Techno-economic Analysis of Traditional Hydrogen Transmission and Distribution Options

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Hydrogen Transmission and Distribution Workshop

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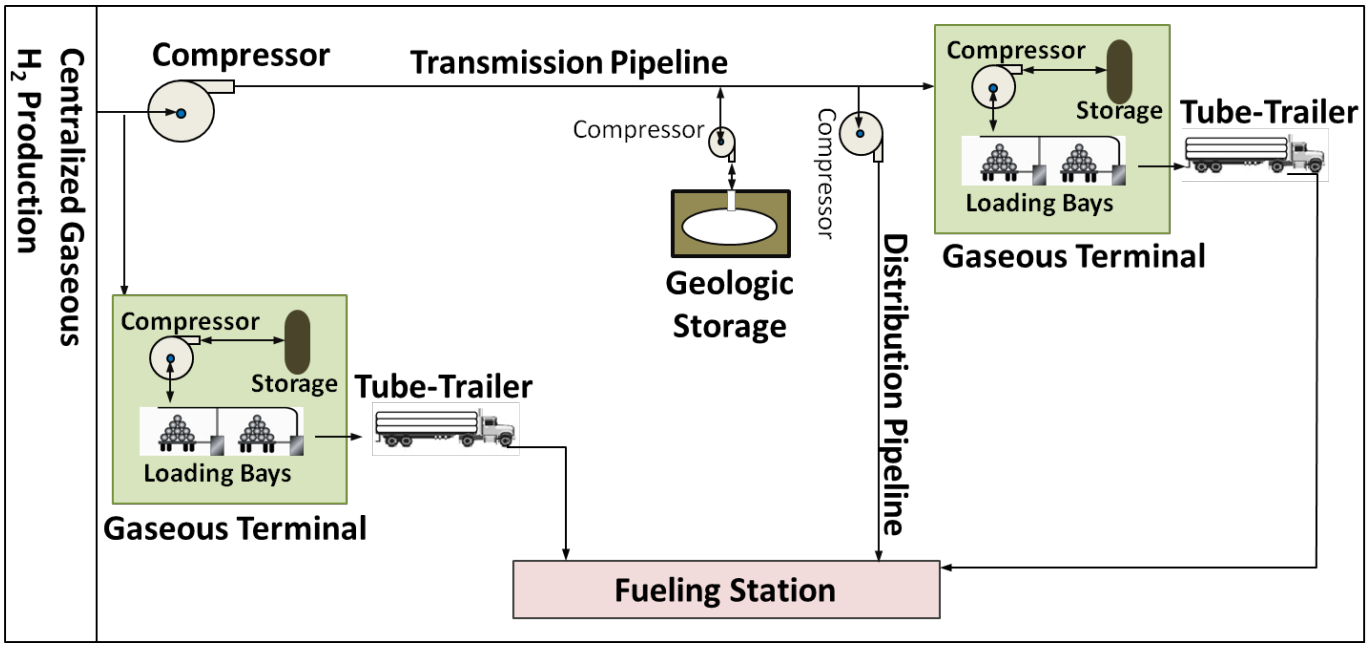
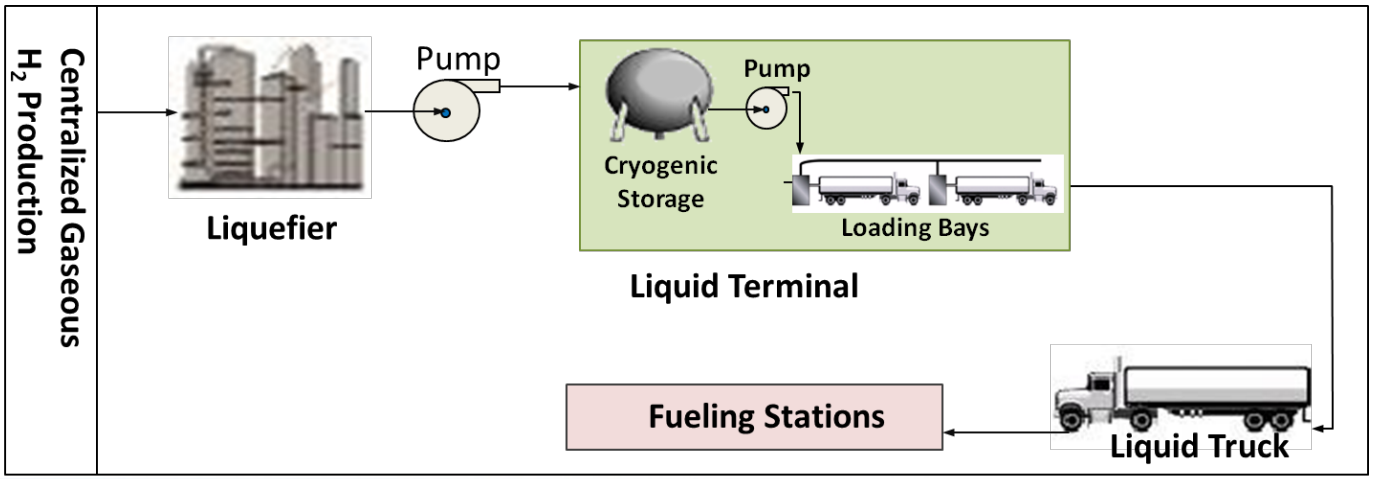
Traditional hydrogen transmission and distribution (T&D) options

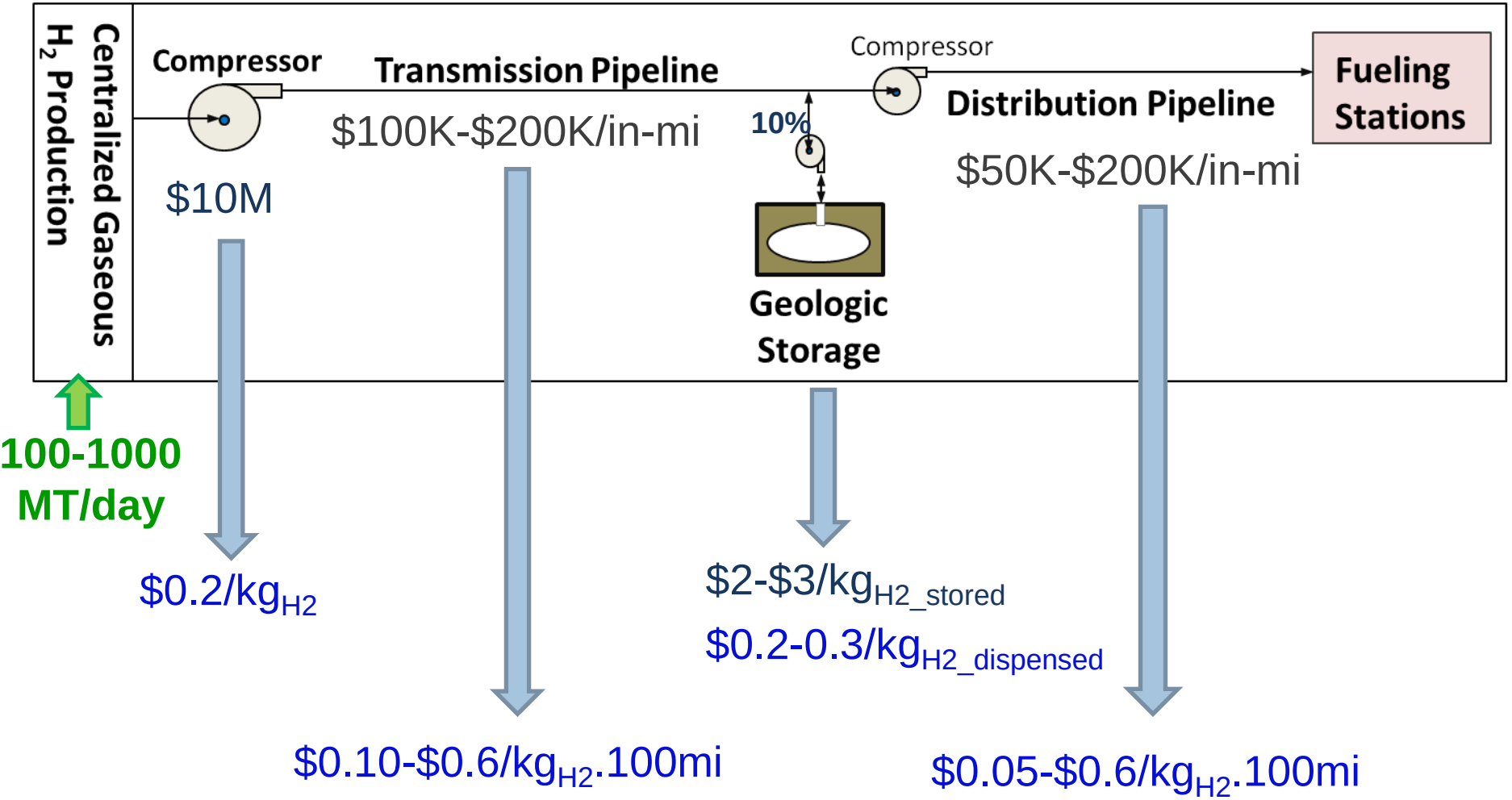
Gaseous Form



Liquid Form



Cost contribution of components in pipeline T&D

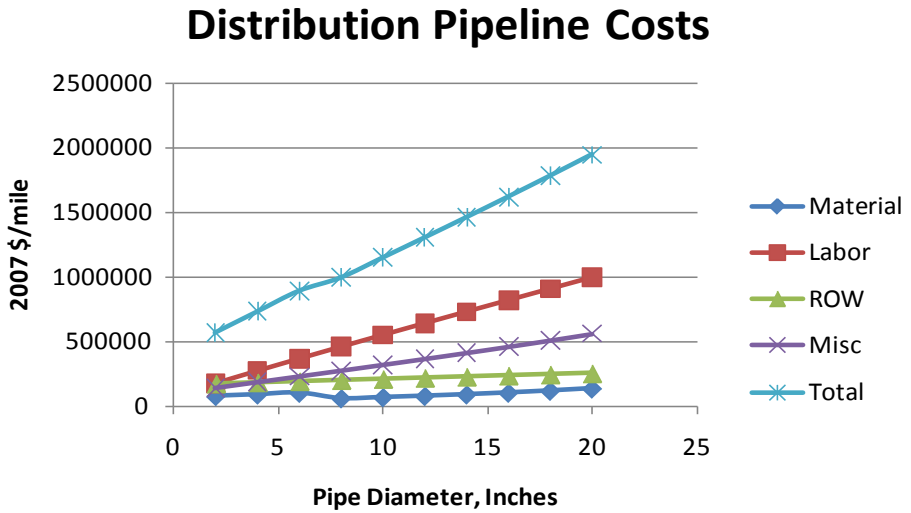


Total T&D cost <$1 : $2.5 / kg$_{H2}$

1000 MT/day 100 MT/day

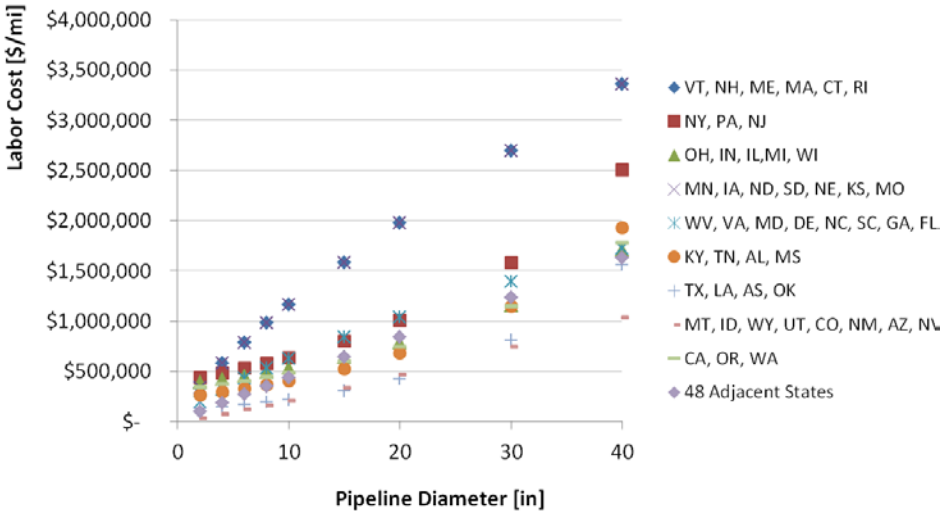
Key factors affecting pipeline T&D cost contribution

- Market demand
  - Pipeline capacity ~ D^2
  - Pipeline cost ~ D
  - ✓ Significantly large demand with solid projection is needed to justify pipeline investment



- Labor Cost
  - Labor cost contribution is significant (up to 50% of total pipeline cost)
  - ✓ Find alternative ways to reduce labor cost (e.g., FRP pipeline)

- Regional variation
  - Labor and ROW cost vary greatly by region
  - ✓ Pipeline installation may be more economical in certain regions compared to others



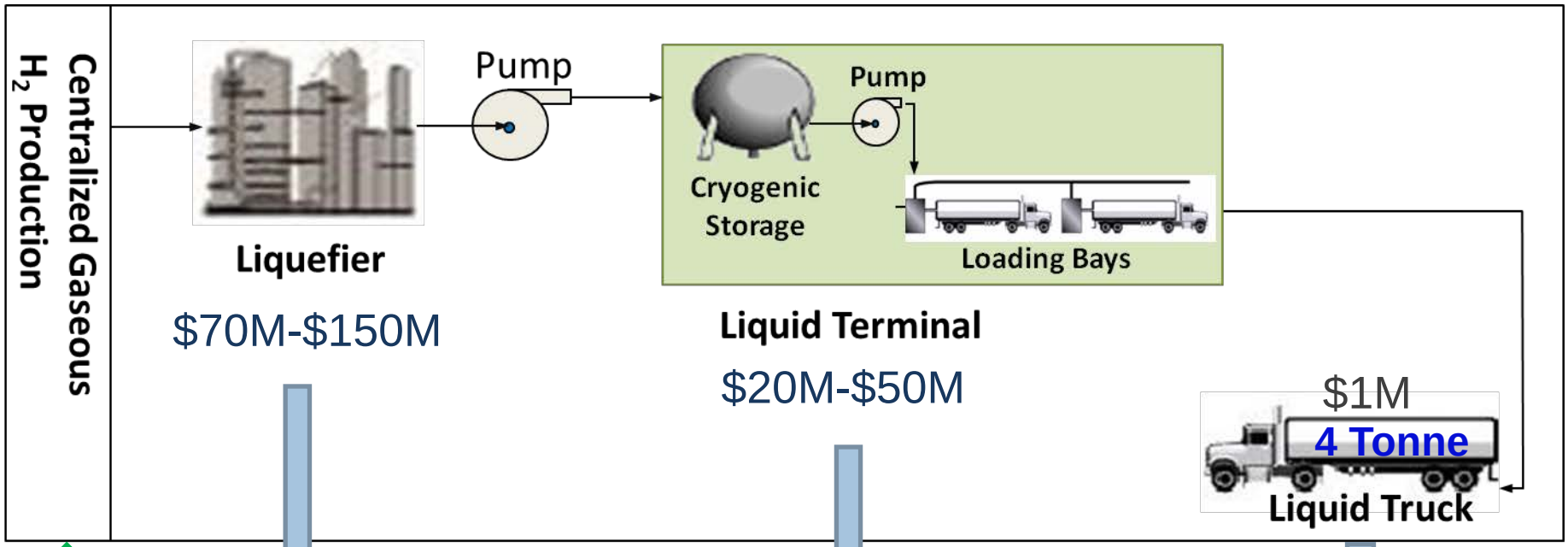
Discussion points for pipeline T&D option

- What demand/projection levels and regions justifies pipeline investment?
- What is the cost premium of H2 pipeline over NG pipelines?
- What are the pros and cons of steel vs. FRP pipeline?
  - ➢ FRP suitable for high capacity transmission?
- What is the optimum (or permissible) pipeline pressure (and range of operating pressure)?
  - ➢ Are service lines permitted to operate at 20 bar everywhere? (implication on forecourt compression)
- What is the trade off between larger pipes vs. need for booster compression?

Discussion points for pipeline T&D option- Continued

- Can pipelines be used as storage?
  - ➢ What is the storage capacity and effects of pressure cycling?
- What is the impact or regional availability and suitable type/size of geologic storage?
- Does geologic storage impact hydrogen purity?
- What is the H2 leakage rate (pipeline and caverns) and odorant suitable for FC applications?
  - ➢ Can leakage rate exceed boiloff losses of LH2 T&D?
- What R&D activities are needed to reduce the cost of pipeline T&D and address technical barriers?

Cost contribution of components in LH2 T&D



$70M-$150M

$20M-$50M

30-100 MT/day

$1.5-$2/kg$_{H2}$

$0.3-$0.4/kg$_{H2}$

$0.2/kg$_{H2}$.100mi

Total T&D cost $2 : $2.5 / kg$_{H2}$

100 MT/day

30 MT/day

Energy Penalty and GHG Emissions of Liquefaction

SMR-H2 → 12 kg_{CO2e}/kg_{H2}

	GHG Emissions (g_{CO2e}/kWhe)	GHG Emissions (kg_{CO2e}/kg_{H2})*	Liquefaction Capacity (ton/day)
California	380	4.5	30
Louisiana	610	7.4	70
Indiana	1070	13	30
New York		0	40
Alabama	580	7.0	30
Ontario	130	1.6	30
Quebec	20	0.20	27
Weighted Average		**5.0**	
If US mix	670	**8.0**	

Gasoline WTW → 11 kg_{CO2e}/gal

*Assuming liquefaction energy of 12 kWhe/kg_H2

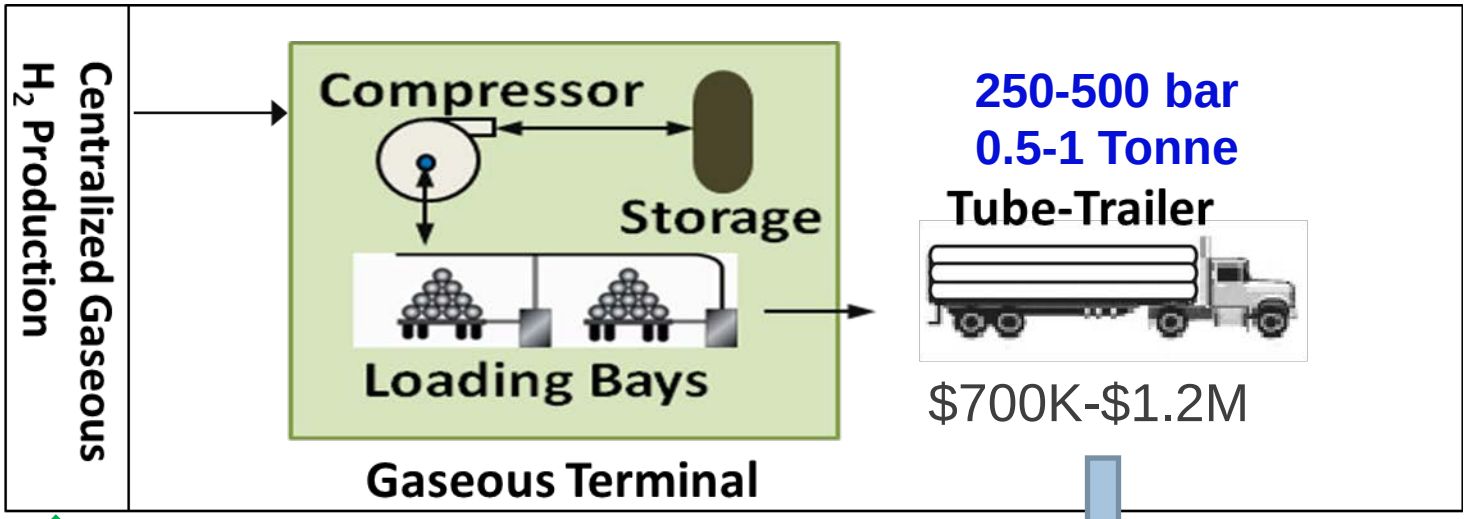
Discussion points for LH2 T&D option

- What is the surplus capacity of current liquefaction plants in North America (if any)?
  - ➢ What regions/markets can surplus capacity serve?
- What demand/projection levels (by region) justifies liquefaction investment?
  - ➢ Which regions have low cost/ renewable electricity or hydrogen as a byproduct of industrial process?
- Is there a difference between current cost (marginal?) vs. cost of depreciating new capital?
- What demand level/rate justifies liquid delivery? (H2 Boiloff rate vs. boiloff losses)

Discussion points for LH2 T&D option- Continued

- What is the impact of trucking distance on cost of delivered H2 and boiloff losses?
- Is there purity advantage of LH2 delivery for FC applications?
- Can liquefaction efficiency be improved?
  - What is the impact of improved efficiency on H2 cost? (capital vs. operating cost)
  - What is the impact of efficiency and electricity source on GHG? (33% renewable requirement in CA)
- Does liquid delivery help with refueling cost reduction?
- What R&D activities are needed to reduce the cost of LH2 T&D and address technical barriers?

Cost contribution of components in tube-trailer T&D



Total T&D cost $2 / kg$_{H2}$

Discussion points for tube-trailer T&D option

Terminals for loading high-pressure tube-trailers with large market demand do not exist and are not well understood

- What compression technology is suitable for loading tube-trailer?
- Is there compressors with high throughput and high pressure ratio, while maintaining H2 quality?
- Is liquid pumping an option? What are cost and WTW energy/GHG of liquefaction?
- What is the loading time? Is precooling required for fast fills?

- What demand/projection levels (by region) justifies investment in tube-trailer terminals?
- What frequency of delivery is practically acceptable for various end use?
- What is the trade off between trucking distance and payload/ frequency of delivery?

Discussion points for tube-trailer T&D option - Continued

- What is the practical/optimum heel (return) pressure for tube-trailer?
- What are the pros and cons of many small tubes vs. few large tubes?
- What are the pros and cons of type III vs. type IV?
- What are the impacts of depth and frequency of pressure cycling?
- What is the tube-trailer lifetime? What is the retesting frequency/cost?
- Does tube-trailer delivery help with refueling cost reduction?
- What R&D activities are needed to reduce the cost of tube-trailer T&D and address technical barriers?

Thank you!

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