TECHNO-ECONOMICS AND PROCESS ENGINEERING ANALYSIS OF INTRODUCING HYDROGEN IN NATURAL GAS PIPELINE INFRASTRUCTURE:A CASE STUDY FOR NEW DELHI,INDIA

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INDIA:Hydrogen-Opportunities and Challenges

$5 Trillion Economy by 2025

46.3% of Installed Renewable Energy Capacity at present

Hydrogen Market Size- $8 Billion by 2030

OPPORTUNITIES

- Govt. Initiatives- National Hydrogen Mission
- 2070 Net zero emission goal
- 5 MMT green H_2 by 2030
- 30 million jobs in the decade ending 2030
- R&D investments

CHALLENGES

- Energy Import Bill- $90.3 billion
- Supply Chain Challenges
- Integration with other energy vectors-Natural Gas
- High Capital Costs
- Energy Storage

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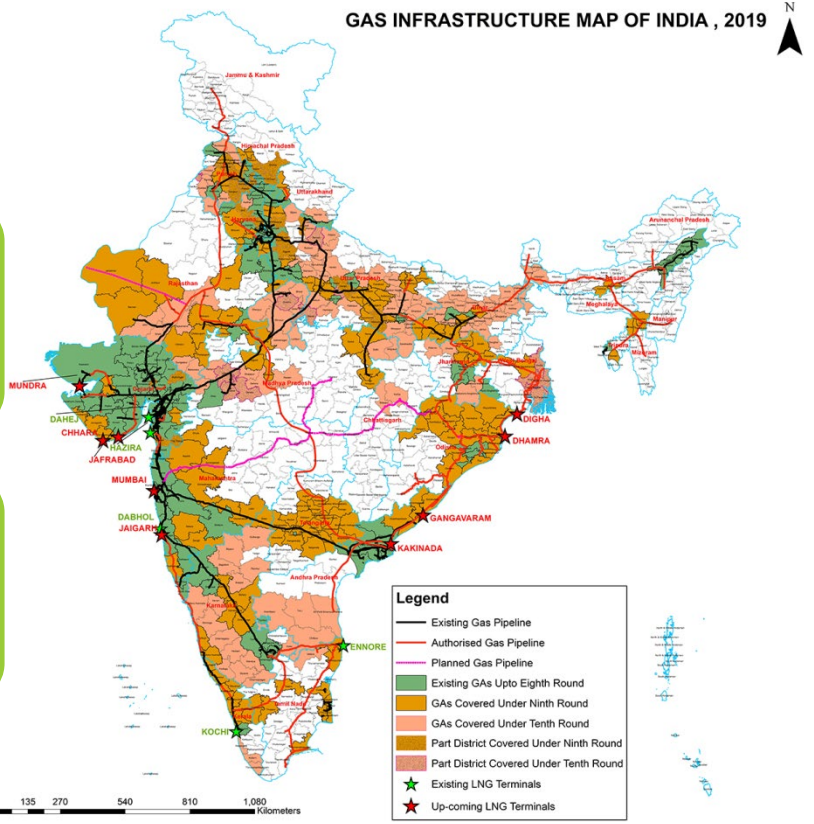
GAS INFRASTRUCTURE MAP OF INDIA

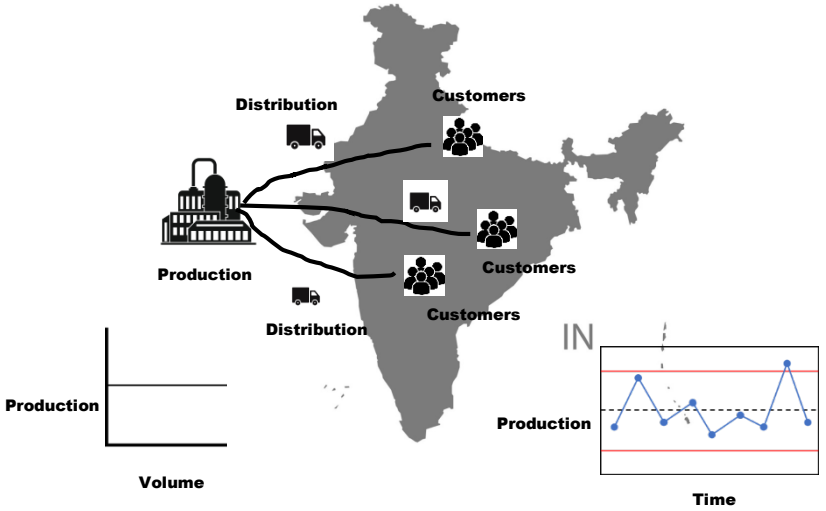
	Grey Hydrogen	Blue Hydrogen	Green Hydrogen
Process	Steam Methane Reforming or Gasification	Steam Methane Reforming with Carbon capture	Electrolysis
Source			



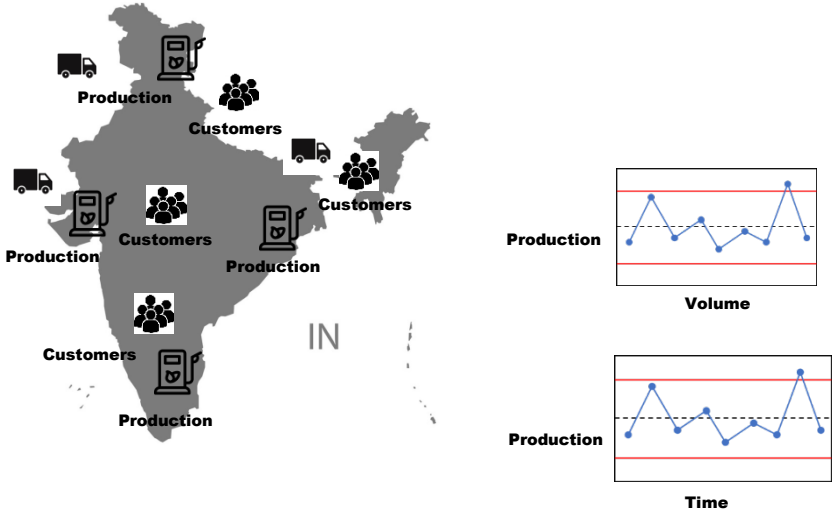
Source: *MoP&NG, India*

Emerging Opportunities in INDIA

CENTRALIZED Production

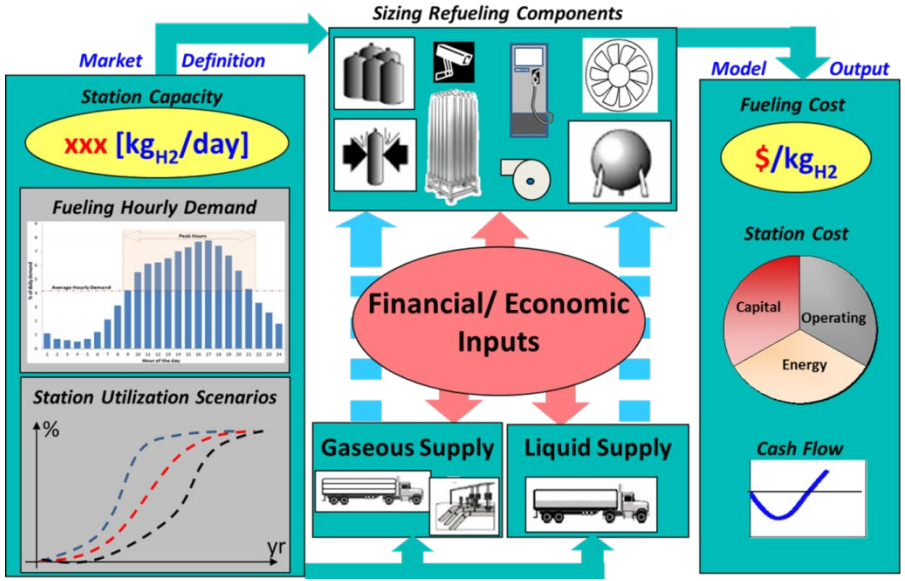


DECENTRALIZED Production



- Centralized Production model vs. Decentralized Production Model
- Use of Techno-Economic Tools for Hydrogen Production and Distribution Analysis
- Investment Directions
- Integrating Process Engineering Science and Policy

Hydrogen Delivery Scenario Analysis Model-HDSAM



Source: USDOE

General Economic Assumptions	Input values
Operating Capacity Factor (%)	90
Assumed start-up year	2025
Basis year	2016
Depreciation Type	MACRS
% Equity Financing	25
Interest rate on debt, (%)	8
Debt period (years)	10
Inflation rate (%)	5
After-tax Real IRR (%)	10
State Taxes (%)	6
Federal Taxes (%)	17.5

Delivery Scenario
= *f* (Market, Market Penetration, Delivery Mode)

based model

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Hydrogen Delivery Scenario Analysis Model (HDSAM)

Using a design calculation and engineering economics approach HDSAM tool models the various hydrogen delivery scenarios from the central production gate to the vehicle.

The analysis is concentrated around National Capital Territory (NCT Delhi). The city area is 573 square miles.
The hydrogen market is urban and the population data is taken from the census of India.

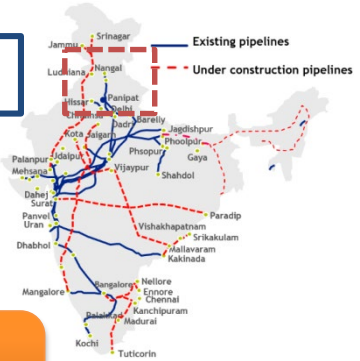
The cost parameters are determined for 3 scenarios

a) Cost of gaseous hydrogen with pipelines as the transmission and distribution medium
b) Cost of gaseous hydrogen with tube trailers as the transmission and distribution medium
c) Cost of liquid hydrogen from delivery and transmission by trucks.

RESEARCH OBJECTIVE

Modeling Approach

HDSAM MODEL



Liquid H_2 truck

Pipelines

Tube Trailers

Transmission

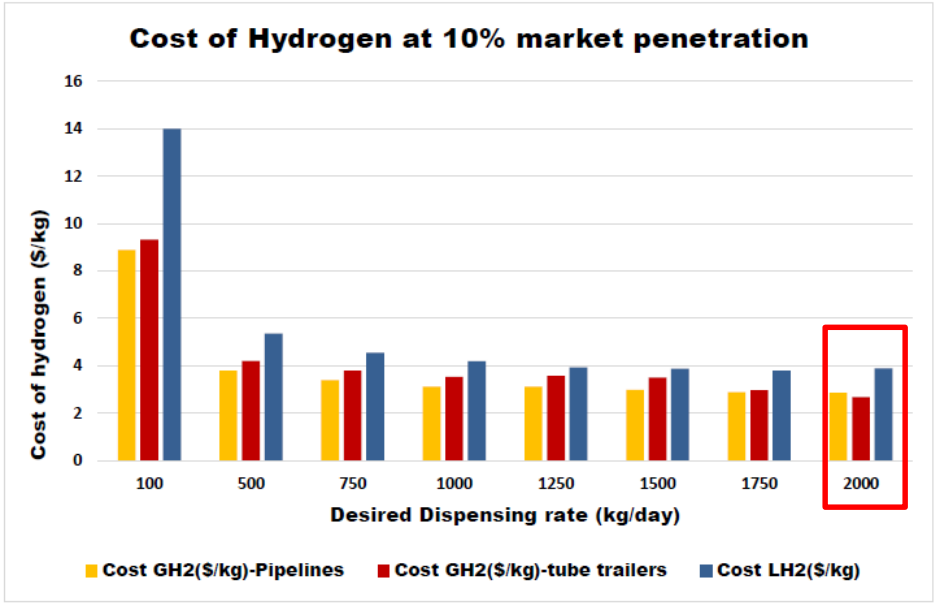
Distribution Terminal

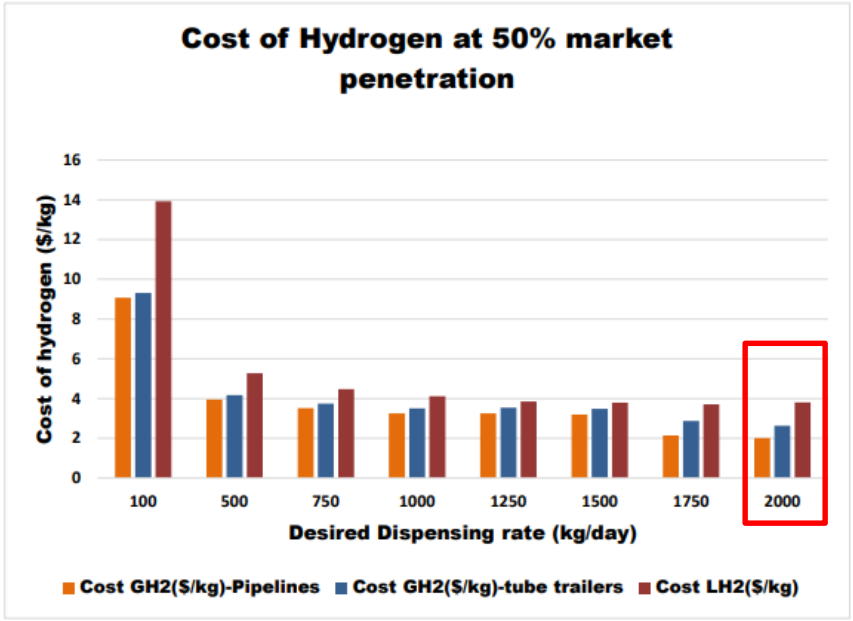
Storage and Distribution Conditions

- New Delhi-Nangal Region- Techno-Economic Analysis
- Fundamental Pipeline Modeling-Process Engineering Analysis

HDSAM Results for New Delhi

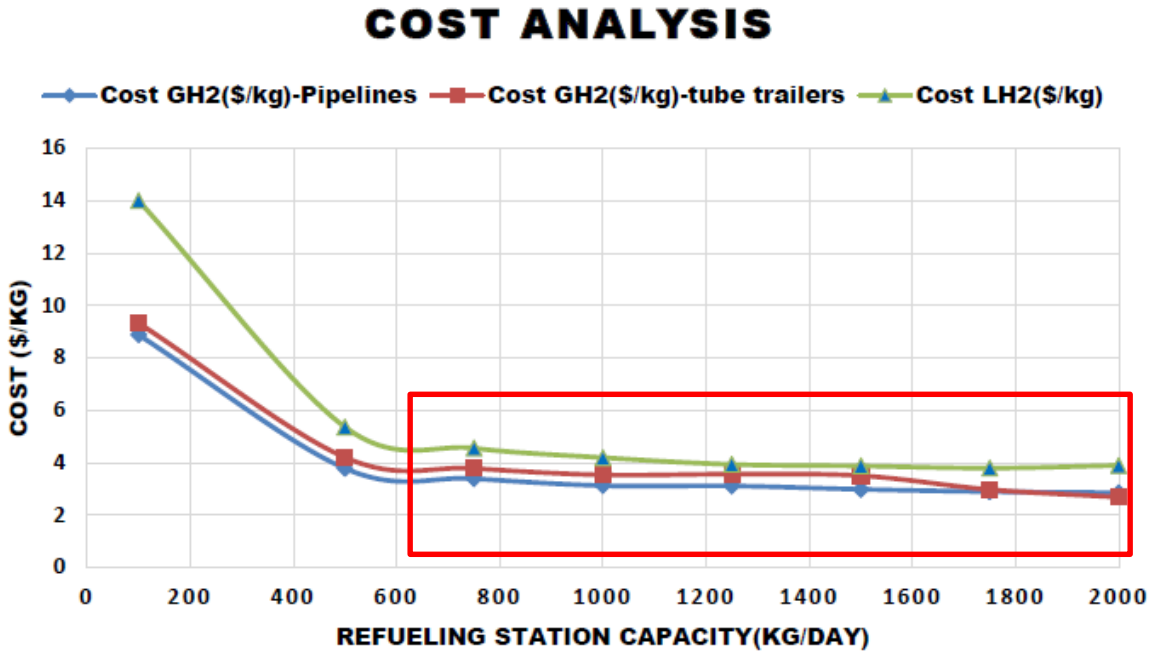
Market penetration does not play a significant role in determining the delivery cost of hydrogen, but it is the desired dispensing rate which plays a major role in determining the delivery cost.



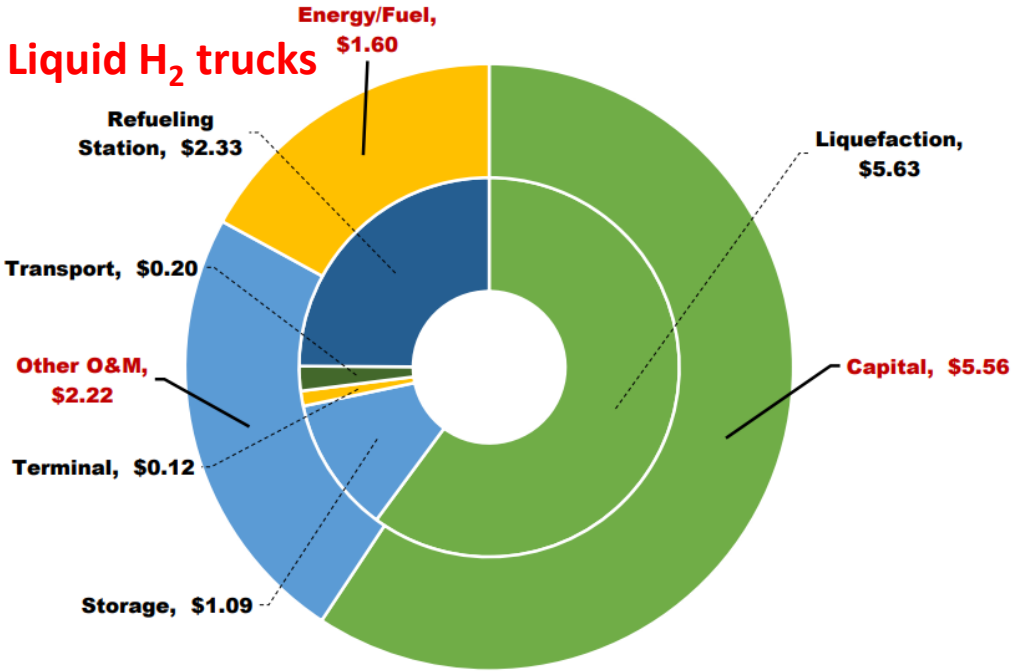


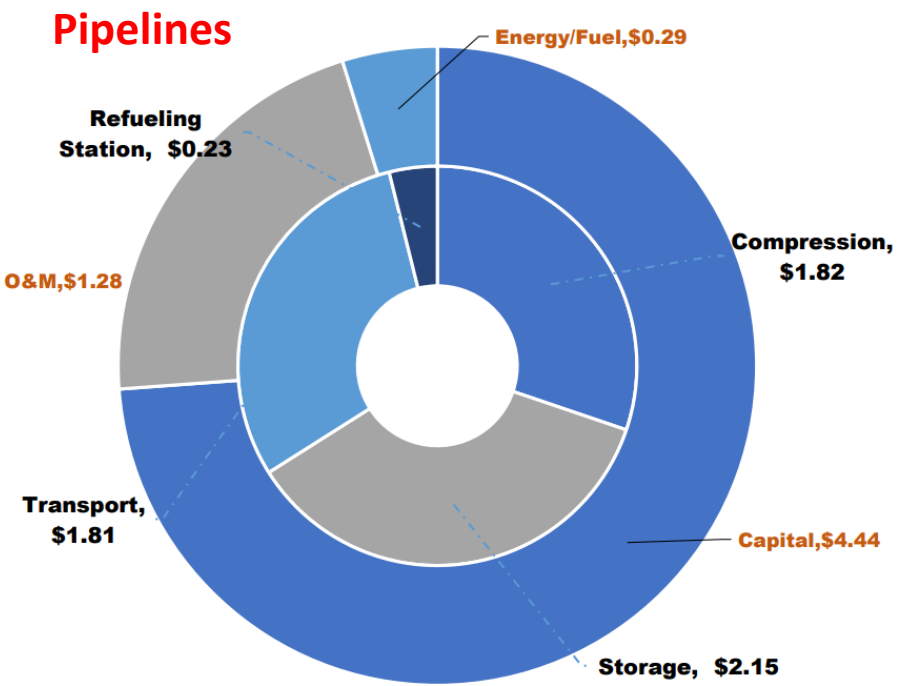
HDSAM Predictions for New Delhi

- For low refuelling station capacity of 100 kg/day there is a significant difference between the cost of gaseous and liquid hydrogen.
- At high refuelling station capacity the cost of hydrogen is at par with the cost of conventional fuels like natural gas.



Representative HDSAM Results

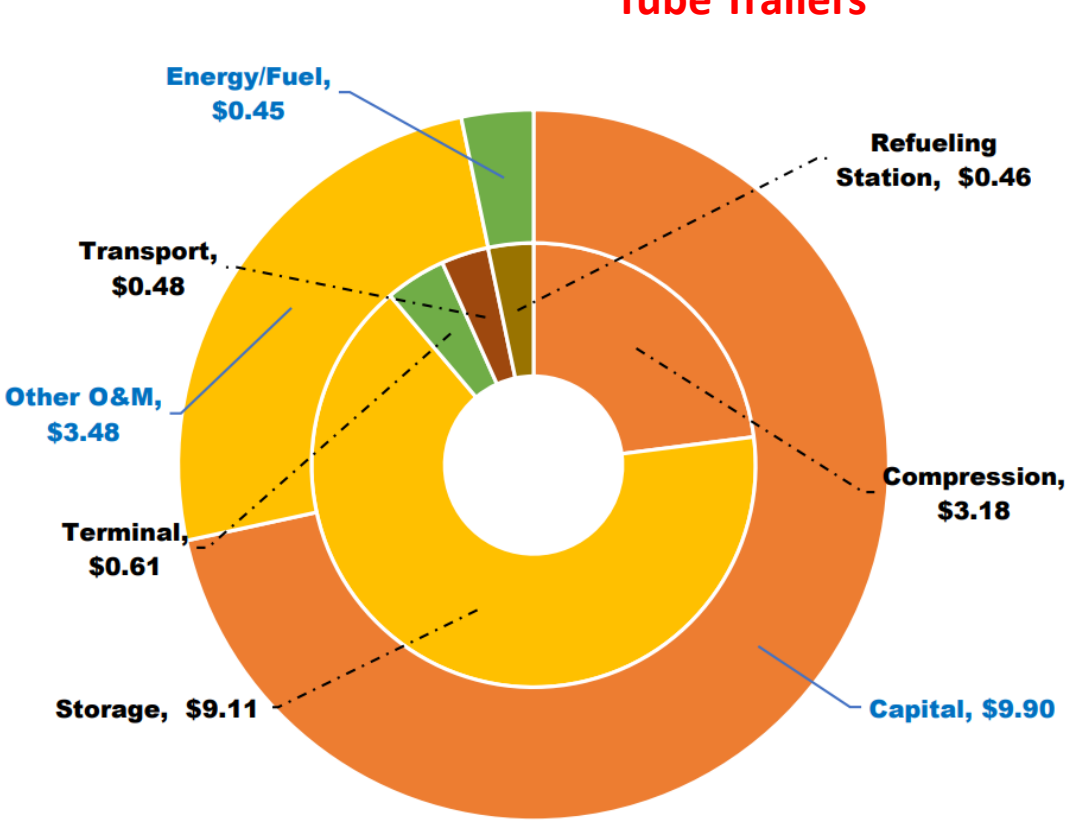




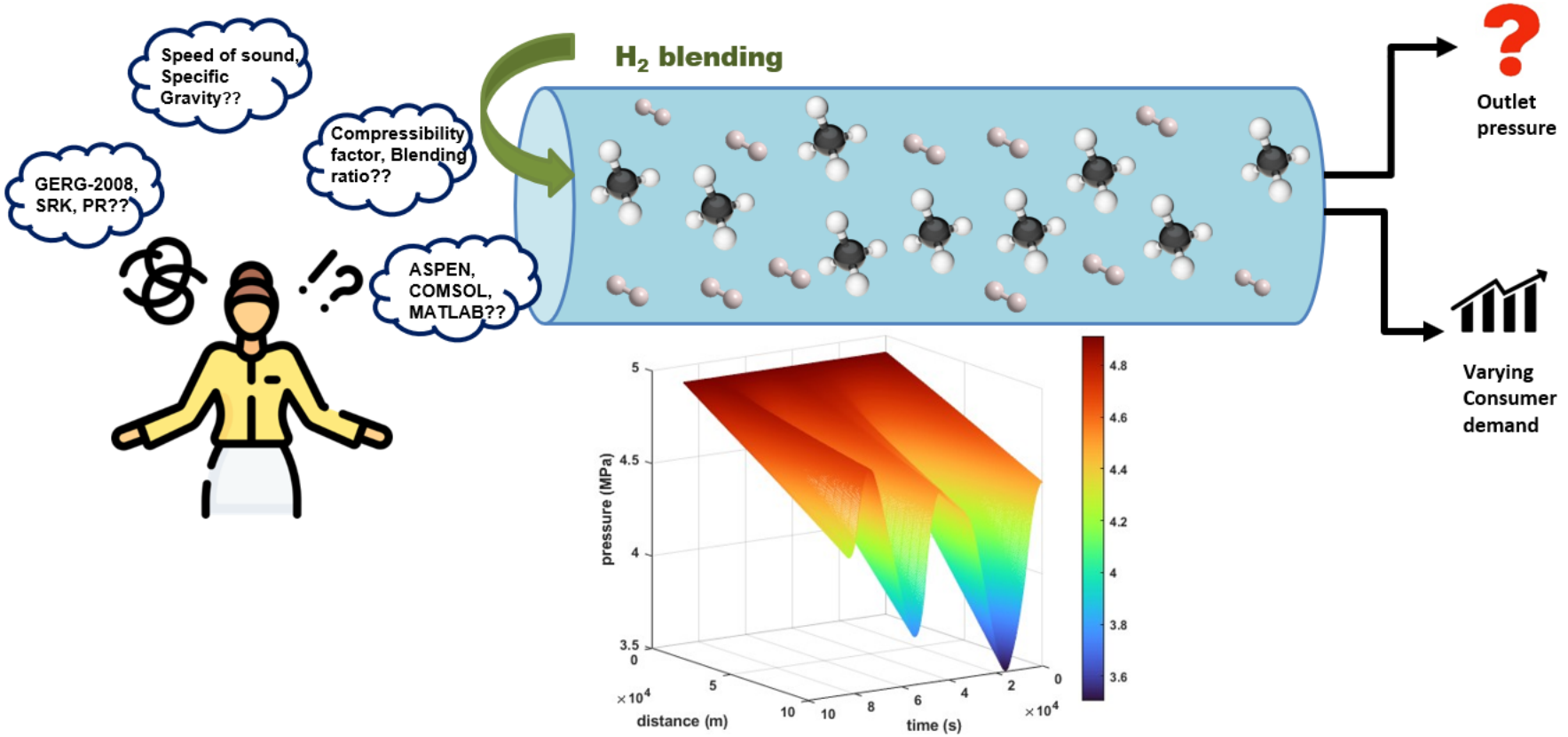
- Cost and Component breakdown for Liquid H_2 trucks and Pipelines
- The levelized cost of hydrogen is estimated at $9.37/kg and $6.01/kg for trucks and pipelines respectively.

Representative HDSAM Results

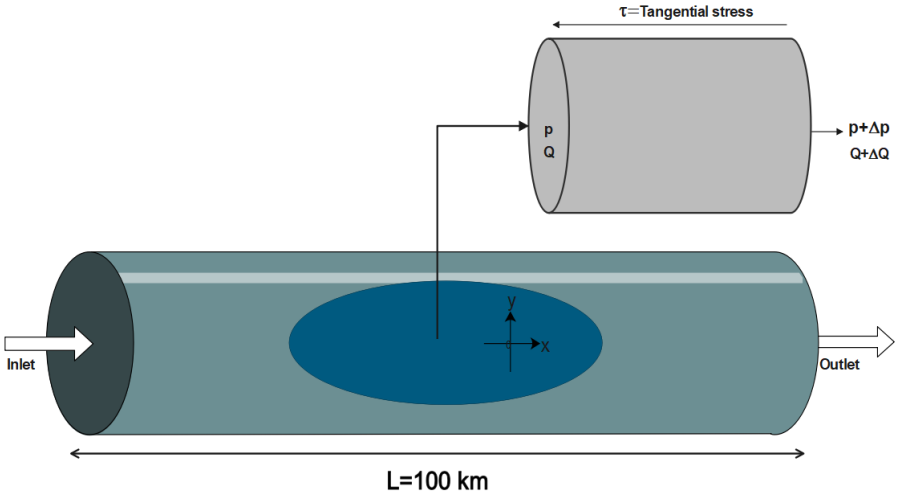
- The levelized cost is estimated at $13.83/kg.
- The compression and storage costs are the highest in terms of function at 350 bar cascade dispensing.
- The primary reason for the highest cost of delivery by tube trailers is their limited storage capacity (typically 850 kg/day)

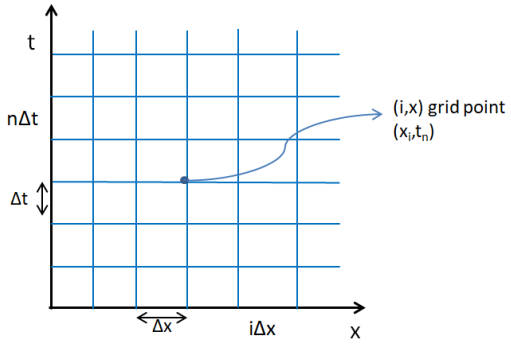


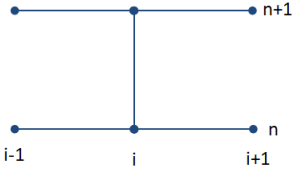
How Techno-economic analysis influences the course of research?



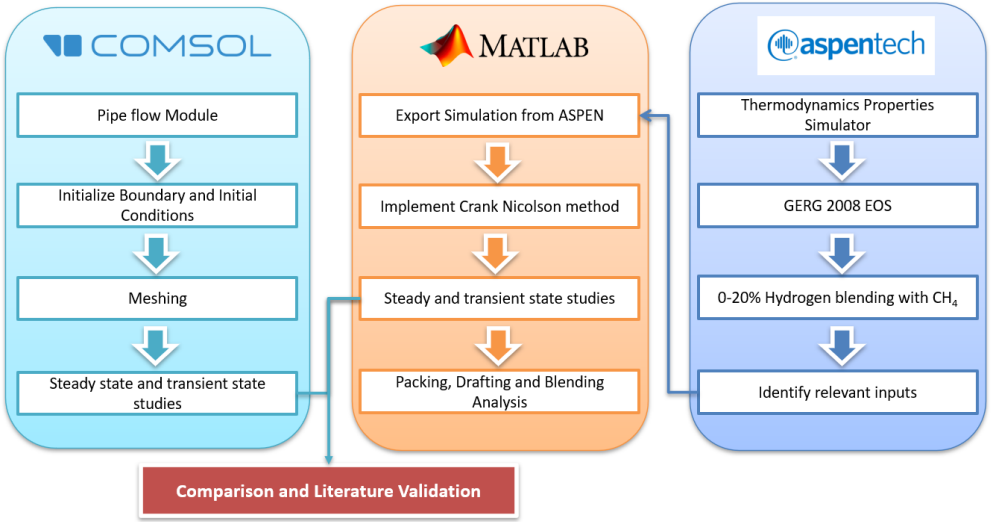
Process Engineering Analysis



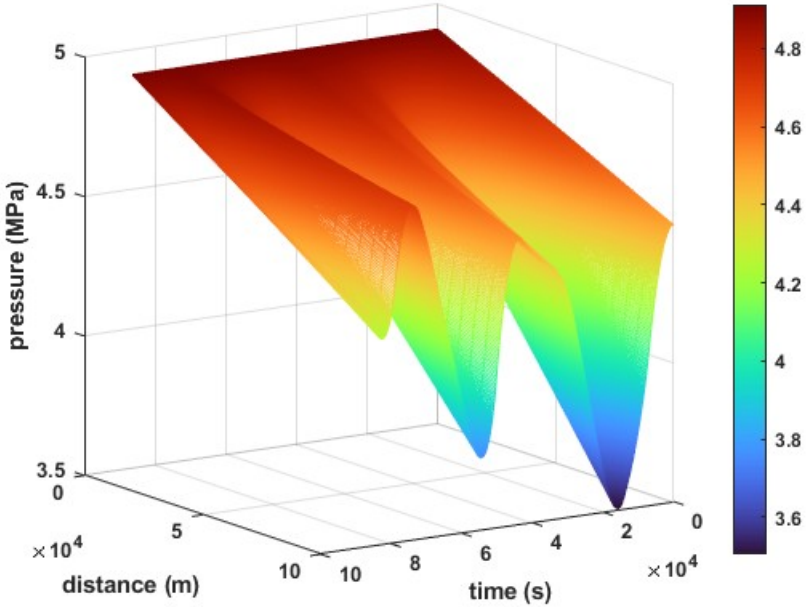




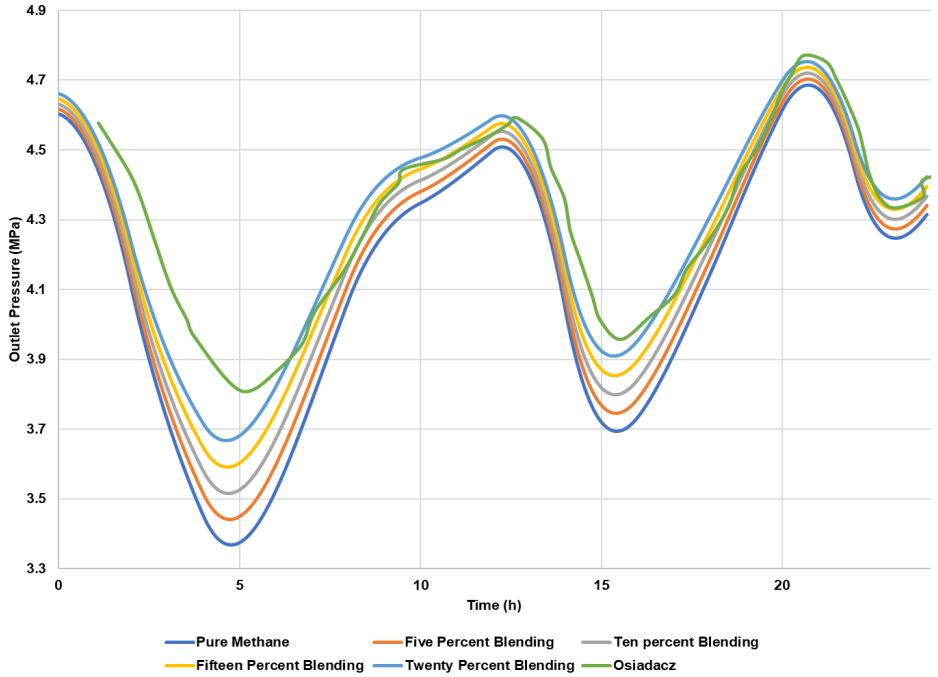
Modeling Approach



Impact of Hydrogen Blending using COMSOL and MATLAB

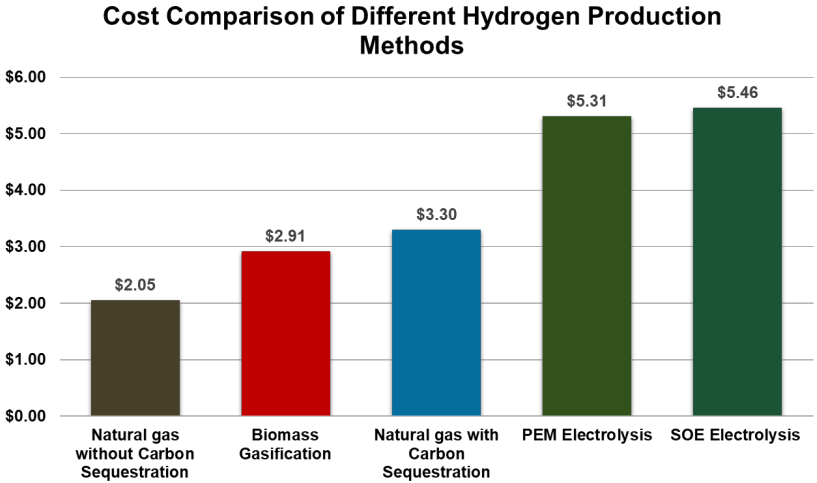


MATLAB modeling of Pipeline



A PERSPECTIVE IN POLICY DESIGN AND IMPLICATIONS

- The existing pipeline infrastructure can be modified to make it more cost-competitive
- Liquid H_2 trucks are also viable options for delivery infrastructure if scaled up with cost incentivization with infrastructure development, subsidies and tax credits.
- The scope lies in building refueling stations, pipelines and storage facilities.
- The key to finance hydrogen market is derisking of finance structures. Various production-linked incentives (PLIs) need to be introduced to encourage a green hydrogen supply and demand chain market.



Sharma, S., Sahir A.H., "A Techno-Economic analysis perspective on Hydrogen Production and Utilization for India", 44th IAEE International Conference, February 3-8, 2023, King Abdullah Petroleum Studies and Research Center (KAPSARC), Riyadh.

THANK YOU

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