

# Hydrogen-CNG Auto Fuel: A stepping stone towards Hydrogen Economy

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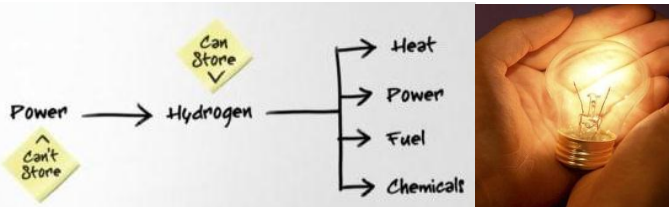
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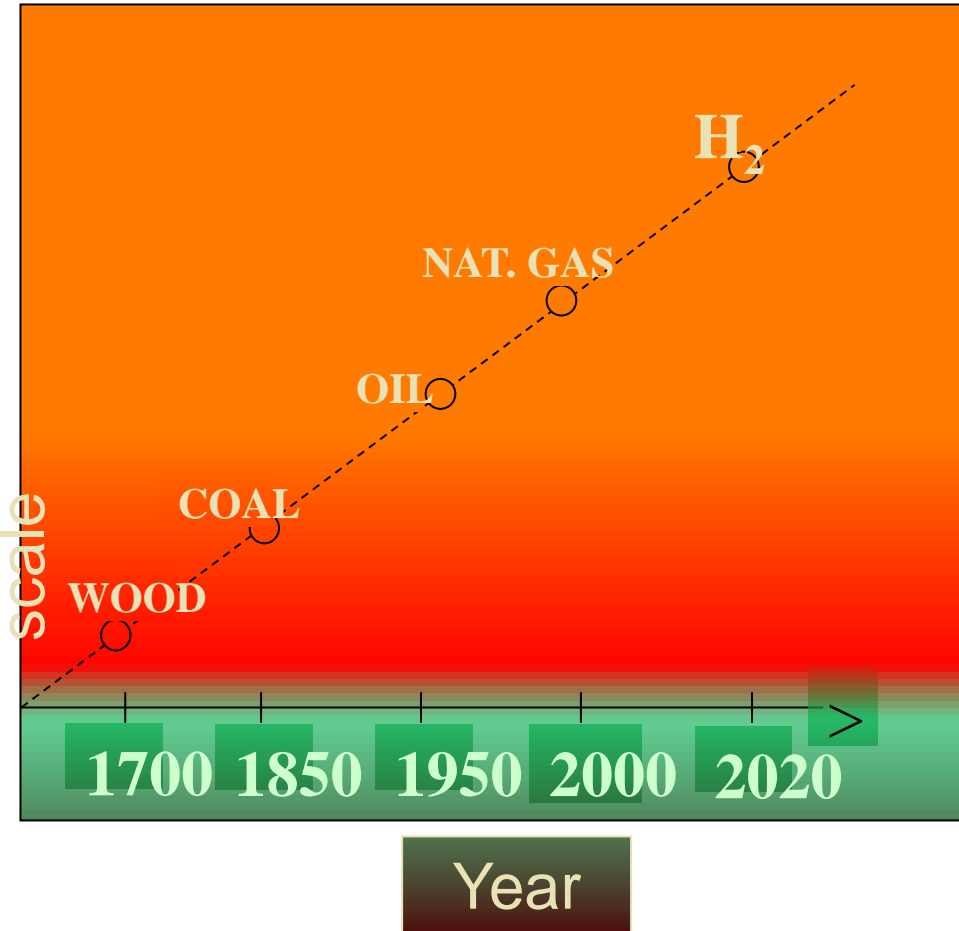
- Clean energy carrier –water only combustion product
- Can be produced from renewable sources – reduction in GHG emissions
- Stationary power applications
- Meeting peak energy demands – storing energy in the form of Hydrogen
- Decentralized production
- Very efficient when used in fuel cells

## Expected role of hydrogen?

- Medium for energy sector decarbonisation
- Electrification of Mobility sector - Fuel cells
- Electrification of heat – Decentralized power generation
- Optimizing energy systems – energy carrier & storage medium

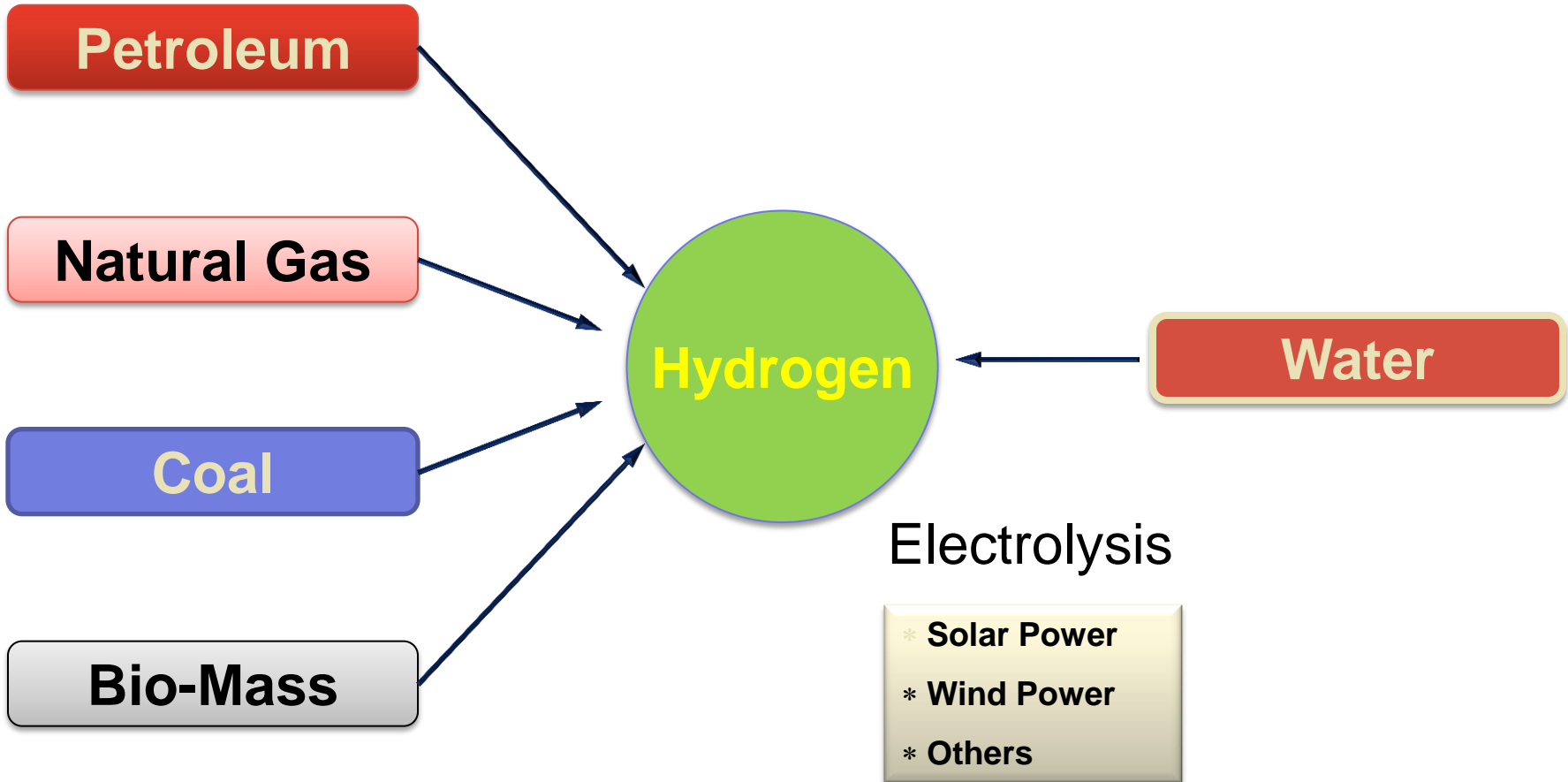


H/C ratio log.



***Hydrogen is the answer for meeting stringent environmental norms and mitigating climatic change without impacting the growth pace***

# Hydrogen Production Pathways



**Hydrogen can be produced from variety of sources**

# Hydrogen Production Pathways

## Recent Research Trends

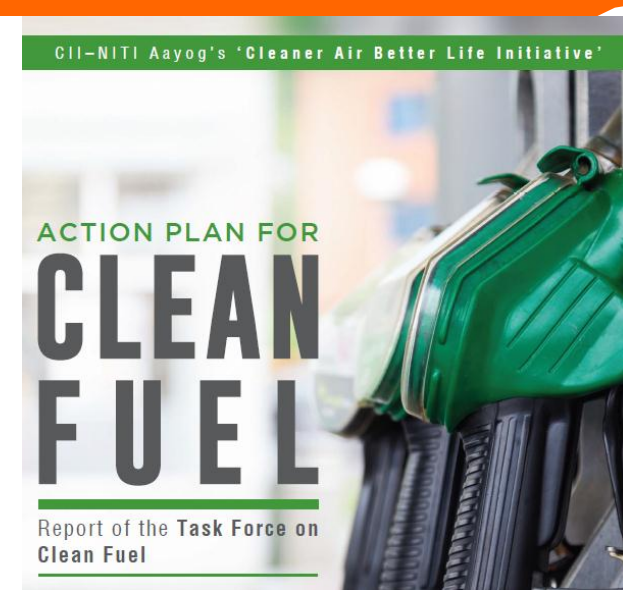
Hydrogen Source	Current H <sub>2</sub> -Prod Process	New H <sub>2</sub> -Prod Process Options	Research Focus
<b>Natural Gas</b>	Steam Reforming & Water Gas Shift	Advanced reforming & Membrane Processes	Catalysis & Materials Microchannel reformers
<b>Petroleum</b>	Naphtha reforming	On-board/On-site Reforming & Adsorption Desulfurization	Reactor Configuration Processing Scheme
<b>Coal</b>	Gasification, Cleanup & water Gas Shift	Advanced integrated Process & O <sub>2</sub> /H <sub>2</sub> Membranes	Product Separation Membrane Separation
<b>Biomass</b>	Gasification/Reforming & Water Gas Shift	Catalytic Production/Separation Biological H <sub>2</sub> Production	System Optimization Integrated Systems
<b>Water</b>	Electrolysis Using Electrical Energy	Thermochem Cycle & Membrane Photo-catalytic/Photo-electrochemical	Innovative Concepts / use of solar, wind or any other form of renewable energy

# Challenges for Hydrogen Economy

- Low specific volume energy density – Range is a problem for automobile applications at lower storage pressure
- High pressures and very low temperatures required for storing in liquid phase
- Safety concerns – poor public acceptance
- Infrastructure for transport, distribution and storage not well developed
- Cost

## ❖ Hydrogen

- Clean carbonless fuel
- Exhaust emission: only water
- Blending Hydrogen in CNG
  - ✓ More stable combustion
  - ✓ Minimal modifications in existing IC engine technology
  - ✓ Reduction in pollutants such CO and THC
  - ✓ Infrastructure for CNG dispensing in place
  - ✓ Intermediate option



HCNG can be used as a fuel for heavy duty engines after minor engine optimisation.

**An interim pathway towards Hydrogen Economy using existing infrastructure**



# HCNG Initiatives by IndianOil

- IndianOil set up India's first Hydrogen & HCNG Dispensing Station at its R&D Centre, Faridabad in Oct, 2005
- Aimed towards development and demonstration of HCNG vehicles



# HCNG Initiatives by IndianOil

- IndianOil set up India's 1<sup>st</sup> semi-commercial Hydrogen/HCNG dispensing station at Dwarka, Delhi (2009)
- Used for fuelling vehicles running on HCNG blends for demonstration projects
- Both Station have following components:
  - Electrolyser for Hydrogen production (5 Nm<sup>3</sup>/hr)
  - Compression system (350 Bar)
  - Storage
  - Blender /Dispenser
    - ✓ Hydrogen at 350 bar
    - ✓ HCNG at 250 bar



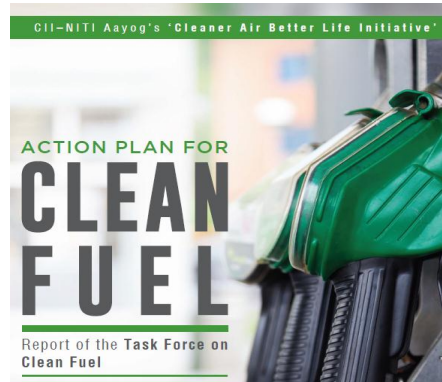
- Collaborative project undertaken with consortium of Automotive OEMs
- HCNG blends evaluated on 7 light duty vehicles
- 18% HCNG shortlisted based on Power and Emission characteristics
- Long duration trials conducted on HCNG optimized vehicles
- Considerable reduction in CO & HC emissions and reasonable increase in Fuel Economy as compared to CNG

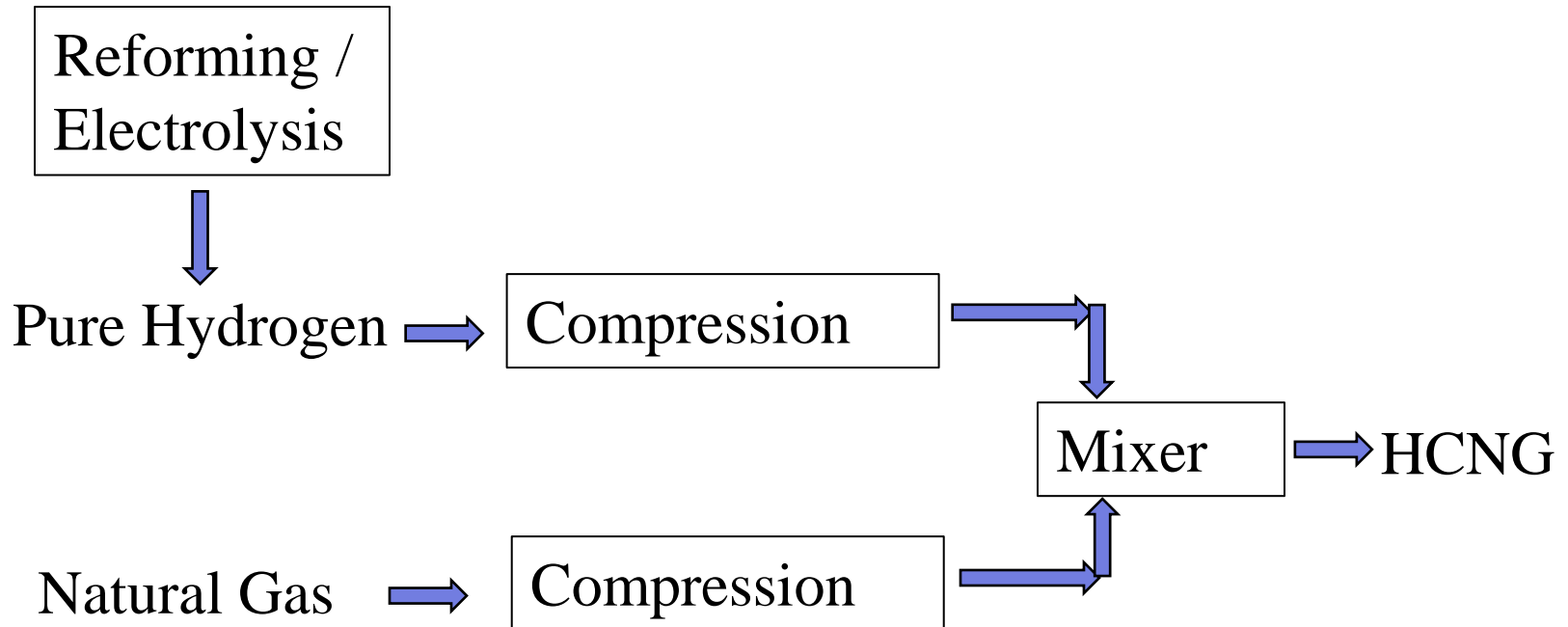


# 18% HCNG.....a Cleaner Fuel

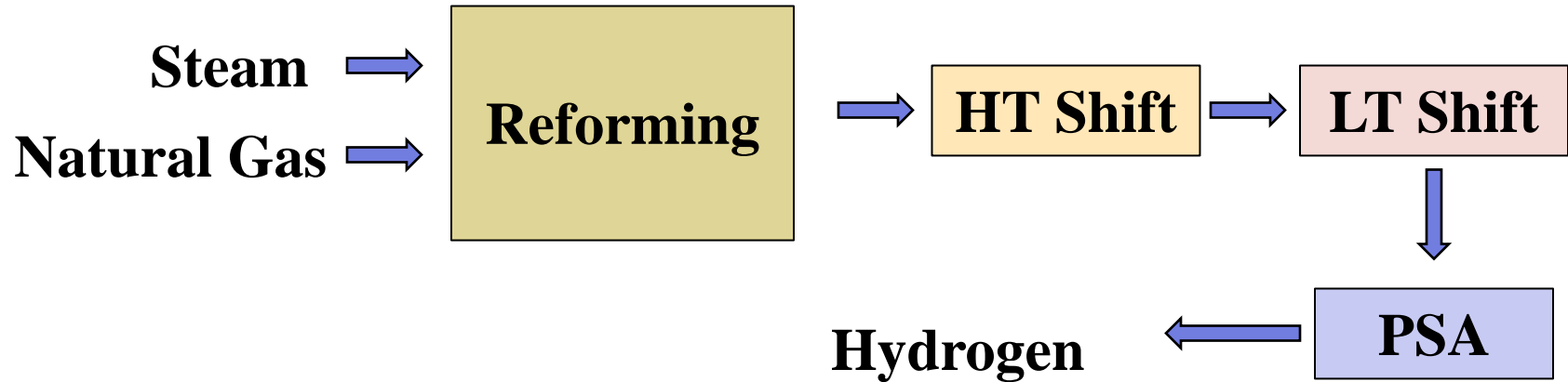
- ❖ **18% HCNG denotes blend of 18% Hydrogen in CNG by volume.**
- ❖ **Hydrogen addition in CNG**
  - **Lowers carbon content of fuel → Reduces CO & HC in tailpipe emissions of vehicle**
  - **Improves flame speed & calorific value → better combustion efficiency.**
  - **Lowers flame quenching gap → Reduces hydrocarbon emission**
- ❖ **HCNG a step for introducing Hydrogen**

Properties	Hydrogen	CNG	18% HCNG
Limit of Flammability in air, vol %	4-75	5-15	5-35
Flame Temp in air, K	2318	2148	2210
Burning velocity in NTP air, cm s <sup>-1</sup>	325	45	110
Quenching gap in NTP air, cm	0.064	0.203	0.152
Calorific Value, MJ/Kg	120	43.5	45.6





## ❖ Conventional Reforming



- High severity reforming: Temperature 850<sup>0</sup>C, Pressure ~25 bar
  - ✓ Exotic metallurgy
- Multiple steps to get pure H<sub>2</sub>
  - ✓ Expensive

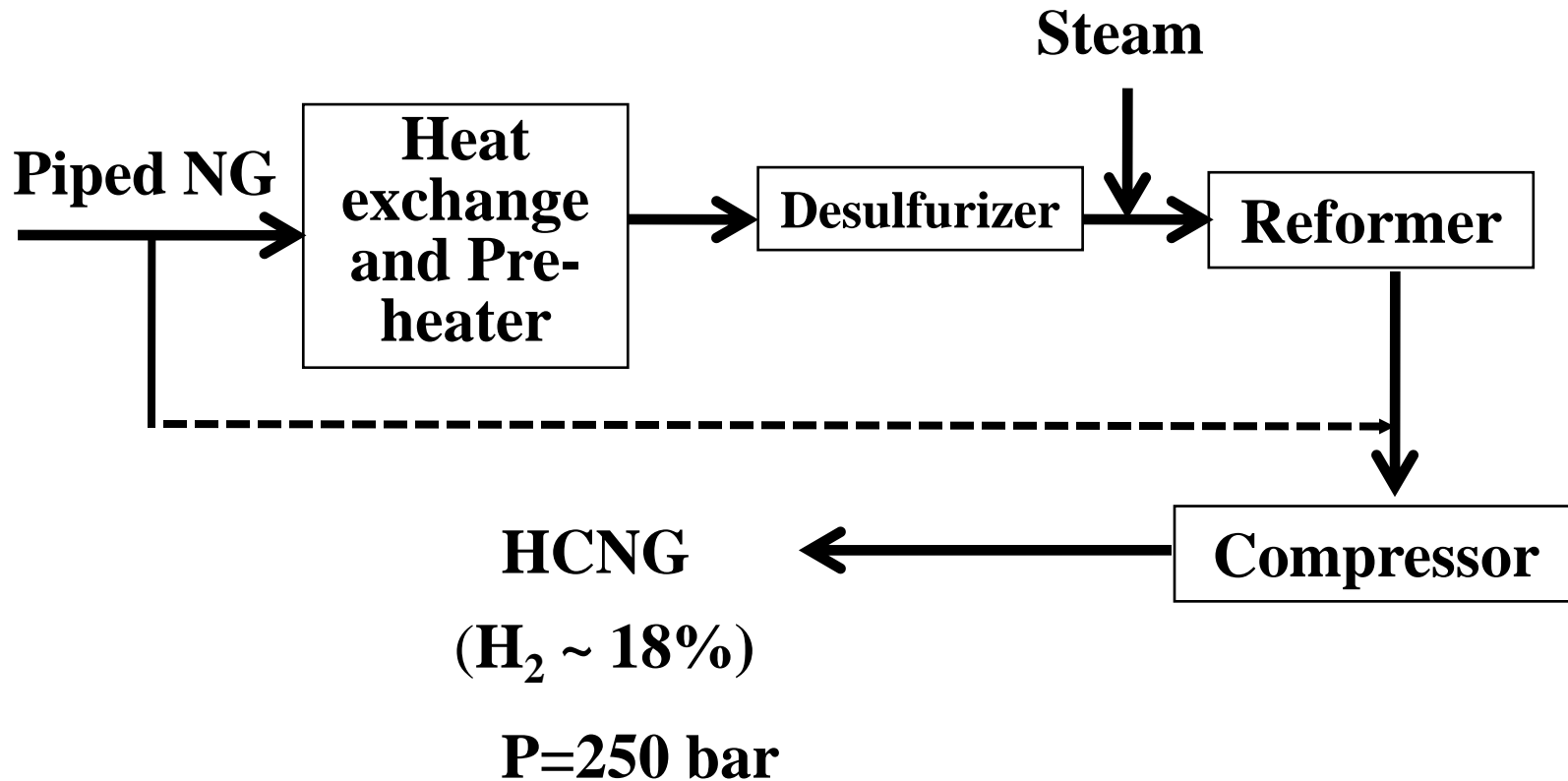


### ❖ Limitations

- Separate production of pure Hydrogen
  - ✓ Electrolysis of water: Expensive
  - ✓ Reforming: Multiple steps & high severity operation
- Separate compression for Hydrogen & Natural Gas
- Transportation & storage of high pressure Hydrogen
  - ✓ Safety
- Mixing of Hydrogen and CNG

**Multiple steps make HCNG production expensive**

## ❖ Process Flow Scheme





- ❖ In-house developed compact reforming process
  - Single step process
    - ✓ Direct conversion of Natural Gas into HCNG (15-20 % hydrogen) using conventional catalyst: Sulfur removal followed by Reforming & Shift reaction in single reactor
    - ✓ No separate Hydrogen production, compression & storage: more safe
  - Low severity operation
    - ✓ Mild operating conditions
  - Simpler process configuration
    - ✓ Fixed bed down flow vapor phase reactor

### ❖ Advantages

- Single step process
  - ✓ Direct conversion of Natural Gas into HCNG (15-20 % hydrogen) using conventional catalyst
- Low severity operation
  - ✓ Mild operating conditions
- Simpler process configuration
  - ✓ Fixed bed down flow vapor phase reactor
- No Carbon Monoxide in the reactor Effluent
  - ✓ No further CO processing
- Process designed for quick start / stop
  - ✓ Suitable for bus depots

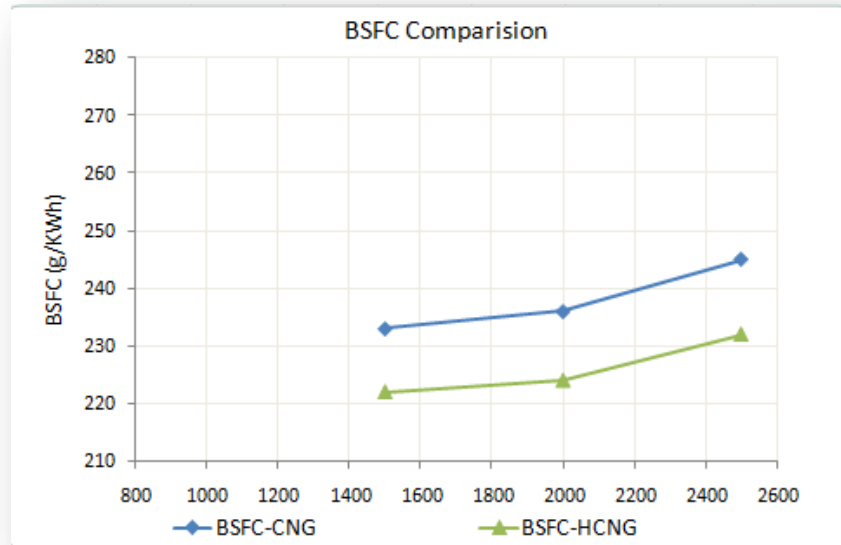
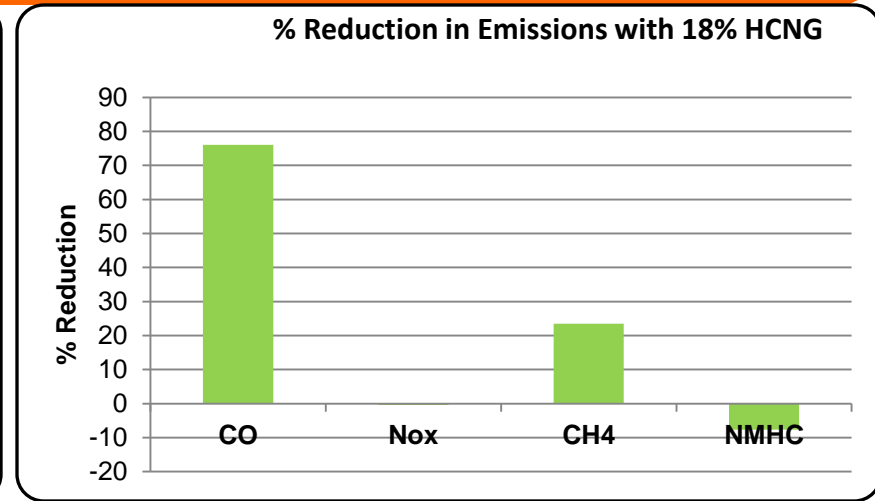
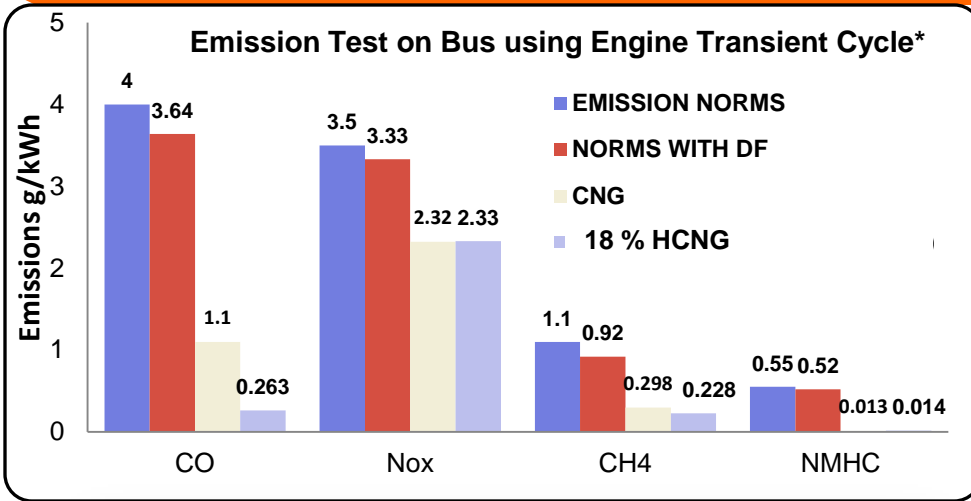
### Demonstration Unit

- Process developed using pilot plant (0.2 Nm<sup>3</sup>/hr capacity)
- Scaled up to 2.5 Nm<sup>3</sup>/hr Demo unit
  - ✓ Demo unit successfully installed & commissioned at IOCL R&D Centre – Scale up data generated
  - ✓ New HCNG car / bus dispenser installed & commissioned



**Scale Up Data Generated and BDEP Prepared alongwith  
M/s Technip for 250 Nm<sup>3</sup>/hr Capacity**

# HCNG Performance in Heavy duty Bus engine at ARAI



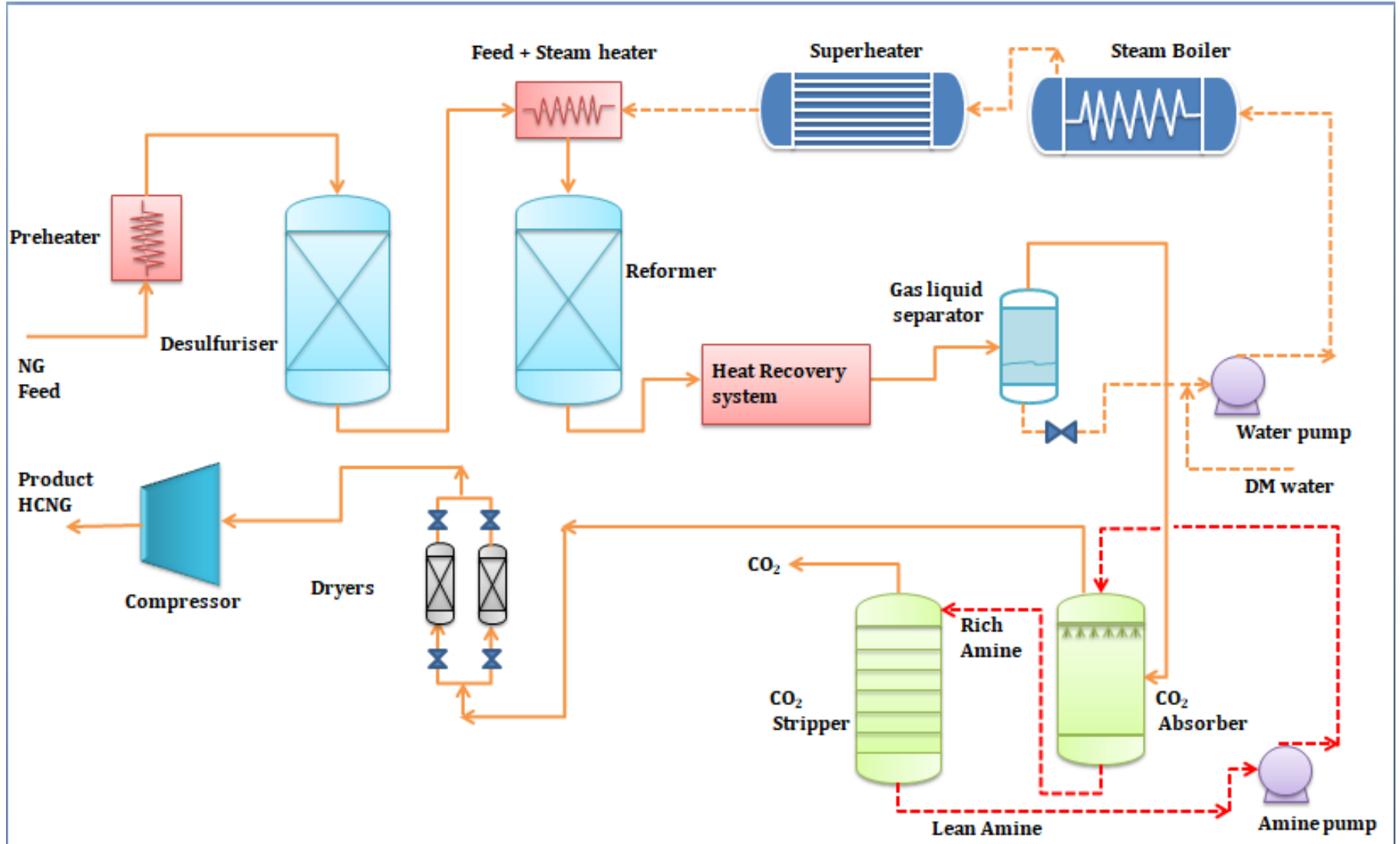
- CO emission :~70 % reduction
- THC emission :~15 % reduction
- NOx emission: at par with CNG
- Average fuel economy improvement 3%

*\*Based on tests conducted at ARAI,Pune on Heavy duty bus engine*

- ❖ **Hon'ble Supreme court took cognizance thru amicus curie & seeks implementation- Aug 2018**
- ❖ Affidavit submitted in **Aug 2018** by IOCL & MoPNG to conduct demonstration trial
  - ✓ Demonstration in one bus depot of Delhi comprising of a fleet of minimum 50 BS IV compliant CNG buses
  - ✓ Would require 4 TPD of HCNG mixture
  - ✓ **To complete the trials in 18 months**
    - Design & installation of unit for HCNG dispensing
    - Baseline data with CNG
    - Calibrate buses for HCNG & generate data to validate the test bench findings
  - ✓ Hon'ble court approved Rs 15 Crores from ECC for conducting the trial
- ❖ **Hon'ble court directed EPCA to monitor the progress**

- ❖ **Commercial demo unit being set up at Rajghat bus depot**
  - ✓ Hon'ble Supreme Court ordered to put up a Semi-commercial unit at a Bus Depot in Delhi and demonstrate the process in 50 BS-IV buses
  - ✓ Capacity 250 Nm<sup>3</sup>/hr (4TPD)
  - ✓ Cost of 4TPD reformer ~ 15 crore (Funding from ECC fund)

# 4 TPD HCNG Demonstration Unit



# Status of 4 TPD HCNG Plant

- **Plant Designed and Fabricated by M/s Technip**
- **Plant installed and ready for start up-PESO approval awaited**
- **O&M by Indraprashtha Gas Ltd**



**Commissioning by Feb 2020**  
**Trial Completion & Report to SC – July 2020**



**TIMES OF INDIA** NEW DELHI | SATURDAY, JULY 21, 2018

TO MEET OCTOBER DEADLINE, DELHI GOVT GIVES NOD TO MORE FUNDS FOR MUCH-DELAYED SIGNATURE BRIDGE | 5

UMAR KHALID JNU ADMINISTRATOR

# Better than CNG? Your bus may be more fuel-efficient, emit less carbon

## Delhi Govt Explores Use Of CNG-Hydrogen Blended Fuel

**Low-FLOOR CNG BUSES**  
Introduced in Delhi in 2001 following an SC order  
Approximate cost Rs 85 lakh; running cost Rs 18.54/km

**ELECTRIC BUSES**  
Delhi govt plans to procure 960 electric buses  
Approximate cost Rs 2-2.5cr; running cost Rs 17.25/km



**HYDROGEN-CNG BUSES**

- Tech that Delhi govt is toying with after SC directions
- HCNG is a blend of hydrogen with CNG, with hydrogen's portion being 18-20%
- Lower emissions; mileage also 4-5% higher than CNG-run buses

**HYDROGEN BUSES**

- Being developed by Tata Motors in India, but R&D still on
- Only produces water and heat instead of emissions, making it the cleanest
- These buses use hydrogen fuel cells that function like a battery, but don't need to be charged

**Delhi transport minister Kailash Gahlot told TOI** that the government will explore the possibility and the sport will be placed before C. Senior government officials said that they plan to introduce HCNG in the present lot instead of getting hydrogen-run buses, which are difficult to procure. "Hydrogen is extracted from methane and is blended with CNG to create HCNG. It uses carbon emission is far less than CNG. HCNG has 18% hydrogen and the rest is CNG. Indian Oil Corporation has a laboratory in Faridabad where HCNG is produced. We will need to modify our CNG-run buses slightly to use this fuel," said an official. The official said that they initially plan to use HCNG in 50 buses of the Cluster Scheme for which dispensing infrastructure would be installed at one depot. "HCNG is much more environment friendly than CNG. It would not be very difficult to use this fuel in our current fleet of buses. Hydrogen fuel cell buses, however, will take more time to be introduced," he added. SC had said that hydrogen buses are running successfully in other countries and their procurement might not be a problem as the Tata Group has started manufacturing such vehicles. Delhi government officials, however, said that procuring pure hydrogen-run buses would be difficult and it will take a long time to create such a fleet.

**You can soon buy DTC pass online**  
Soon, bus users will not have to stand in a queue to get a monthly pass made. Delhi Transport Corporation plans to make the process online and is working out the modalities, a DTC official said. "Bus commuters will be able to apply and pay online for a monthly pass and we will take a print out, laminate and send it to their residence through post," said a DTC official. DTC, along with the IT department of the Delhi government, has created software to issue passes online. The facility would first be available for general passes and then for concessional ones as they require verification. Every month, DTC issues over 1.5 lakh bus passes, including general and concessional for different categories like students, senior citizens. Monthly general passes are available for Rs 1,000 for air-conditioned and Rs 800 for non-air-conditioned buses. The

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**US national collapses, swift action**

- Demonstration agreement with the concessionaire M/s Antony Road Transport Solutions Private Limited (ARTSPL).
  - ✓ Identified 50 heavy duty CNG buses for the trial.
  - ✓ Shortlisted 7 buses for Fuel economy & emission testing at iCAT Manesar.
  - ✓ Field data logging commenced
- Comprehensive insurance lined up:
  - ✓ Insurance of 7 buses identified for testing at iCAT, Manesar - during transit to Manesar & testing at iCAT
- Testing at independent lab- iCAT Manesar– Baseline CNG vis-à-vis HCNG
  - ✓ Emission testing with PEMS by running DBDC, Idle and high idle emission tests, Constant Speed Fuel Consumption Test
  - ✓ Two set of tests on 7 buses completed  
(Tests to be done in 1<sup>st</sup>, 3<sup>rd</sup> & 6<sup>th</sup> month of trial)

- ✓ Successful demonstration may pave the way for mass adoption
- ✓ Centralized HCNG production
- ✓ Even the PNG Networks can be Converted to HCNG
- ✓ Reduction in emissions and improvement in efficiency

**HCNG- An Intermediate step towards Clean Environment and Hydrogen Economy**

*It's the **HY** time*



*Thanks*

Hydrogen  
blended CNG



**The Future to Hydrogen May be Nearer**