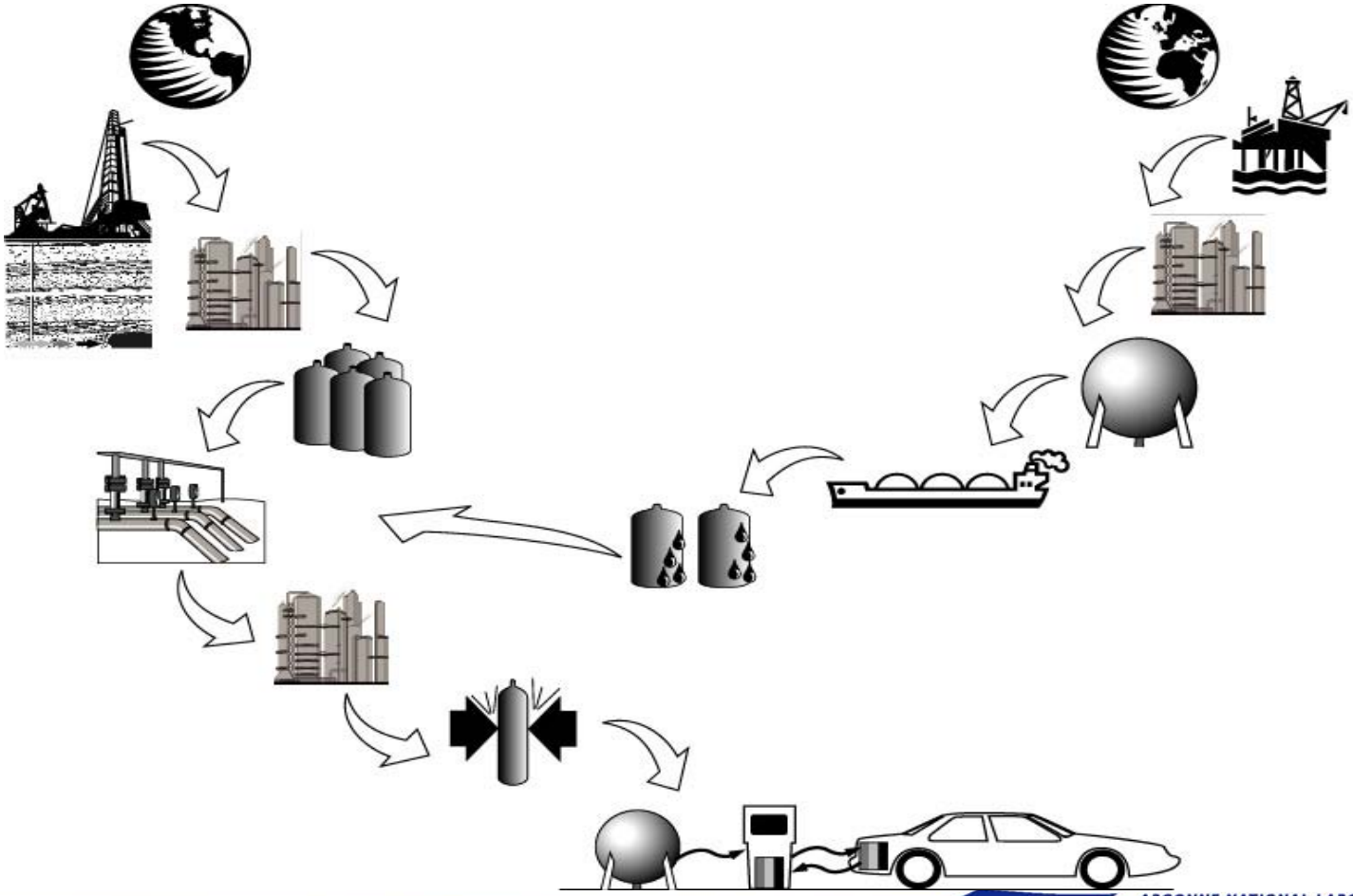
Stock Adjustment and Infrastructure Models Estimate Pathway Costs



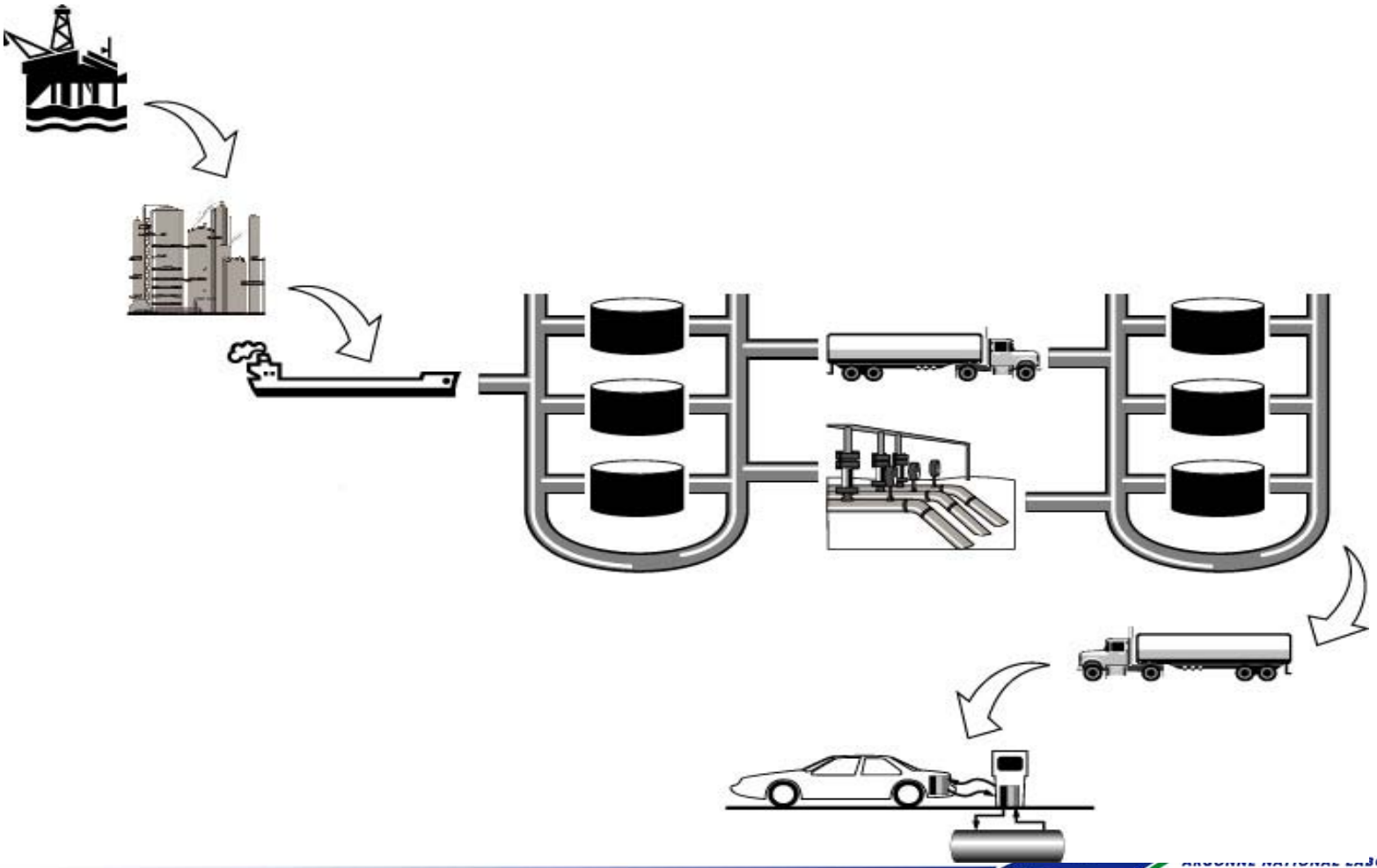
Cost Modeling Is a Five-Step Process

- Define "well-to-pump" (WTP) paths
  - NG compression, storage and transport
  - Hydrogen production
  - H_2 compression, storage and transport
  - Hydrogen dispensing
- Determine "tank-in" fuel requirement
  - HFCV market penetration & efficiency
- Size pathway components
- Estimate component costs
- Calculate pathway costs (CHAIN model)

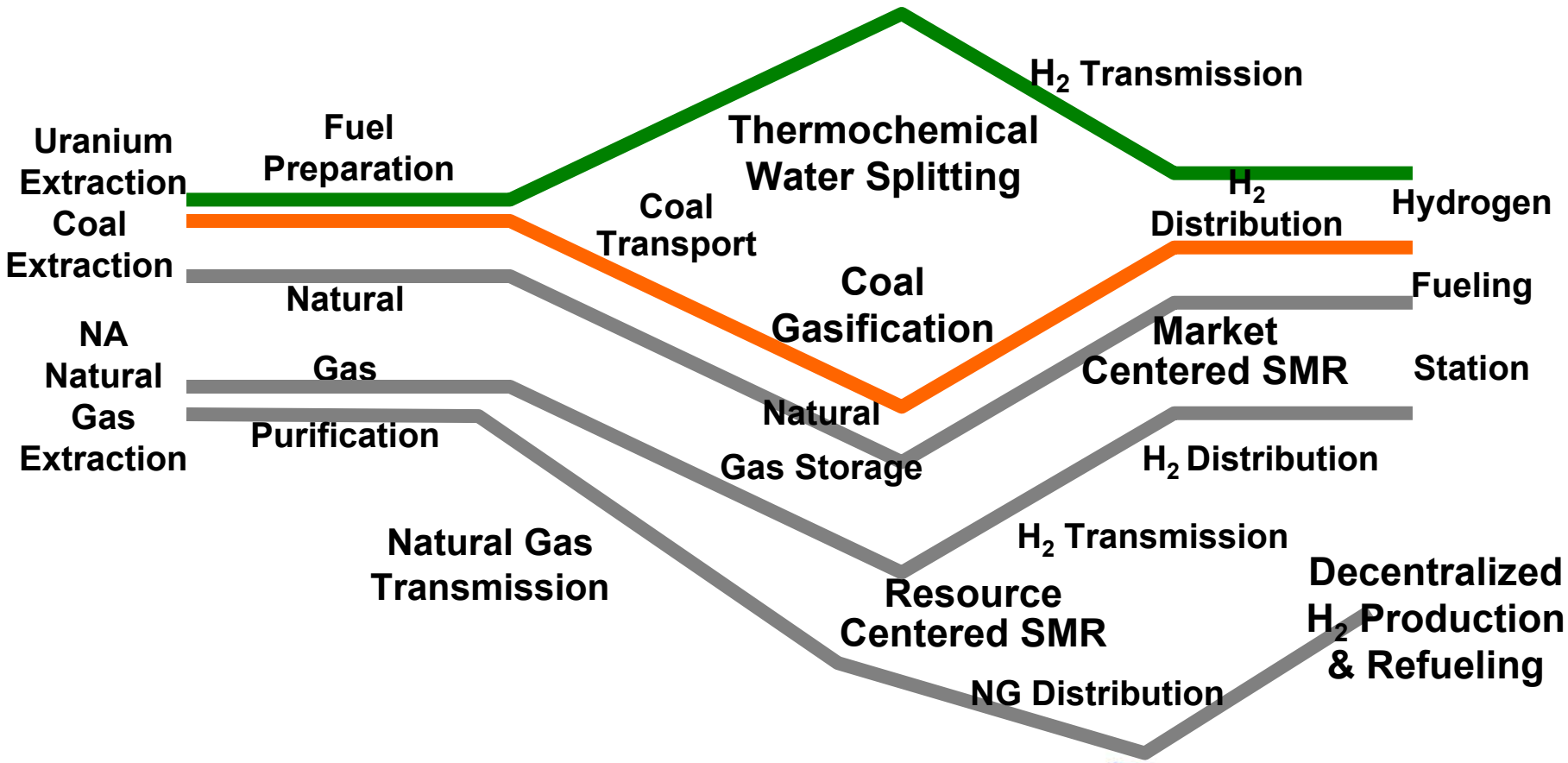
Hydrogen Could Take Many Paths from Well to Pump (WTP)



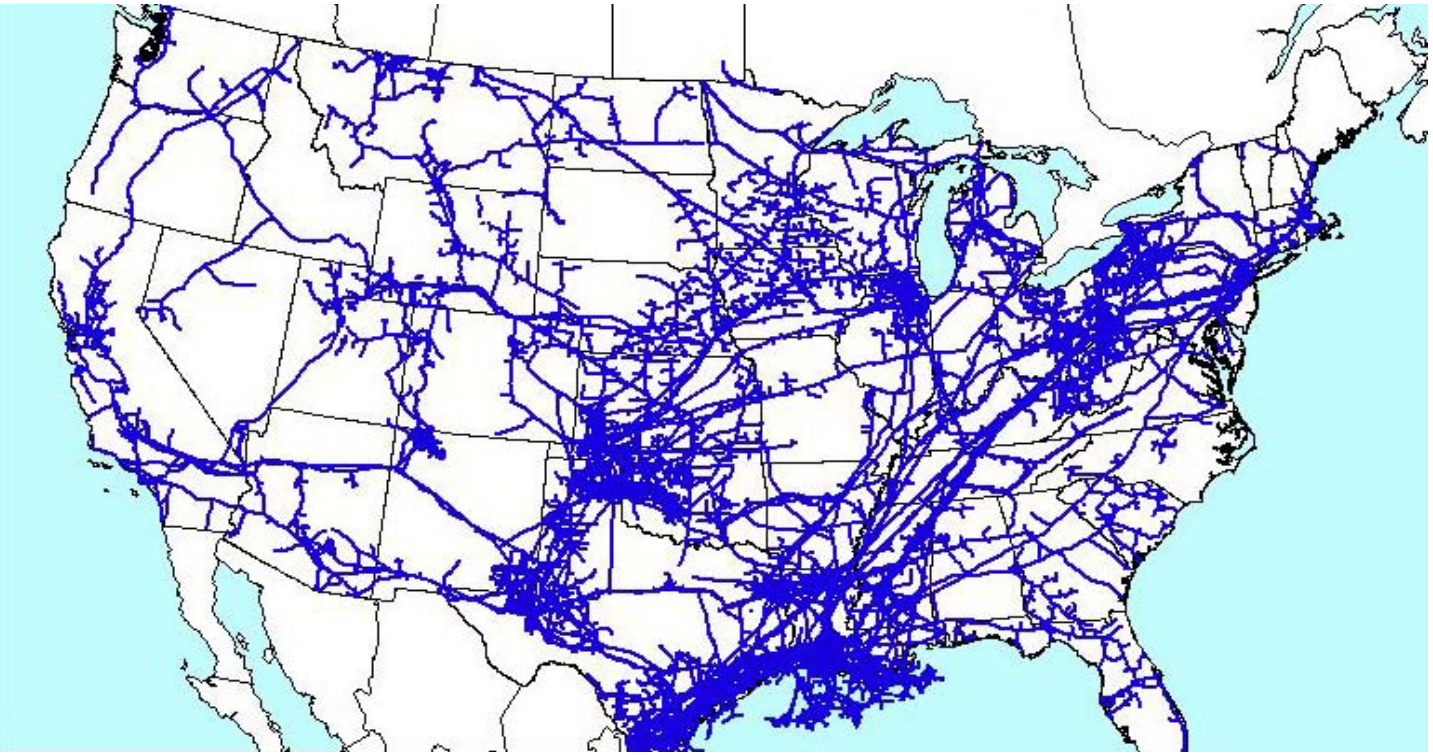
Including a Liquid "H2 Carrier" Reformed On- or Off-Board



Infrastructure Costs Have Been Estimated for Several Pathways



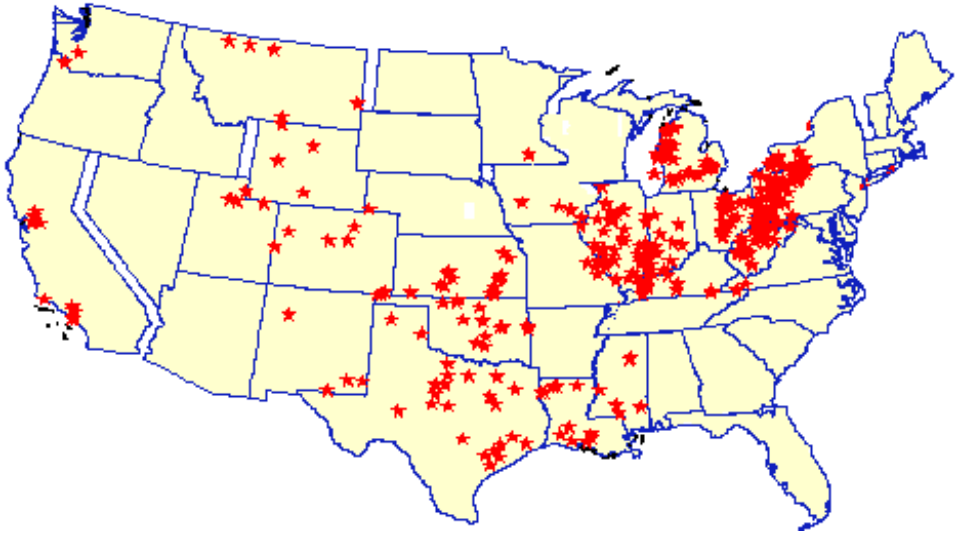
NG-Based Pathways Require Additional NG Transmission Lines



The US has an extensive in-place NG transmission infrastructure …..

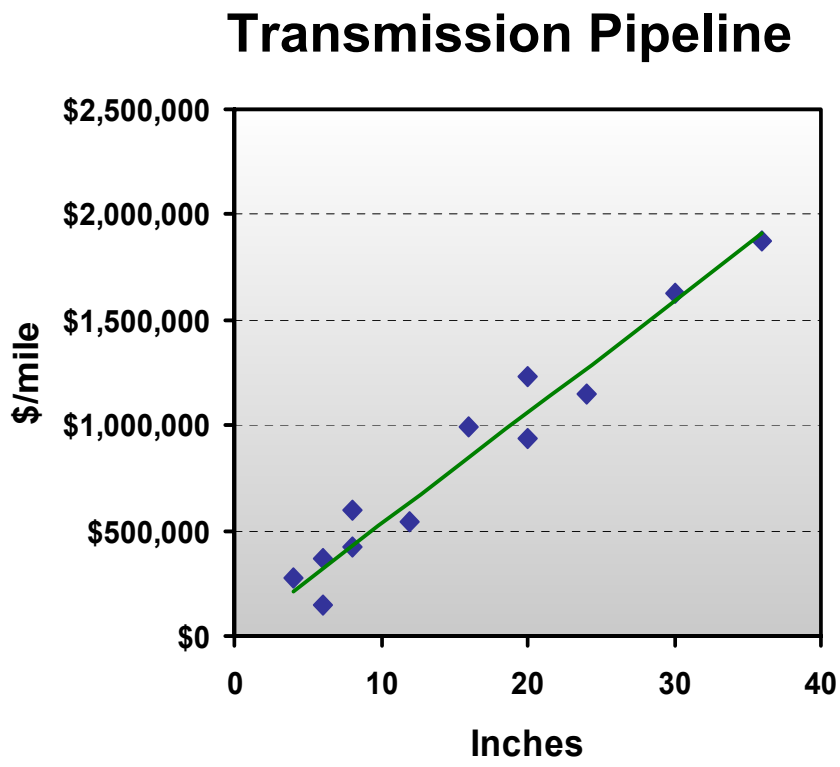
And Underground Storage

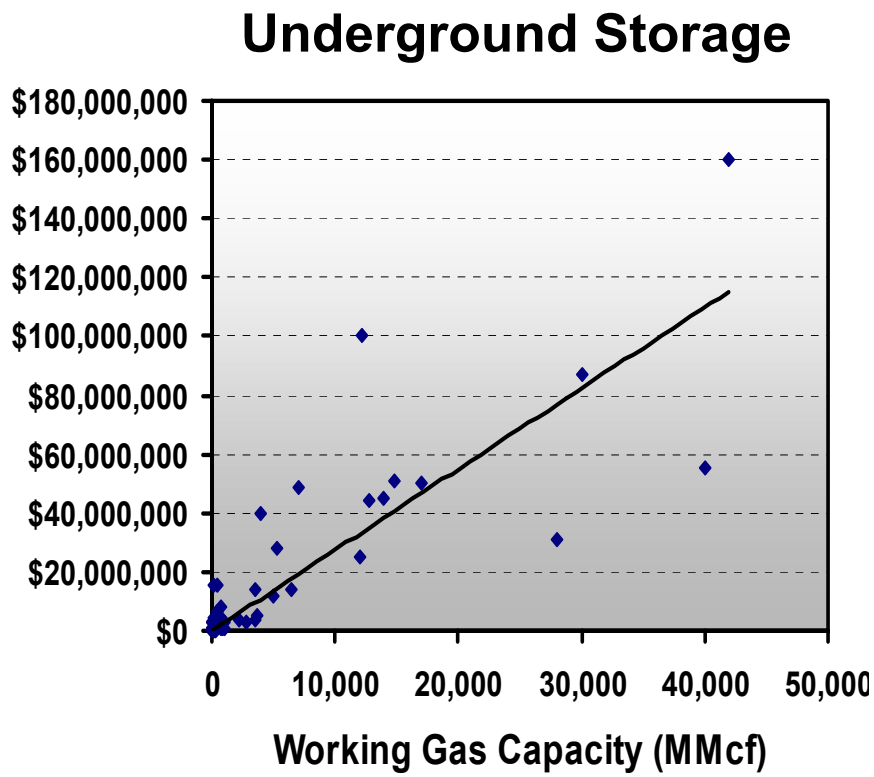
At the end of 1998 there were 410 underground natural gas storage sites in the U.S.



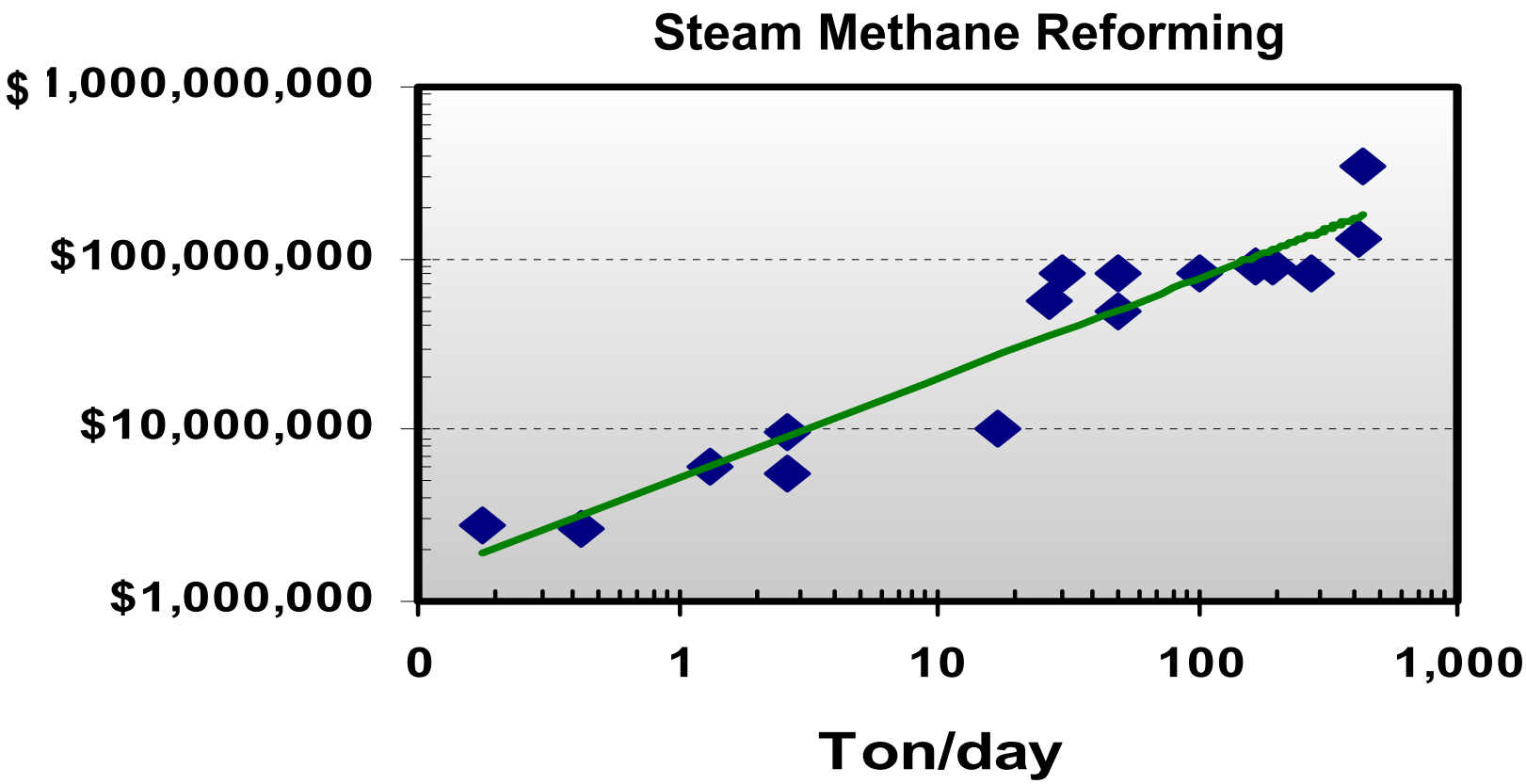
With 76 Bcf per day of Withdrawal Capability and 3.933 Bcf of Working Gas Capacity

Equipment/Facility Sizing Are Critical for Cost Estimation

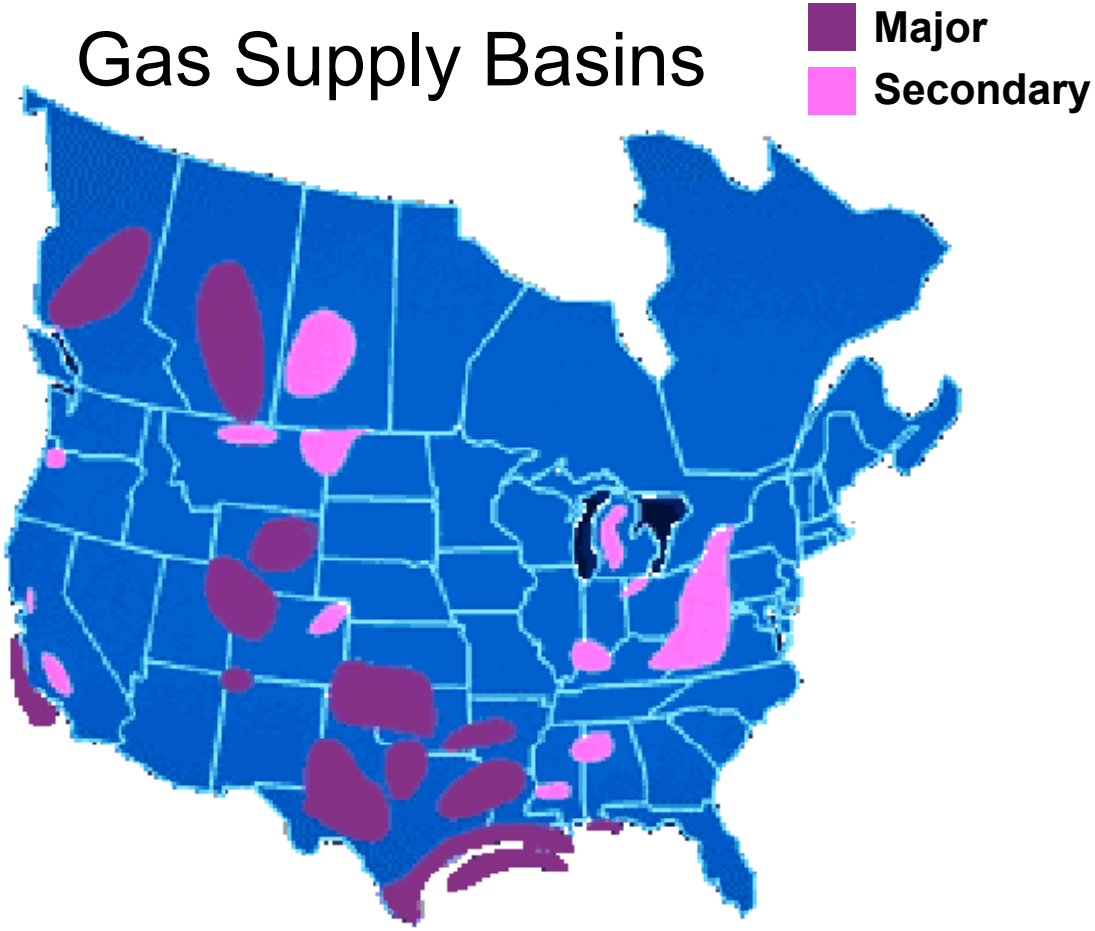




Especially Where There Are Large Economies of Scale

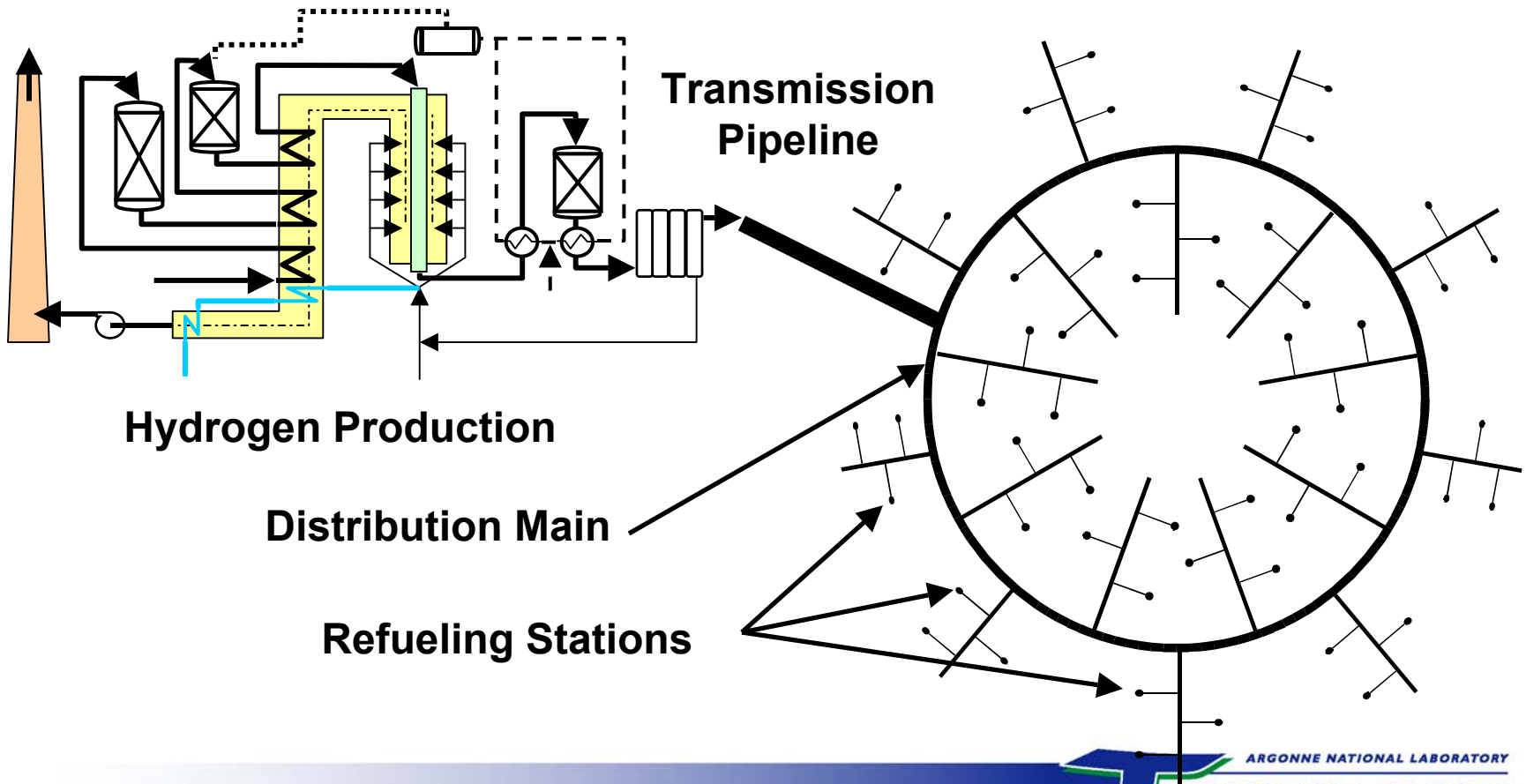


But Scale Economies May Be Offset by Increased Transport Costs

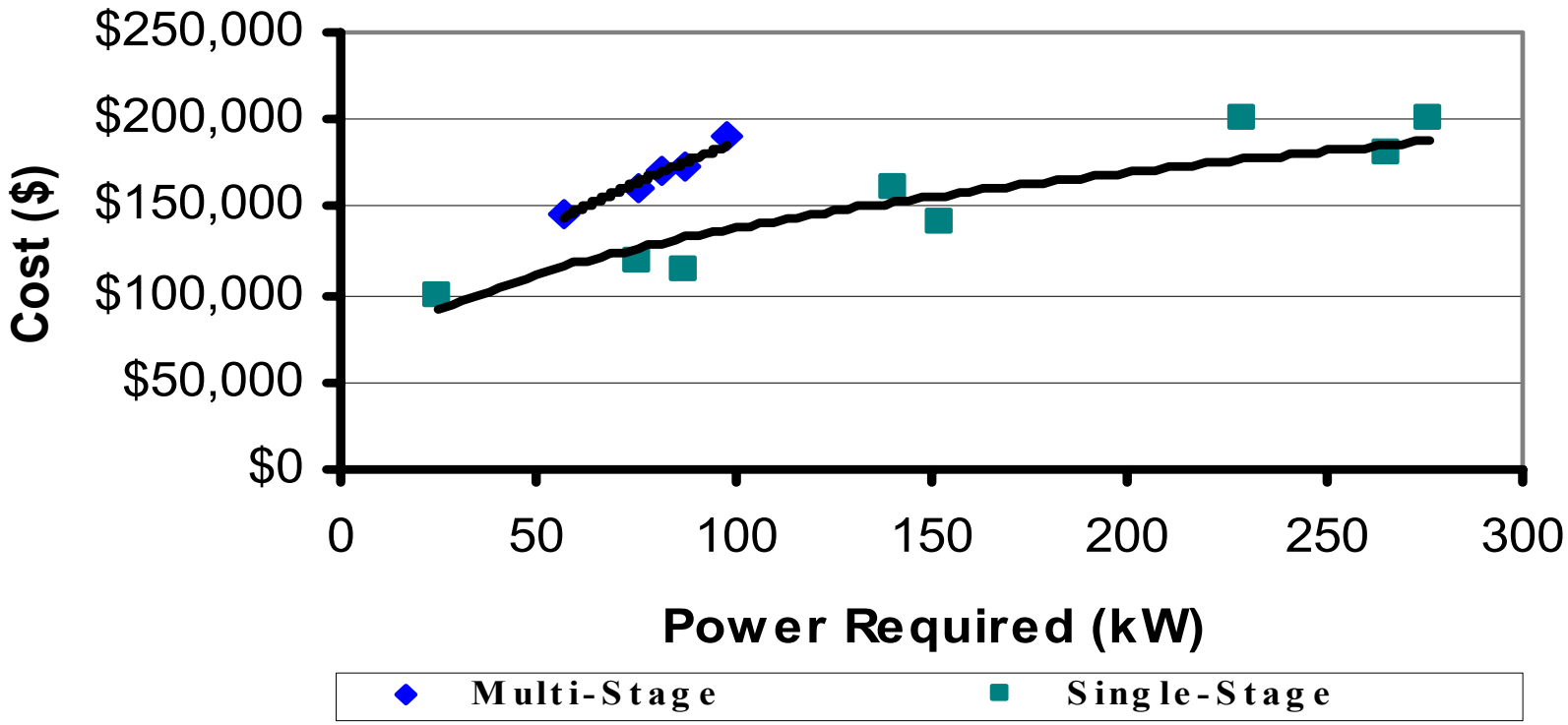


Necessitating a systems approach and demand analysis

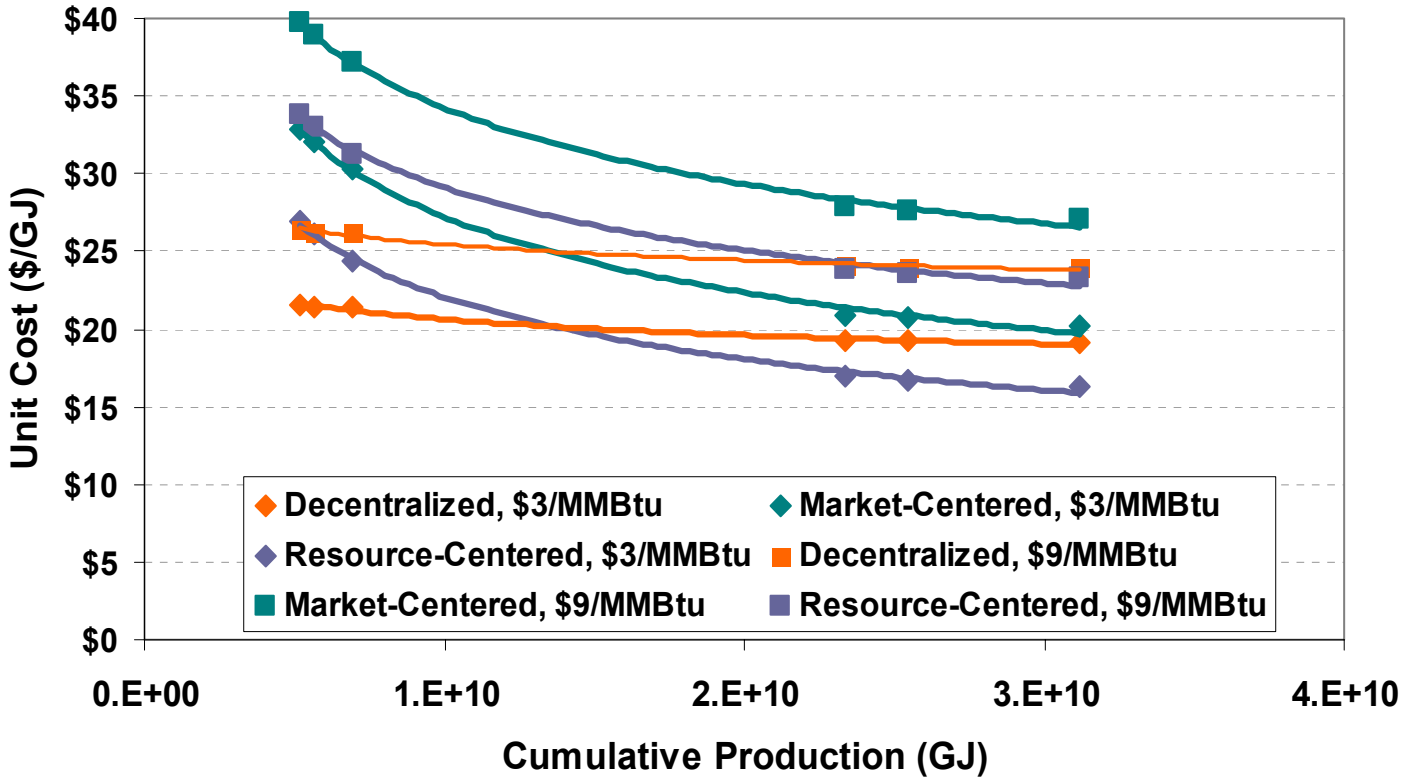
Pipelines Support Local Hydrogen Delivery in Centralized Pathways



All Pathways Require Compression for NG and H_2 Transport and Storage

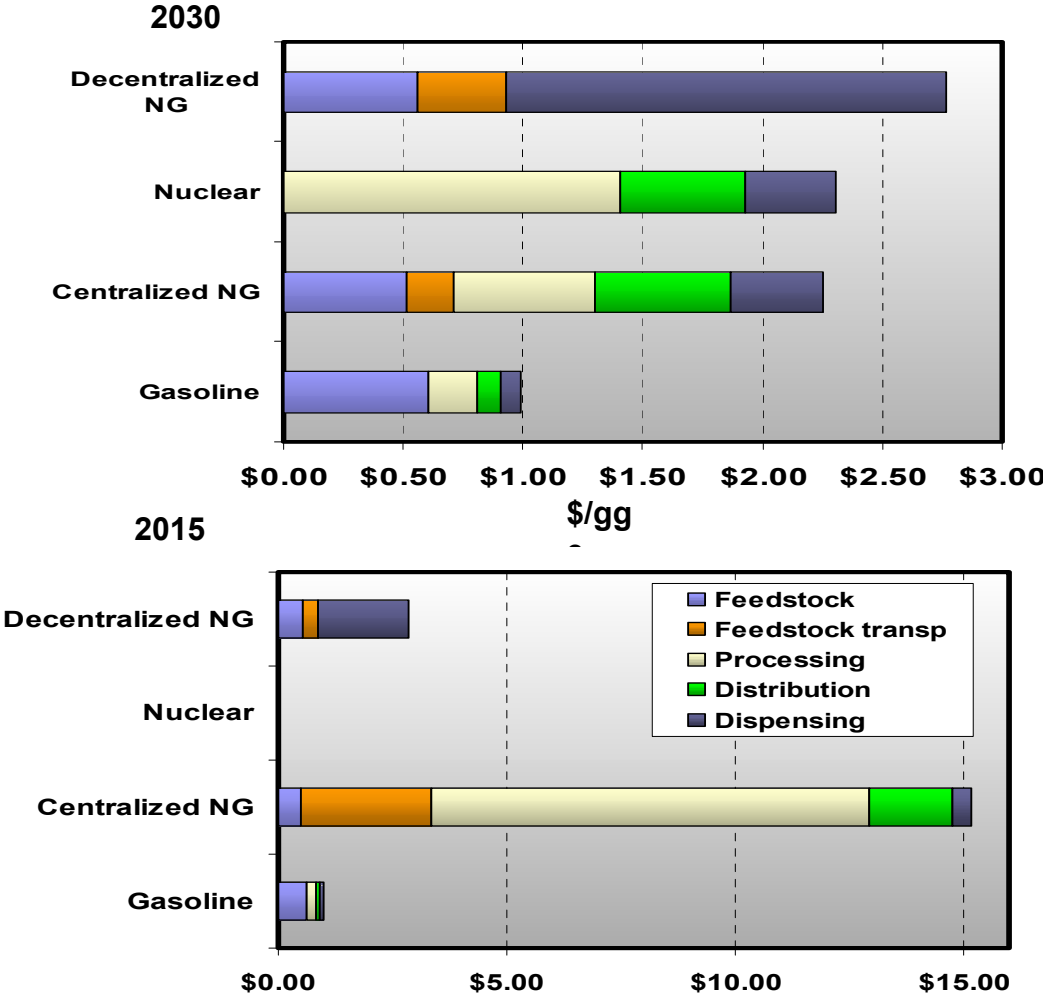


H_2 Cost Varies by Pathway and Feedstock Price



Volume Matters for Centralized Pathways

More Costly Production and Distribution Increase H_2 WTP Cost Relative to Gasoline



- Crude oil represents 61%, distribution 10%, and refining 21% of gasoline cost (for $28/bbl crude)
- H_2 production accounts for >60% of cost in nuclear path; ~25% in centralized NG path
- Distribution accounts for ~25% of H_2 cost in nuclear and centralized NG paths
- Costs decline over time as infrastructure is "built out" and amortized

Note scale change in charts

Conclusions

- With current technologies, WTP cost of H_2 is likely to be at least 2-3 times gasoline. Thus, mpge of H_2-fueled LDVs must be 2-3 times gasoline vehicles.
- H_2 transport and production are the biggest costs of all paths examined, hence appropriate focus for cost reduction.
- "Bi- fuel" distribution networks offer potential cost reductions, especially in the transition.
- WTP pathways provide a systematic rubric for identifying gaps in codes and standards, as well as for estimating the cost of infrastructure options.

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