Mega Conference

Pioneering Technical Innovations for a Safe Tomorrow, New Delhi, 16-17th December 2024

Reducing Carbon Emissions through Sustainable Fuels

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Sustainable Fuels

HYDROGEN

National Green Hydrogen Mission – Jan 2022

SIGHT Programme: Financial incentive mechanisms

- ✓ *Targeting domestic manufacturing of electrolysers and*
- ✓ *Production of Green Hydrogen*

Pilot projects:

- ✓ *Green Hydrogen Hubs for emerging end-use sectors and production pathways*

R&D Projects:

- ✓ *Public-Private Partnership framework for R&D*

Likely Outcome 2030

- *Green hydrogen production capacity of at least 5 MMT per annum & ssociated renewable energy capacity addition of about 125 GW; 60-100 GW eletrolyser capacity*
- *1 lakh crore cumulative import savings*
- *~50 MMT of annual GHGs abatement*

METHANOL & DME

Feedstock

- Natural gas
- High ash coal
- Agricultural residue
- Fossil CO_2

	DME	Diesel
LHV MJ/kg)	27.6	43
Cetane Number	~60	~51
Density (kg/m3)	~735	~830
g CO_2e/MJ	<20 from biogas	~70

	Methanol	Gasoline
LHV (MJ/kg)	19.7	43.9
RON	109	91
Density (kg/m3)	790	740
g CO_2e/MJ	<40 (from biogenic feed)	~94

ETHANOL

- The blending % has increased from 1.53% (38 crore litres) in 2013-14 to 12% in 2022-23.
- As per National Policy on Biofuels, 20% Ethanol blending in petrol by 2025.
- Ethanol procurement / blending under EBP increased from 38 crore litres in 2013-14 to 433.6 crore litres in 2021-22.
- CO_2 emissions lowered by 318.2 lac ton in 8 years
- Cumulative foreign exchange impact due to ethanol blended petrol programme is estimated over Rs. 53,894 crores.

Future Outlook

- Nov' 23, India's ethanol production capacity ~1380 crore Ltrs (~875 crore Ltrs molasses based and ~505 crore Ltrs grain based)
- 20% blending by 2025 requires ~1016 crore Ltrs ethanol
- In 2022-23, with production of about 502 crore Ltrs ethanol, India saved about ₹ 24,300 crores of foreign exchange and improved India's energy security.

Sustainable Vehicle: Hydrogen ICE

Benefits of Hydrogen ICE

- Carbon Free Energy & higher efficiency (~30%)
- H_2 has RON of 130 vs 91 of Gasoline
- Higher Flame Speed→ Faster Combustion → Nearer to Cont. Volume Combustion → Closer to Otto Cycle Efficiency
- H_2 can be produced from water

Challenges of Hydrogen ICE

- Highly Flammable, safety concerns
- Smokeless combustion: Hard to detect, safety concerns
- Engines need to be redesigned to take care of pre-ignition & potential backfire in intake manifold
- Conventional Lubricants are incompatible
- Low Volumetric Energy Density, Even at 800 bar, H_2 tank only contains 1/7th of energy of Gasoline tank

H2 ICE in India

- Few hundred H_2 ICE vehicle running in testing & development stage

Next gen lubricants for H_2 ICE need to address the following challenges:

- Excess Water from Hydrogen combustion (65g/MJ Vs 32g/MJ for gasoline)
- H_2 can potentially change the lubrication regimes.
- Lubricant need to cater broader temperature range
- Lubricants with higher thermal stability and oxidation resistance are needed
- Material Embrittlement issue with H_2 requires diffluent metallurgy for engine component hence lubricants improvement.
- Improved base oil composition to prevent interreference in combustion

Compressed H_2	Liquified H_2	Through Material carrier
		
• 1.25 kWh/L (at 700bar) • 20% of energy goes in compression	• 2.20 kWh/L (at -253°C) • 40% of energy goes in liquefaction	• 5.50 kWh/L • Metal hydrides, Methanol, Ammonia, etc.

Source: H2 Storage Roadmap, DoE, USA

Sustainable Vehicle: Hydrogen Fuel Cell

Benefits of Hydrogen Fuel Cell

- Carbon Free Energy
- High Efficiency (~50%)
- Zero Emission
- H_2 can be produced from water

Challenges of Hydrogen Fuel Cell

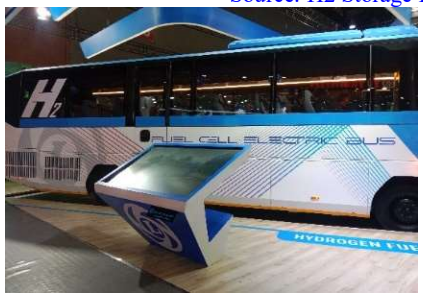
- Highly Flammable, safety concerns
- Smokeless combustion: Hard to detect, safety concerns
- Low Volumetric Energy Density, Even at 800 bar, H_2 tank only contains 1/5th of energy of Gasoline tank
- Fuel cell technology still under development in India

H2 Fuel Cell Vehicles in India

- Several prototypes have been launched
- Not yet adopted

Characteristic	H_2ICE	H_2FC
Efficiency	Good: mid – high load [30 to 45 %]	Excellent: low – mid load [50 to 60 %]
Emissions	Low NOx with aftertreatment	None
Durability	High	Improving with new R&D
Robustness	High	Sensitive to vibration
Noble metal consumption	Low – intermediate (after-treatment systems)	High
Fuel purity	Tolerant to contaminants	High-purity H2 required
Fuel flexibility	Diesel/NG backup	Can be flexible, efficiency penalty
Upfront cost	Low	High
Cold start	No issues	Temperature conditioning

Source: H2 Storage Roadmap, DoE, USA



Fuel Cell Vehicle Auto Expo 2023 & 2024

Sustainable Vehicle: Flex Fuel Vehicles (E20-E85)

Creating Future Fuels

Benefits of Flex Fuel Vehicles (FFV)

- Use of Renewable Feedstocks, Reduction in Oil Import & Environment friendly
- FFVs are compatible to any ethanol-gasoline blend from 20 to 85%.
- Higher Octane number offers more resistance to knock.

Challenges of FFVs

- 30% lower energy density for E85 vs gasoline vehicle
- High affinity to moisture and corrosivity of ethanol
- Higher fuel flow required due to lower calorific value, injector/fuel pump design change needed.
- Seal material/ elastomers and metals needs to be replaced with compatible materials.
- Cold start issue at higher ethanol blend % due to higher heat of vaporization

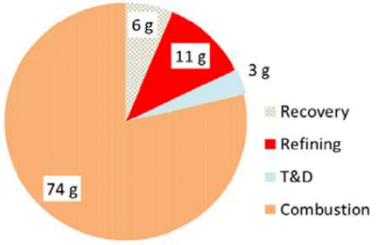
FFV in India

- Several prototypes have been launched
- Not yet adopted

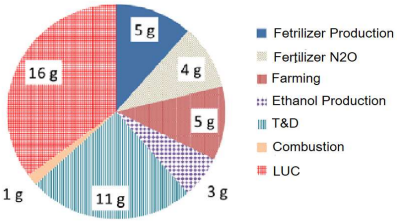
Outlook of FFVs in India

- Exemption or reduction of road tax on FFVs has been requested by Govt. of India to the State Govts.
- Production Linked Incentives (PLI) Scheme for automobile components of FFVs
- In the short term, FFVs in India likely to operate on ethanol blends less than E85
- Even if FFVs run on E30, import substitution and financial gain will be huge for the country

Prototype Flex Fuel Vehicles, India, Auto Expo 2024



Gasoline (94g CO_2e/MJ)



Sugarcane Ethanol (45g CO_2e/MJ)
After allocation based on energy

Source: Environ. Res. Lett. 7 (2012) 045905 (13pp)

Sustainable Vehicle: DME

Benefits of DME Vehicles

- Renewable/Indigenous Feedstock
- High Efficiency than gasoline ICE (~35%)
- Smokeless combustion
- Handled like LPG with minor modifications

Challenges of DME Vehicles

- Fuel availability
- Material compatibility
- Energy density 70% of Diesel

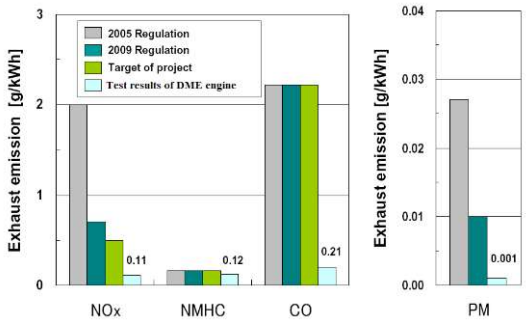
DME Vehicles/Engines in India

- Few demonstrations (Dual Fuel CI by IITD and IIP and LPG DME Blend in SI by IIP)
- Not yet adopted
- Several demonstration program in Japan, China, Europe and USA

Fuel Elastomer Interaction

Source: Dept. of Chemical Engineering, Penn State

Demonstration of LPG DME Blend in SI Engine at CSIR-IIP



NTSFEL & Nissan Diesel Motor Co. Ltd., Japan

CSIR-IIP Eco-Campus

Creating Future Fuels