# Alternative Fuels – Regulatory & Technology Perspective

Presentation By

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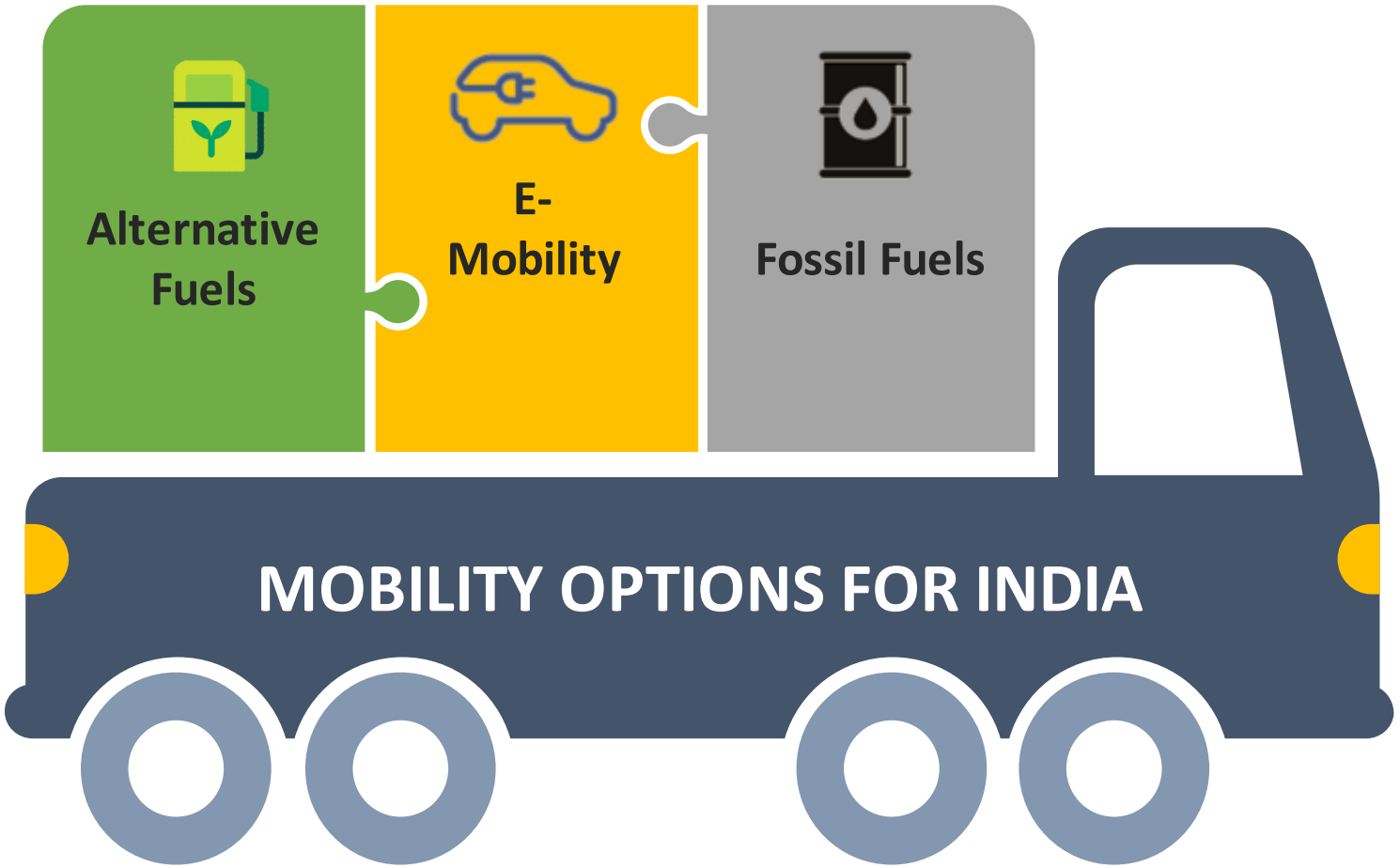
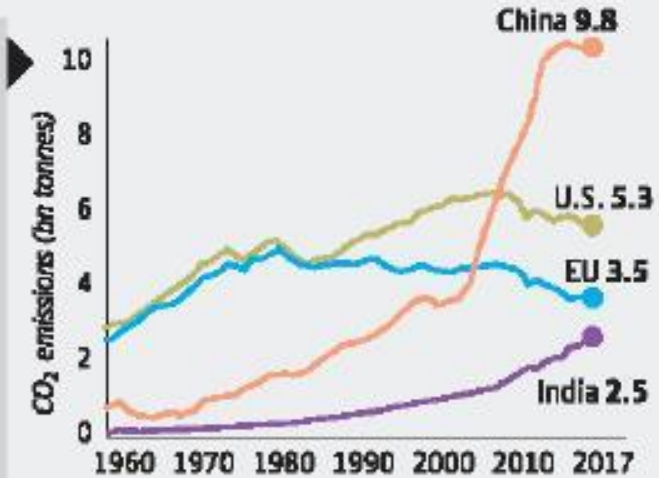
# MOBILITY OPTIONS FOR INDIA



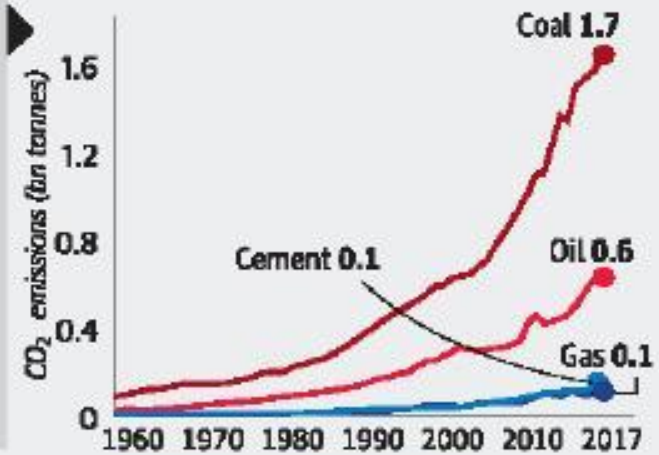
# A breath of foul air

India's projected carbon emission of 2.6 billion tonnes in 2018 would account for 7% of the global $CO_2$ levels, which are set to hit an all-time high this year

Global $CO_2$ emissions have risen steadily over the decades. China's emissions accounted for 27% of the global total. India was the third-highest contributor




Although India is rapidly going in for solar and wind power, coal usage continues to grow strongly. Coal is responsible for 65% of India's $CO_2$ emissions



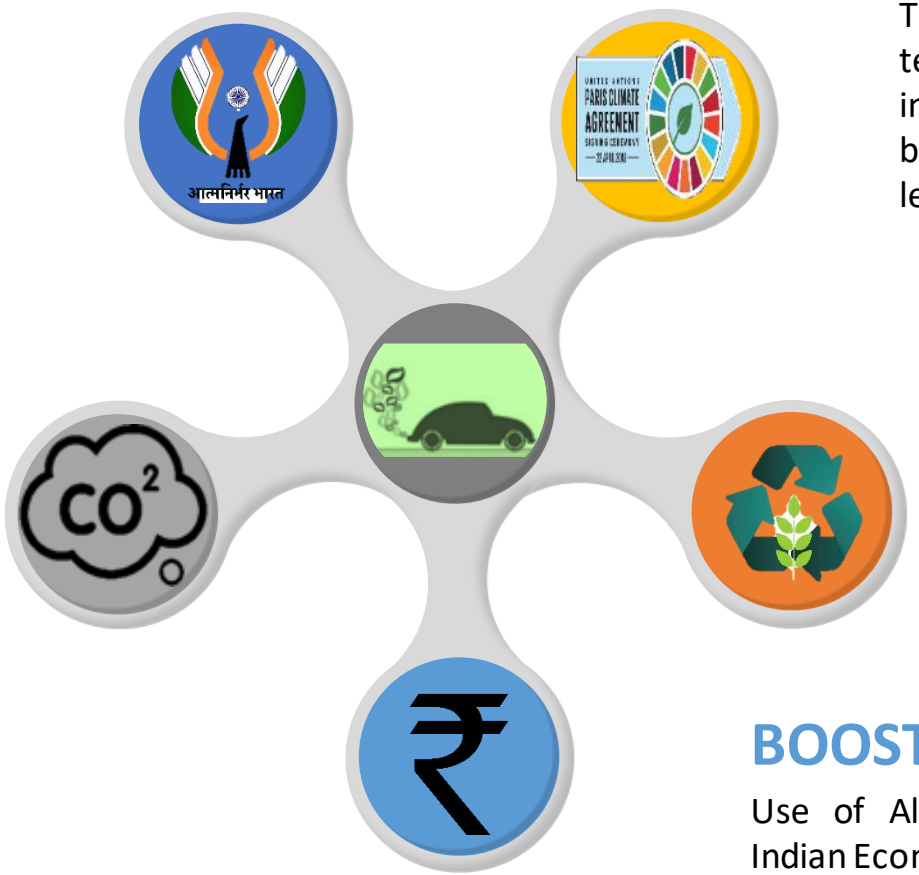

# PRESENT NEED FOR ALTERNATIVE FUELS

## VISION – ATMANIRBHAR BHARAT

Use of home grown alternate fuels can reduce the fossil fuel import and can save import duty, this envisaging the 'Atmanirbhar Bharat' vision

## GHG MITIGATION

Effects of Green House Gases can be mitigated by active usage of alternate fuels




## PARIS COP AGREEMENT

The Paris Agreement's long-term temperature goal is to keep the increase in global average temperature to well below 2 °C (3.6 °F) above pre-industrial levels

## LOCAL ENVIRONMENTAL POLLUTION

Use of Alternative Fuels will help to reduce the local Environmental Pollution problem and increase the amount of clean air.

## BOOST INDIAN ECONOMY

Use of Alternative Fuels can boost Local Indian Economy

# ALTERNATIVE FUELS – NOTIFICATIONS

| Bio-CNG / Bio-Methane | Biodiesel (B–20 and B-100) | Compressed Natural Gas (CNG) | Di-Methyl Ether (DME) | Dual fuel – Diesel/CNG/ Bio-CNG/LNG | Ethanol (E–20) |
|---|---|---|---|---|---|
| GSR 498 (E) dated 16th June 2015 | GSR 412 (E) dated 11th April 2016 | GSR 889 (E) Notified for BS VI | GSR 37 (E) dated 17th January 2020 | GSR 1151 (E) dated 29th November 2018 | GSR 156 (E) dated 8th March 2021 |

| Ethanol (E-85, ED-95, E-100) | Hydrogen | Hydrogen – CNG (HCNG) | Liquified Petroleum Gas (Auto LPG) | Liquefied Natural Gas (LNG) | Methanol M-15/ M100 & Methanol MD95 |
|---|---|---|---|---|---|
| GSR 682 (E) dated 19th May 2015 | GSR 889 (E) Notified for BS VI | GSR 585 (E) dated 25th Sept 2020 | GSR 889 (E) Notified for BS VI | GSR 643 (E) dated 27th June 2017 | GSR 490 (E) dated 24th May 2018 |

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# REGULATORY RULES FOR ALTERNATIVE FUELS

## 01 VEHICLE TYPE APPROVAL

AS PER CMVR RULES 1989,
AMMENDMENT 2020

## 02 CYLINDERS & VALVES

AS PER GAS CYLINDER RULES 2016

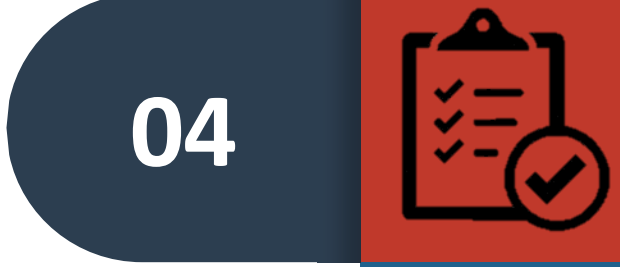
AMMENDED FROM TIME TO TIME

## 03 DISPENSING OF FUEL / GAS STATION

OISD act as competent authority to exercise powers and functions as stipulated in Petroleum and Natural Gas (Safety in Offshore operations) Rules, 2008 to enhance safety in offshore regulations.

## 04 FUEL SALE BY OMCs

PETROLEUM RULES 1976,
AMMENDED FROM TIME TO TIME



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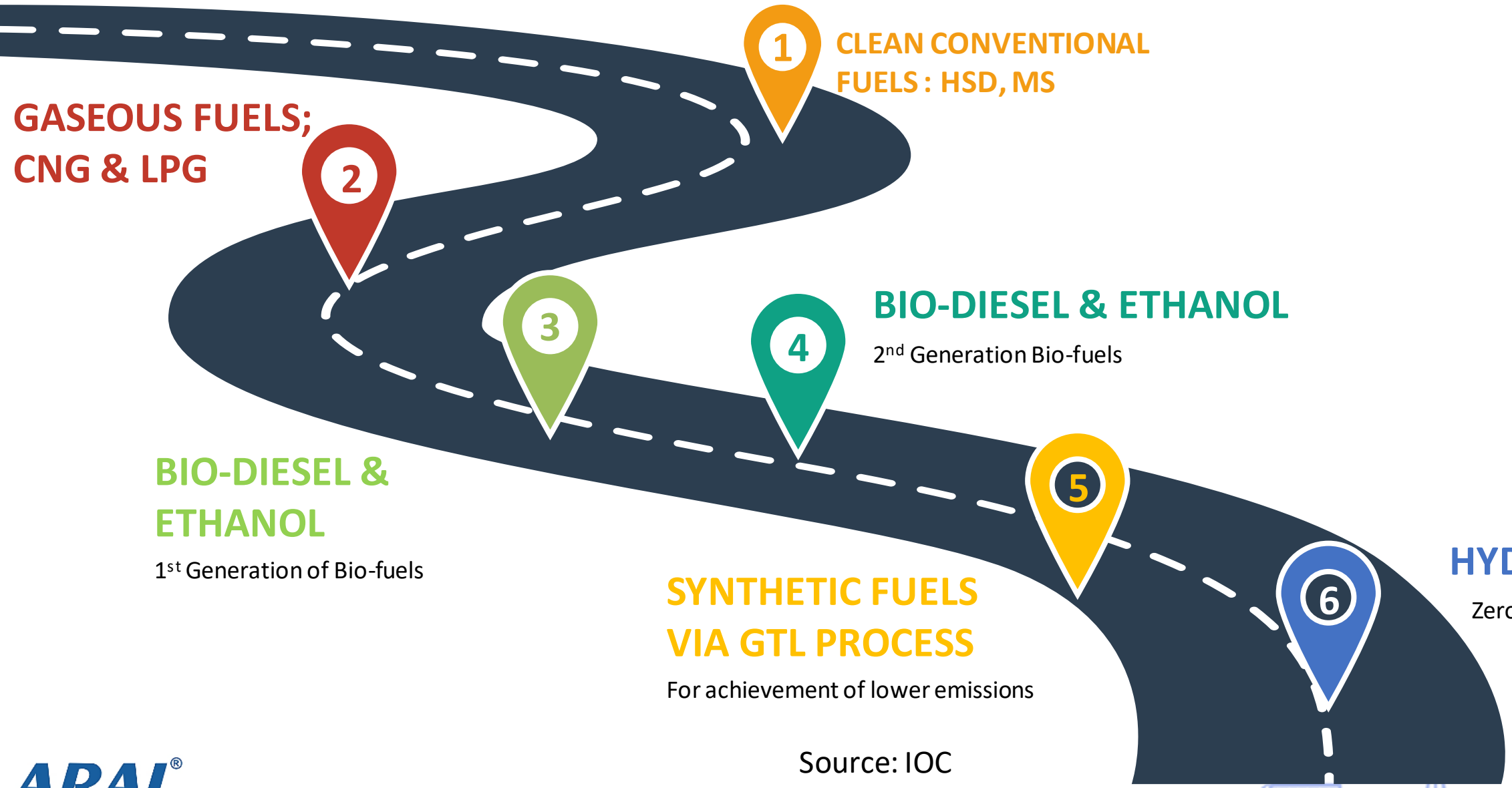
# ROADMAP FOR ALTERNATIVE FUELS




Source: IOC

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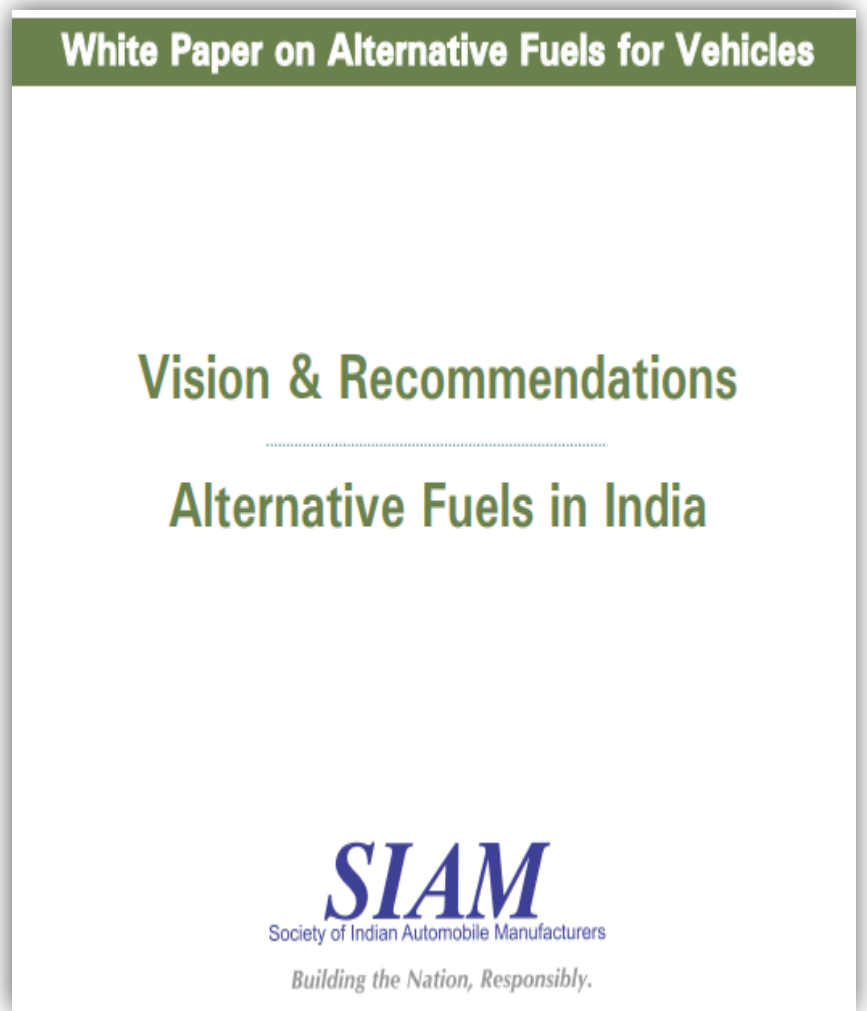
# SIAM WHITE PAPER ON ALTERNATIVE FUELS

- GOI target to reduce crude oil imports by 10% by 2021-22
- India's NDC target: Reduce Energy intensity by 33~35% by 2030
- Energy Security and Improvement in Environment are two National objectives
- Besides electrification of fleet, fuel diversification will be necessary to meet India's National Objectives
- India is world's 2nd largest 2W market, 5th largest PV market and 7th largest CV market
- E10 and B5 blended gasoline and diesel fuels are low hanging fruits enabled by availability of material compatible vehicles in fleet
- A clear roadmap is required for fuel and infrastructure availability
- Take small but confident and concrete steps to achieve the big target

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# ALTERNATIVE FUELS & AVAILABLE TECHNOLOGIES

| Alternative Fuels | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Vehicle Type / Technology | CNG | LPG | LNG | E10 | E20 | >E20 | B7 | M3 | M15 | M100 | DME | Hydrogen |
| 2Wheelers | X | X | X | OO | O | ■ | X | OO | O | X | X | X |
| Cars / UVs - SI | OO | OO | X | OO | O | ■ | X | OO | O | X | X | O |
| 3Wheelers - SI | OO | OO | X | OO | O | ■ | X | OO | O | X | X | O |
| Buses | OO | X | O | X | X | X | OO | X | X | O | O | O |
| Trucks | X | X | O | X | X | X | OO | X | X | O | O | X |
| LCV's | OO | X | O | X | X | X | OO | X | X | O | O | X |
| Cars / UVs - CI | X | X | X | X | X | X | OO | X | X | X | X | X |
| 3Wheelers - CI | X | X | X | X | X | X | OO | X | X | X | X | X |

| Legend: | |
|---|---|
| OO | Technology Available, Feasible Fuel |
| O | Technology Needs development, feasibility to be established |
| ■ | Technology Needs development, Feasibility of Fuel less due to availability |
| X | Not a Feasible fuel for the vehicle type |

Source: SIAM white paper on Alternative fuels

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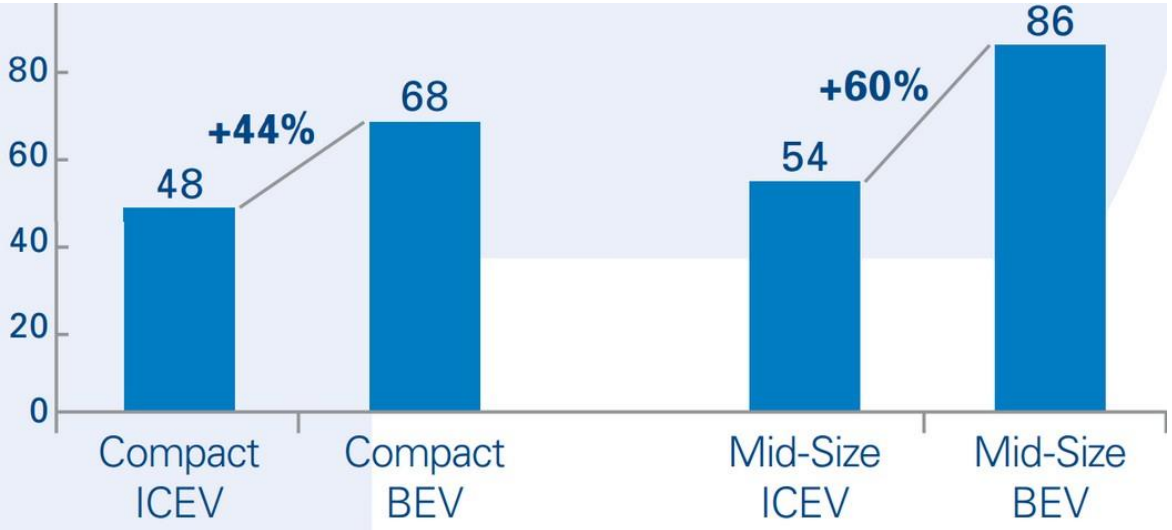
# New Applications for Alternative Fuels

# The Combustion Engine Refuses to Die

*Internal combustion is surviving by adapting.*



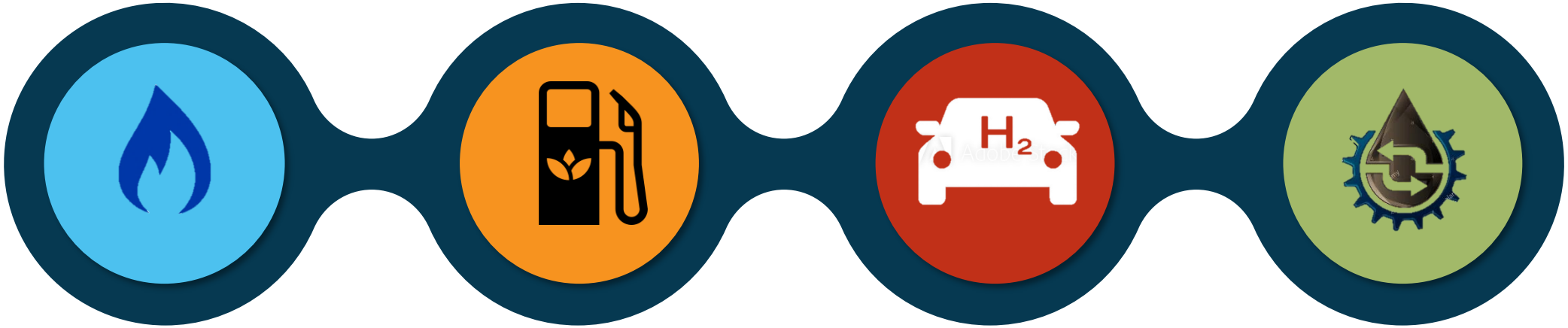

In Thousands of Dollars at Present Value

| Impact Area | ADL |
|---|---|
| Total Cost of Ownership | BEV is 44% more expensive than ICEV |
| Global Warming Potential | BEV has 23% less GWP impact than ICEV |
| Secondary Environmental Impacts | BEV has 3 times greater Human Toxicity Potential |

## Arthur Little Study on BEV Vs ICEV

Even the average engine may soon approach its electric rival in terms of grams of carbon dioxide output of 97 grams per kilometer. In the 2040 time frame, the value will reduce to 30 grams, which makes internal combustion engines competitive with electric vehicles

# ALTERNATIVE FUEL CATEGORIES




## Natural Gas Based Fuels

These include CNG, LPG, LNG, Bio-CNG, etc.

## Bio-Fuels

These include Ethanol, Methanol, Bio-Diesel, etc.

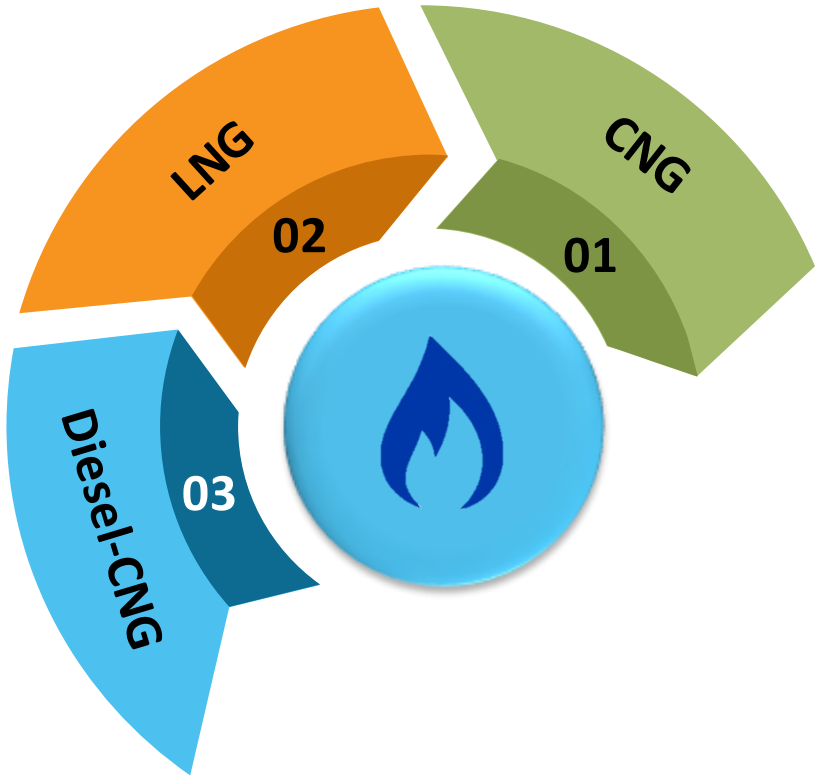
## Hydrogen

Hydrogen is a zero carbon fuel and can be used directly or with fuel cells

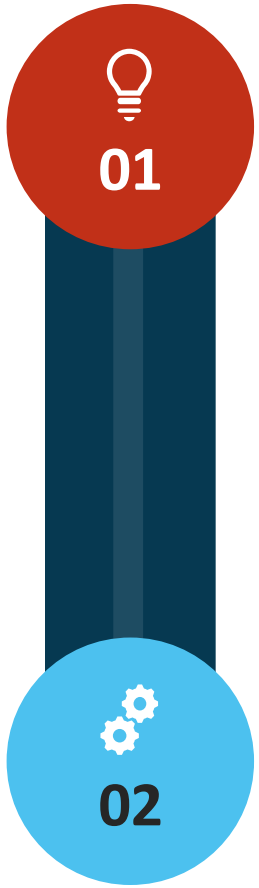
## Synthetic Fuels

These include Dimethyl Ether (DME), GTL, Fischer Tropsch etc.

# Gaseous Fuels



# Compressed Natural Gas (CNG) – Notifications and Standards




## 01

### GSR 889 (E) notified for BS-VI

Notification for CNG to be used as Automotive fuel

## 02

### Fuel & Component Standards

IS 15856:2017 – CNG for Auto applications
IS 15721 – IS 15733 – CNG Components
Gas Cylinder Rules – 2016 for Cylinders

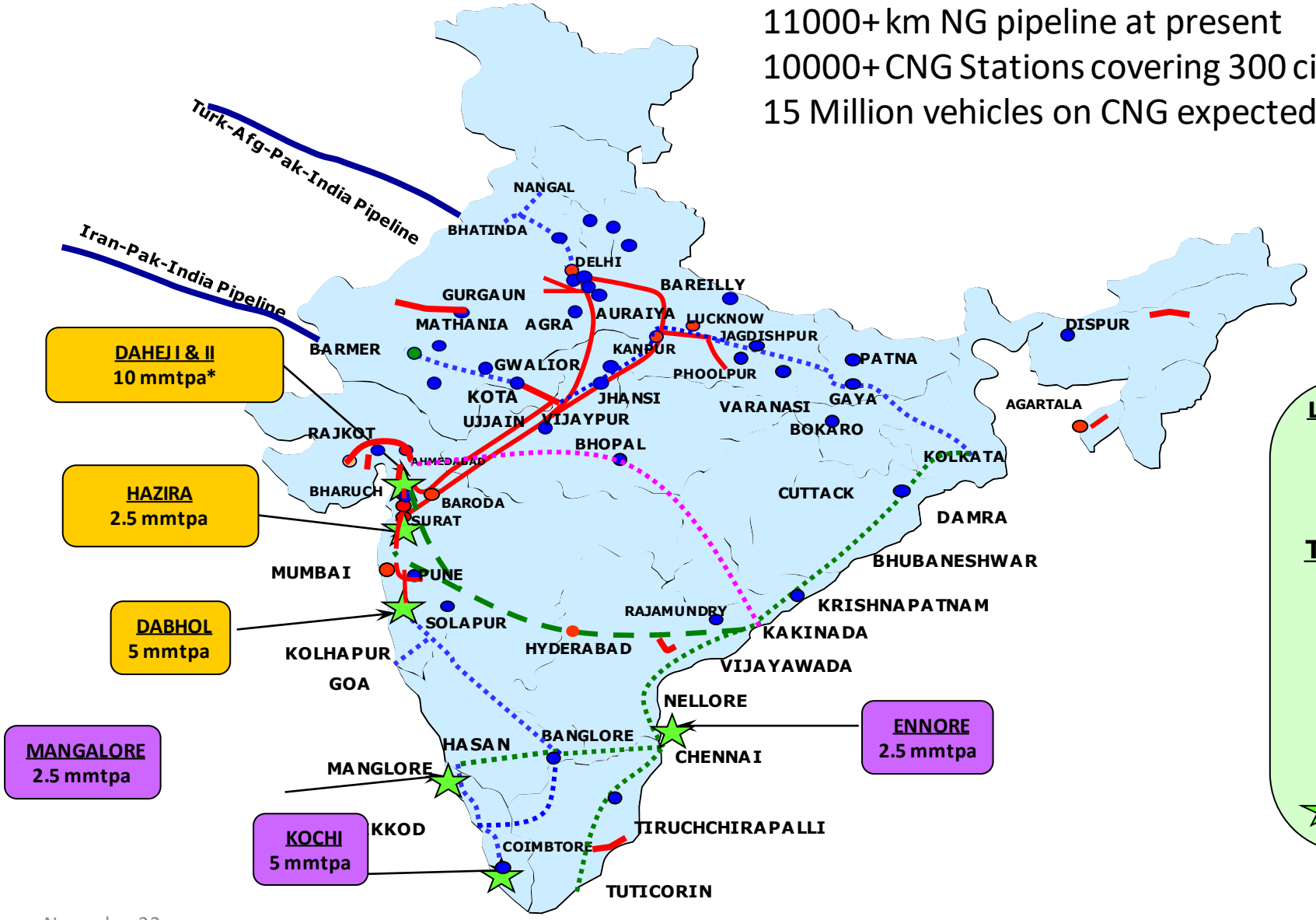
# COMPRESSED NATURAL GAS (CNG)

## CNG

- **Low Carbon Fuel** — Mostly contains methane (CH4). Hence less contribution to CO and HC emissions
- **Lower Particulates** — Particulate Matter and smoke is almost negligible from CNG emissions
- **Renewable Fuel** — Bio-CNG is a renewable source of energy which is obtained from decomposed biological sources like animal waste, dry leaves, etc.
- **Cost Effective** — CNG is cheaper than the fossil fuels and is more affordable

# CNG Infrastructure in India

11000+ km NG pipeline at present
10000+ CNG Stations covering 300 cities planned by 2025
15 Million vehicles on CNG expected by 2025




Courtesy of Gas Authority of India

**LNG**
- Existing
- Upcoming

**Transmission Pipelines**
- Existing
- GAIL's Planned Pipeline
- RIL's East West Pipeline
- RIL's Planned Pipeline
- GSPC's Planned Pipeline

**City Gas/ CNG**
- Existing
- Planned
- LNG Terminal

**Integrated Grid To Link Any Source To Any Market**

# CNG – Technology Applicable for Vehicles

For India, the Hydrogen Fuel technology is best feasible for SI engines for following vehicle categories

Cars / SUVs

3-Wheelers

Buses

- Termed as a clean burning fuel, however emits NOx
- Can be used in Spark Ignited IC Engines in dedicated mode
- Can also be used in CI engines in Dual fuel mode with Diesel
- Lower Calorific Value and Lower Energy Density causes a drop in Power as compared to equivalent Diesel engines
- Widely promoted as an urban transport fuel especially for city buses
- Meets BS-VI with 3-way Catalytic Converter

| *Properties* | *CNG* |
|---|---|
| **Flame speed** | **42 cm/s** |
| **Diffusion coefficient** | **0.16 $cm^2/s$** |
| **Higher Heating Value** | **55 MJ/kg** |
| **Lower Heating Value** | **50.4 MJ/kg** |
| **Flammability limits** | **5.3 – 15 (% vol)** |
| **Minimum Ignition Energy** | **0.28 mJ** |
| **Auto-ignition Temp.** | **813 K** |

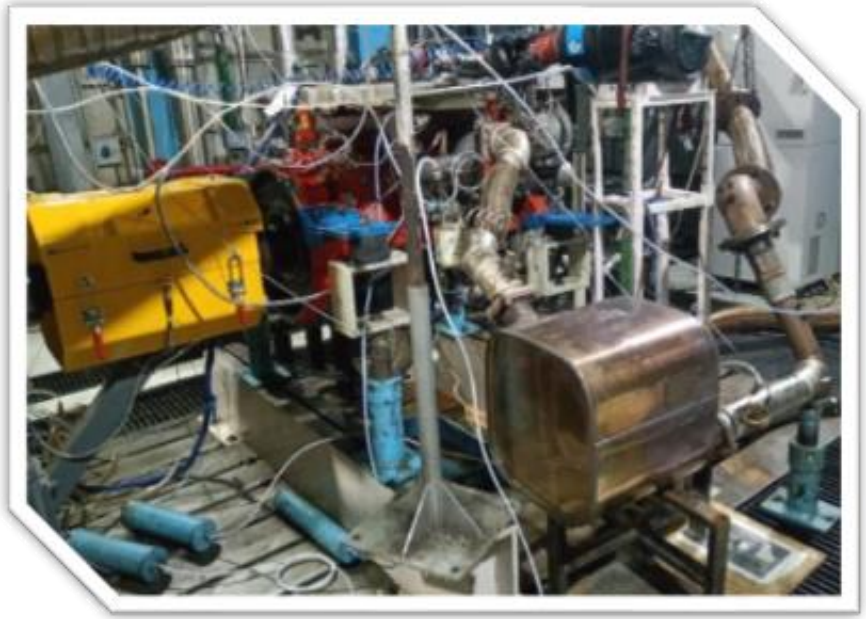
# CNG Vehicle Classification

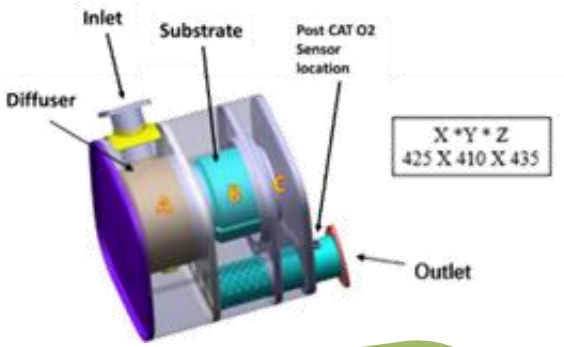
- **Dedicated fuel** ( Cars, SUVs, LCVs, Buses and Tractors)
  - CNG fuel only

- **Bi-fuel** (for 3 wheelers / small cars )
  - Operation on either CNG or Gasoline, 2 separate fuel tanks & fuel delivery systems.

- **Dual Fuel** (Trucks, Buses, CEVs and Tractors)
  - Simultaneous operation on diesel and CNG, different fuel tanks and fuel delivery systems

# BS-VI compliant CNG Engine






### NA & SPFI Technology

First of its kind, naturally aspirated single point injected CNG engine to be certified with BS-VI certificate. Fuel Metering valve used for SPFI system

### Robust Calibration

Cold start and deceleration fuel cut calibration strategy used. Emission consistency proven on 3 engines

### No-EGR & only 3-Way cat-con

Single after-treatment system i.e. 3-way catalytic convertor used without EGR to meet BS-VI emission norms

### Unique Box-Type After-treatment system

Emission proved on box type after-treatment system which is one of its kind, used for CNG engines

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# CEVs on CNG

- Dedicated and dual fuel technology available
- Merits
  - Lower regulatory Emissions
  - Operating cost is lower
- Demerits
  - Wear and Tear
  - Limited range

- List of countries using this technology- Thailand ,New Zealand, Australia

# Bio-CNG / Renewable Natural Gas (RNG) – Notifications and Standards


**GSR 498 (E) dated 27th June 2017**

**Notification for Bio-CNG to be used as Automotive fuel**

**Fuel & Safety Standards**

**AIS 024-028 - Safety Standard for Bio-CNG Vehicles**

**IS 16087 – Bio-CNG Specs**

# Bio-CNG Policy and Infrastructure

- Sustainable Alternative Towards Affordable Transportation (SATAT) scheme was launched by Ministry of Petroleum in October 2018 to encourage development of Bio-CNG infrastructure and production of biogas from waste biomass.

- Under SATAT scheme, oil marketing companies can procure CBG from agri-producers for dispensing

- 5000 CBG plants are planned by 2023-24 which are expected to produce 15 Million Metric Tons (MMT)

- Buses running on Bio-CNG are launched in Pune & Retail dispensing units have been launched by IOCL


# Tractors on CNG / Bio-CNG

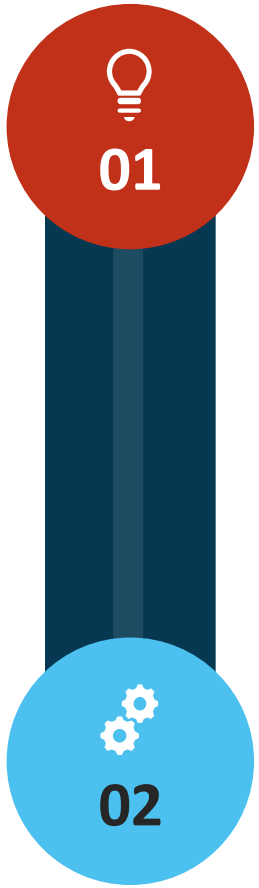
- Dedicated and dual fuel technology available

- Merits
  - Lower regulatory Emissions
  - Operating cost is lower

- Demerits
  - Durability issues
  - Power performance is 6-8% less as compared to base engine
  - Packaging and safety issues

- List of countries using this technology- India, Brazil, Argentina

# Liquified Natural Gas (LNG) – Notifications and Standards




01

**GSR 643 (E) dated 27th June 2017**

Notification for LNG to be used as Automotive fuel

02

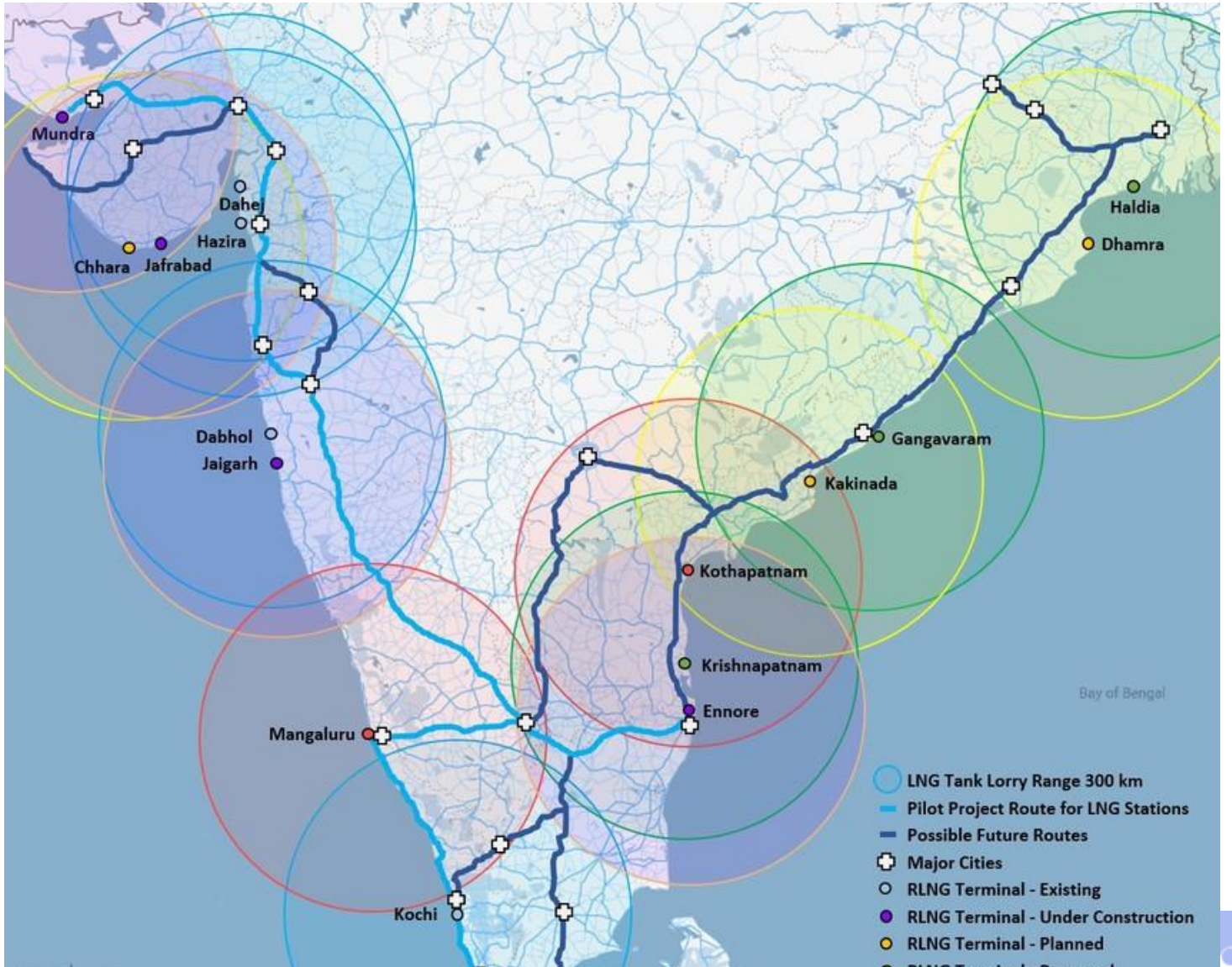
**Component & Safety Standards**

ISO 12614 Series – LNG Components
AIS 024-028 - Safety Standard for LNG Vehicles

# Liquified Natural Gas (LNG) Plans for India

PETRONET LNG LIMITED



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# Liquified Natural Gas (LNG) – Technology Applicable for Vehicles

For India, the LNG technology is best feasible for SI engines for following vehicle categories

Buses

Trucks

LCV's

- LNG is produced by cooling natural gas until it liquefies at -256° F or -162° C.
- In its liquid state LNG occupies 1/600th the volume of its gaseous state
- LNG is not pressurized and is not flammable.
- LNG has been around for a long time:
  - First plant (1917)
  - International transport (1959)

| S. No | Components | Factors |
|---|---|---|
| 1 | Methane % | 87.33-97.25 |
| 2 | Ethane % | 0.09-10.26 |
| 3 | Propane % | 0.03-3.33 |
| 4 | Butane + % | 0-1.48 |
| 5 | Sulphur | <10 ppm |
| 5 | LNG Density kg/m3 | 421.39-467.35 |
| 6 | Expansion ratio m3(n)/m3 liq | 559-600.0 |
| 7 | Gas GCV MJ/m3(n) | 39.91-45.32 |
| 8 | Wobbe Index MJ/m3(n) | 53.51-56.53 |

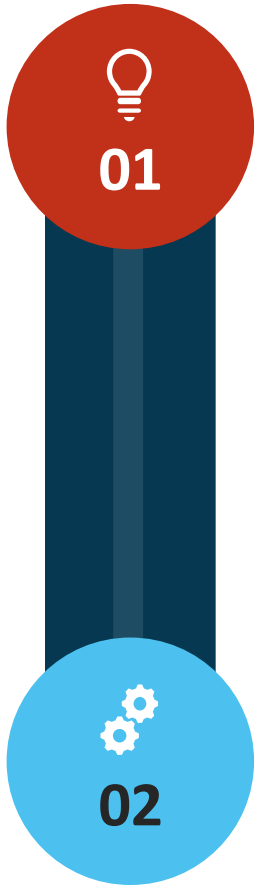
LNG Industry report 2016 of the GIIGNL

# Liquified Natural Gas (LNG) – Possibilities for Indian Market

- LNG and CNG systems are same except the storage methodology.
- Trucks and buses running on highways are ideal candidates for running on LNG.
- LNG is being promoted as an Highway fuel
- Conversion of OEM fitted CNG vehicle to LNG is possible. Same Engine can be used with both the systems.
- As LNG composition is between high range of CNG reference fuel, there will not be any requirement to test the LNG vehicle when the same CNG engine will be used.
- IOCL and Petronet are coming up with new infrastructures with R-LNG which can facilitate both LNG and CNG fueling on same station.


LNG
is ready
for
monsoonproductions.in
01 X2.2 #1
Marcopolo
TATA
PETRONET
LNG

# Diesel-CNG (Dual Fuel) – Notifications and Standards




01

## GSR 1152 (E)

**Notification for Diesel-CNG to be used as Automotive fuel**

02

## Safety Standards

**AIS 024-028 Diesel – CNG / Bio-CNG / LNG**

# Dual Fuel Combustion Technology

- A Diesel CNG (dual fuel Technology )is best suited for heavy duty vehicles
- Dual fuel engine runs on Diesel and Natural Gas simultaneously
- Small Pilot Injection of diesel ignites gas mixture
- Average substitution of Diesel by Gas is 60 – 85 %
- Engine can run on 100 % Diesel anytime
- Technology also suited for Genset Applications

Emission Reduction by 30-40 %

# ARAI Developed Dual Fuel vehicles for Indian OEM's

- Development of a dual fuel diesel-CNG engine for Heavy duty application
- Development of a dual fuel system (Indigenous including ECU) for SUV engine
- Development of a dual fuel diesel-CNG engine for Tractor application
- Development of a dual fuel diesel-CNG engine for Off highway application

# CEVs on Dual fuel Diesel-CNG

- Dedicated and dual fuel technology available

- Merits
  - Lower regulatory Emissions
  - Operating cost is lower

- Demerits
  - Limited range
  - Packaging and safety issues

- List of countries using this technology- Thailand ,New Zealand Australia

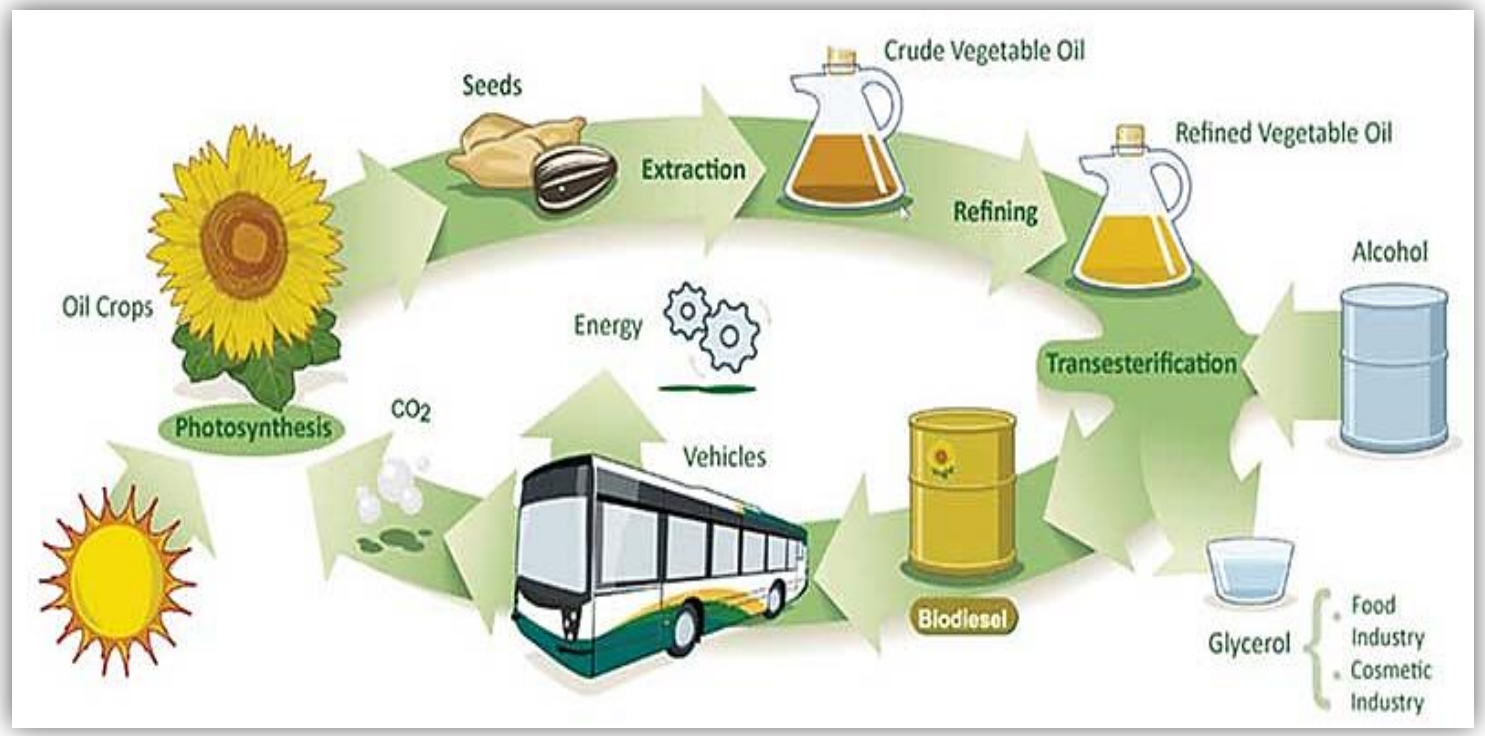
# Bio Fuels

# BIO-FUELS

## BIO-FUELS

- Carbon Neutral
- Lower Emissions
- Renewable Fuel
- Lower Shelf Life

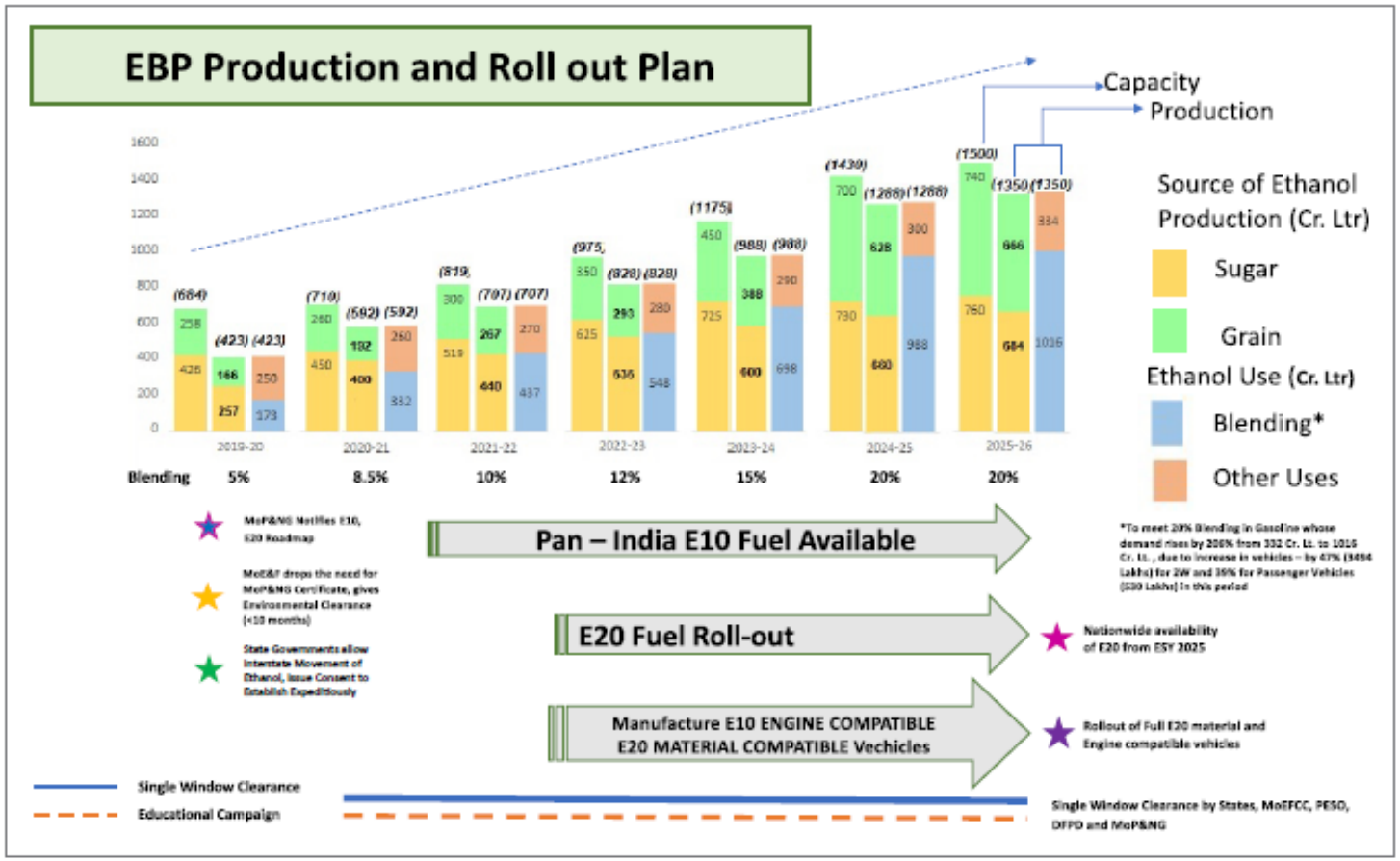
### THE BIO-FUEL CYCLE



# ETHANOL - BIOFUEL POLICY

- The 2018 National Policy on Biofuels had a target of 20 per cent blending of ethanol in petrol and 5 per cent blending of biodiesel in diesel by 2030. *Now the 20 % blending is getting preponed to 2025 from 2030.*
- This was to be achieved by increasing production using second-generation bio-refineries and developing new feedstock for biofuels.
- It allowed the production of ethanol from damaged food grains like wheat and broken rice, which are unfit for human consumption.
- The new policy also allowed the use of excess food grain/ sugar for ethanol in a bounty crop year

# Launch of Ethanol Blending Roadmap by Niti Aayog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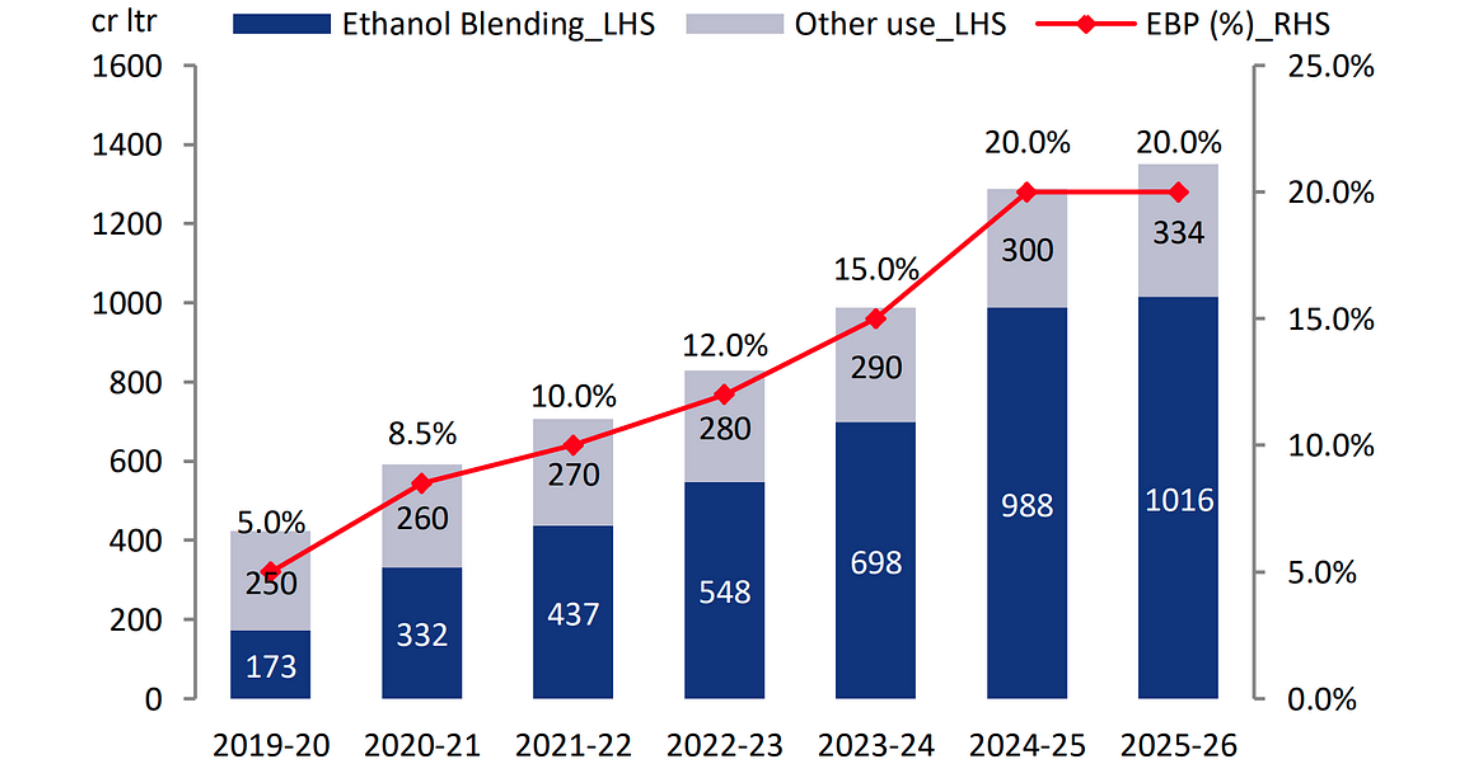
# Launch of E-20 Fuel



## Ethanol End Use




*Source: JM Financial, Roadmap for Ethanol Blending 2020-25 (June 2021)*

Bloomberg | Quint

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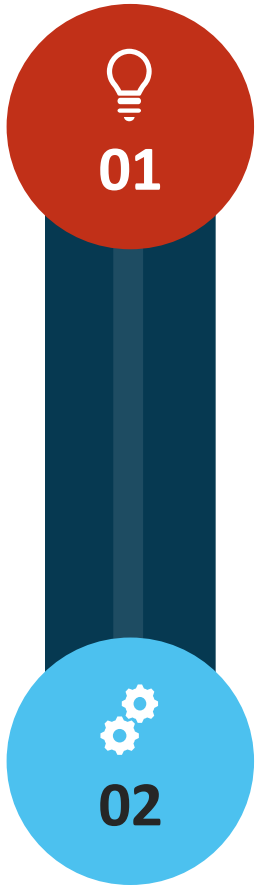
# BIOFUEL POLICY ISSUES

## E0 (100% GASOLINE) CAN BE MIXED WITH ETHANOL AND METHANOL

- ***E5 (5% ETHANOL BLENDING)***
  *AS PER IS 2796 : 2017*
- ***BLENDING ALLOWED UPTO E-10***
  *AS PER IS 2796 : 2017*
- ***<u>PROPOSED BLENDING</u>***
  - ***E-20 IMPLEMENTATION BY 2023***

- ***M-3 (3% METHANOL BLENDING)***
  *(Recommended by SIAM)*
- ***M-15 (15% METHANOL BLENDING)***
  *(Recommended by NITI AAYOG and Notified by MORTH)*

# Ethanol – Notifications and Standards




## 01

### GSR 682 (E) and GSR 156 (E)

Notification for Ethanol E20, E85, ED95 and E100 to be used as Automotive fuel

## 02

### Fuel & Safety Standards

- IS 16629 : 2017 - Hydrous ethanol for use in ED95 automotive fuel
- 16634 : 2017 - E85 fuel (Blend Of Anhydrous Ethanol And Gasoline)
- IS 17021 – Ethanol 20 blend with Gasoline
- AIS 171 – Ethanol Vehicle Safety

# ED95 – Technology Applicable for Vehicles

For India, the Ethanol -Diesel (ED95) Fuel technology is best feasible for CI engines for following vehicle categories

Buses

Trucks

LCV's

- ED95 designates a blend of 95% ethanol and 5% ignition improver; it is used in modified diesel engines where high compression is used to ignite the fuel as opposed to the operation of gasoline engines, where spark plugs are used. This fuel was developed by Swedish ethanol producer SEKAB
- Because of the high ignition temperatures of pure ethanol, the addition of ignition improver is necessary for successful diesel engine operation. A diesel engine running on ethanol also has a higher compression ratio and an adapted fuel system

| Component | Content | | Type of product | Properties |
|---|---|---|---|---|
| | % by weight | % by volume | | |
| Ethanol | 91,4 | 92,66 | Hydrous ethanol Scania specification | Fuel Emission properties. |
| Denaturants (according to Swedish law) | 2,2<br>0,4 | 2,4<br>0,44 | MTBE<br>Iso-butanol<br>Red dye | ▪ Use according to national laws.<br>▪ In accordance with the engine manufacturer. |
| Ignition improver | 5,0 | 3,6 | Polymer. Poly ethylene derivative | ▪ Ignites the ethanol in the compression moment.<br>▪ Some lubricant effect in the injector and the fuel pump. |
| Lubricant | 1,0 | 0,9 | Polymer | Lubricant and detergent component. |
| Corrosion inhibitor | 90 ppm | 90 ppm | Morpholine | Protect engine and fuel system from iron corrosion. |

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# ED95 ETHANOL ENGINE
# COMPRESSION-IGNITION (DIESEL OPERATION) ENGINE SYSTEM

**Ethanol fuel ED95**
Ethanol with ignition improver
EU engine certification fuel.

**3rd generation engine Euro 5/EEV**

**Highly efficient diesel combustion** Ethanol up to 43% efficiency Diesel up to 44% efficiency

**Compression-ignition engine system**
Minor changes to standard diesel engine.
Diesel operation in accordance with compression-ignition or 'CI' engine.

**Proven technology**
Third generation engine
In commercial traffic since 1986.


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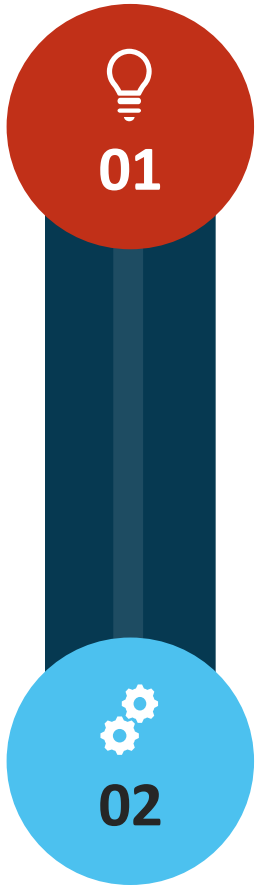
# ED95 BUS IN NAGPUR




# Methanol – Notifications and Standards




01

## GSR 490 (E) dated 24th May 2018

Notification for Methanol M-15/ M100 & Methanol MD95 to be used as Automotive fuel

02

## Fuel Standards

- IS 17075 : 2019 – Anhydrous methanol for use as a blending component in fuels
- IS 17076 : 2019 – M15 fuel-admixture of anhydrous methanol and motor gasoline as fuel

# Methanol – Technology Applicable for Vehicles

For India, the Methanol (M100) Fuel technology is best feasible for SI engines for following vehicle categories

Buses

Trucks

LCV's

- Methanol is often called wood alcohol because it was once produced chiefly as a byproduct of the destructive distillation of wood.
- Most methanol today is produced from the methane found in natural gas, but methanol is also produced from all types of biomass, coal, waste, and even CO2 pollution from power plants.
- It forms explosive mixtures with air and burns with a non-luminous flame. Methanol is also a toxin and should not be ingested – drinking quantities of methanol can result in blindness and severe damage to the central nervous system.

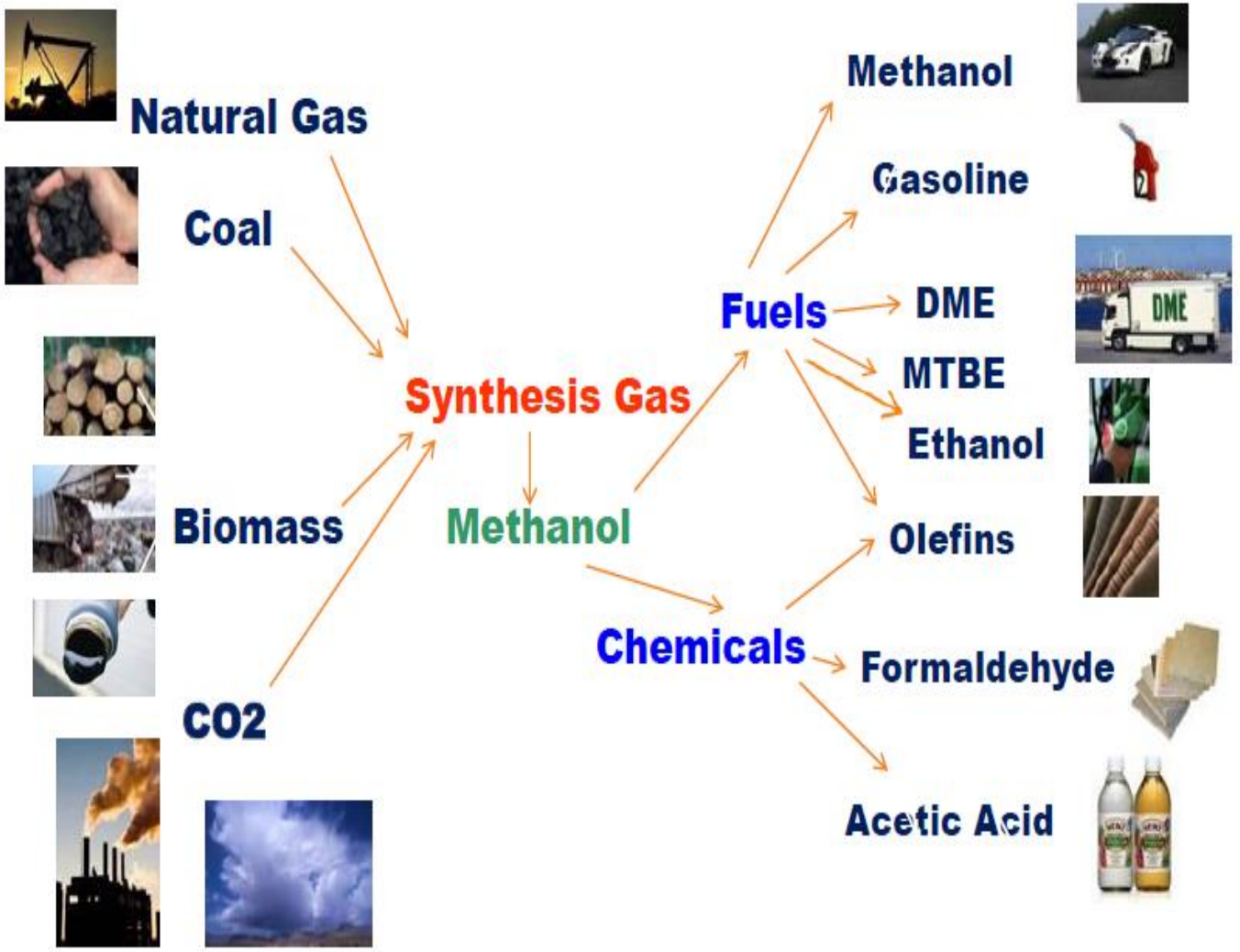
| Parameters | Value |
|---|---|
| $CH_3OH$ | Methanol |
| Molecular Weight/ Molar Mass | 32.04 g/mol |
| Density | 792 kg/m³ |
| Boiling Point | 64.7 °C |
| Melting Point | -97.6 °C |

# Methanol – Production Sources

Methanol is produced from 3 Major sources:

1. Coal
2. Natural Gas
3. Biomass

NITI Aayog is promoting Methanol & recently ARAI is declared as Centre in excellence for Methanol

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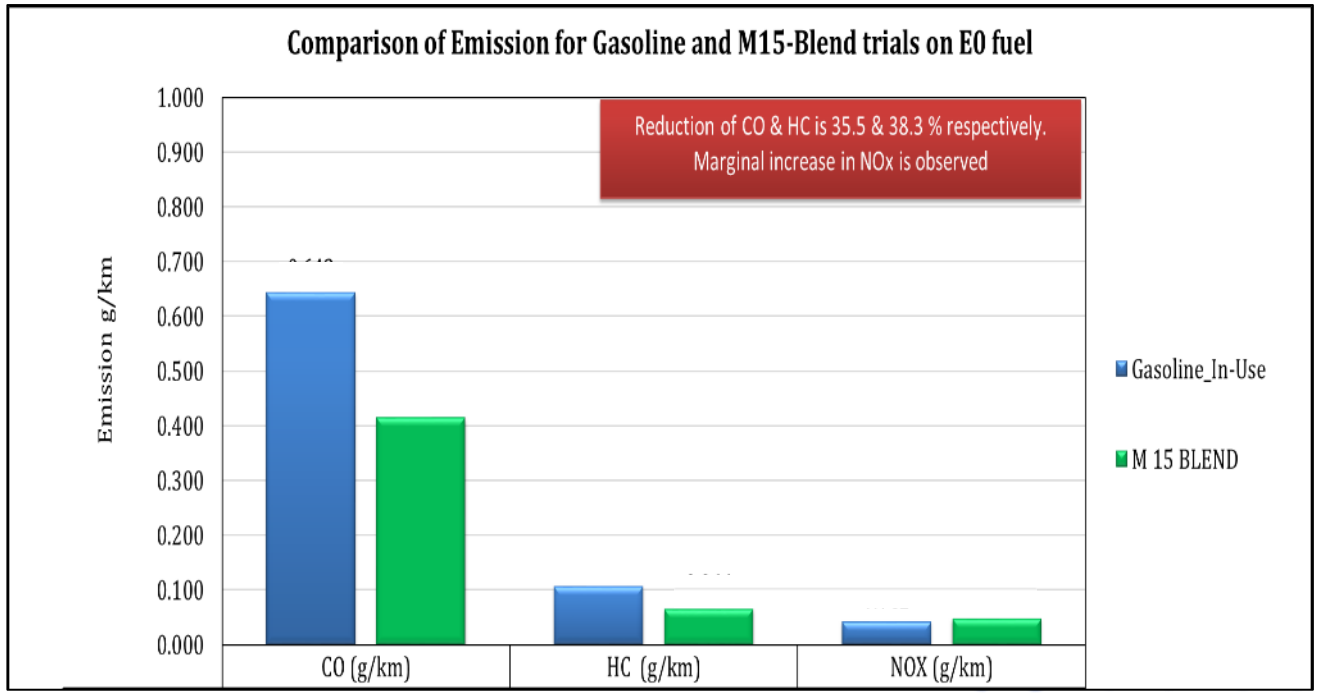
# Methanol – Work at ARAI

## A. Performance and Emission Evaluation of M-15 fuel on Passenger car

- GDI and MPFI passenger vehicle used
- Vehicle run for on gasoline Vehicle for 3000 km each.
- Baseline performance on Gasoline mode
- Emission performance on methanol blended gasoline (M-15) mode




M15

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# Biodiesel – Notifications and Standards


## 01

### GSR 412 (E)

Notification for B-20 and B-100 as Automotive fuel

### GSR 889 (E)

Notification for B-7 as Automotive fuel

## 02

### Fuel Standards

- IS 15607 : Biodiesel Specification

# BIODIESEL INFRASTRUCTURE



- Private suppliers have established Biodiesel outlets
- Most of the biodiesel sold does not confirm to IS 15607
- Cost of biodiesel is 70 – 77 Rs per Litre
- Present biodiesel production is around 11 Crore litres per annum

# Biodiesel – Technology Applicable for Vehicles

For India, the Biodiesel (B100) Fuel technology is best feasible for CI engines for following vehicle categories

Buses

Trucks

LCV's

- Biodiesel can be neat or blended with diesel.
- Biodiesel produces aldehyde and ketone emissions in exhaust
- Biodiesel has excellent lubricant properties
- Currently Biodiesel is not available in India and hence the blending is minimal

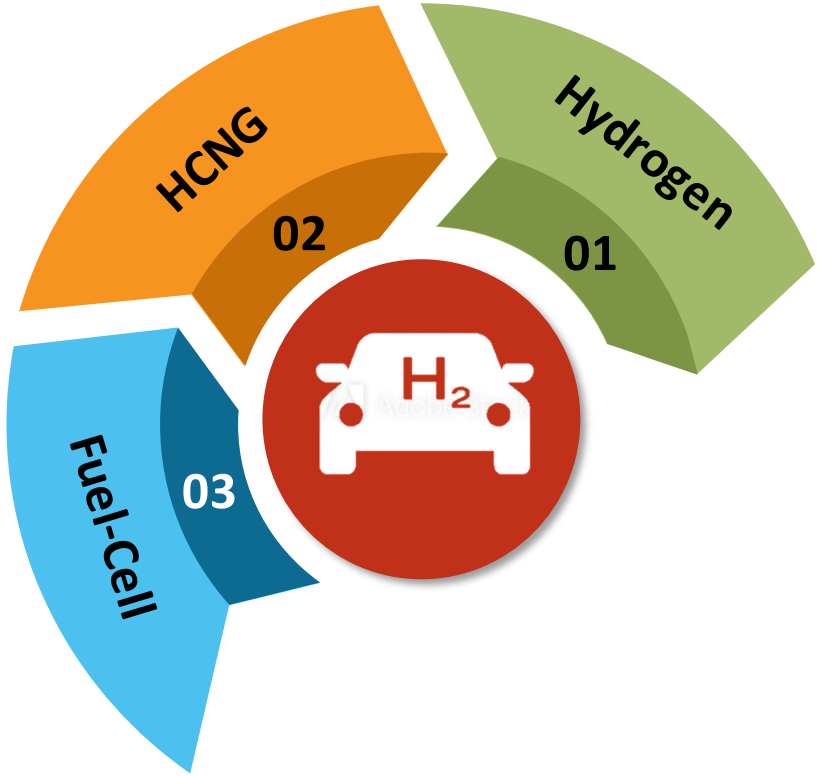
# Bio-diesel for Automotive Engines

- Bio-Diesel is the esterified form of vegetable oil
- Merits
  - Used where vegetable oil is abundantly available
  - Reductions in 40% regulatory Emissions
  - Requires lesser modifications in CI engine
  - Technology best suited for larger engines (>300 kW)
- Demerits
  - Cold starting issues
  - Cylinder Deposits and clogging of FIE
  - No benefit in Nox emissions
  - Oxidation Fuel stability is an issue
  - Fuel quality is an issue
- List of countries using this technology- Brazil, USA, Argentina, Malaysia, Indonesia

# Bio-diesel Tractor

Biodiesel concentrations up to 20 percent (B20) blended in petroleum diesel fuel can be used in tractors, provided the biodiesel used in the fuel blend meets the BIS standard

# Hydrogen Technologies



# Hydrogen ($H_2$)

- Termed as the Freedom Fuel i.e. a clean burning fuel
- Can be used in IC engines and in fuel cells
- Hydrogen is not an ‘energy source‘ .... but an energy carrier which has to be produced and this requires energy
- Considerable technical difficulties in its use as an auto fuel

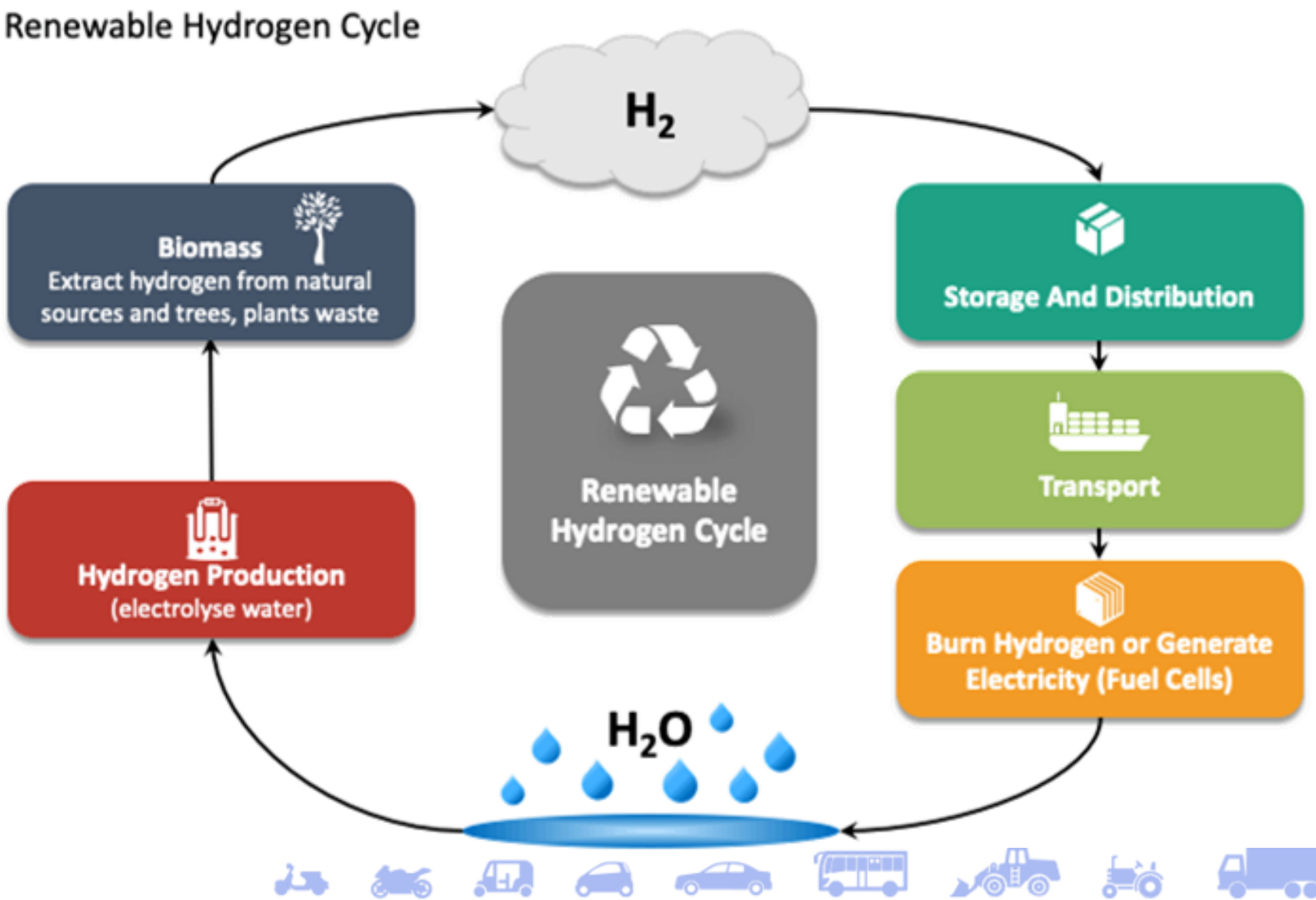
| *Properties* | *Hydrogen* |
|---|---|
| Flame speed | 237 cm/s |
| Diffusion coefficient | 0.61 $cm^2/s$ |
| Higher Heating Value | 142 MJ/kg |
| Lower Heating Value | 120 MJ/kg |
| Flammability limits | 4 - 75 (% vol) |
| Minimum Ignition Energy | 0.02 mJ |
| Auto-ignition Temp. | 858 K |

# HYDROGEN FUEL

**Energy Carrier**

**Zero Carbon**

**Highly Efficient**

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# HYDROGEN PRODUCTION METHODS

## GREY HYDROGEN

Split Natural Gas into Hydrogen and CO2

**CO2 emitted in the atmosphere**

## BLUE HYDROGEN

Split Natural Gas into Hydrogen and CO2

**CO2 stored or reused**

## GREEN HYDROGEN

Split water into Hydrogen by electrolysis powered by water or wind

**No CO2 emitted**

# Hydrogen ($H_2$) – Notifications and Standards

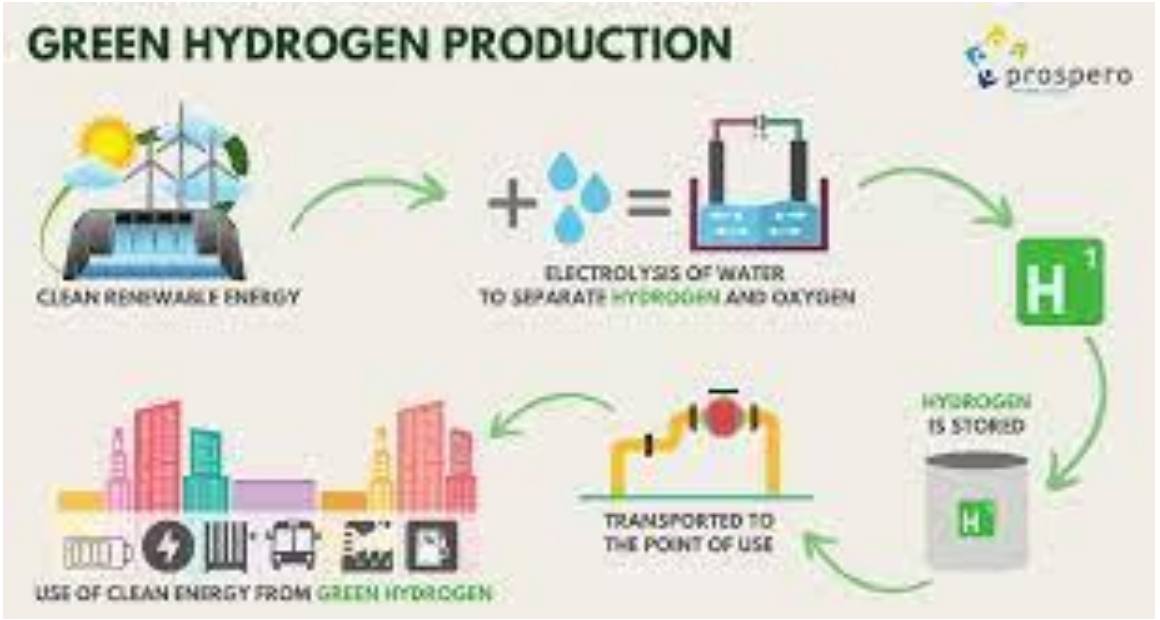

## GSR 889 (E) Notified for BS VI

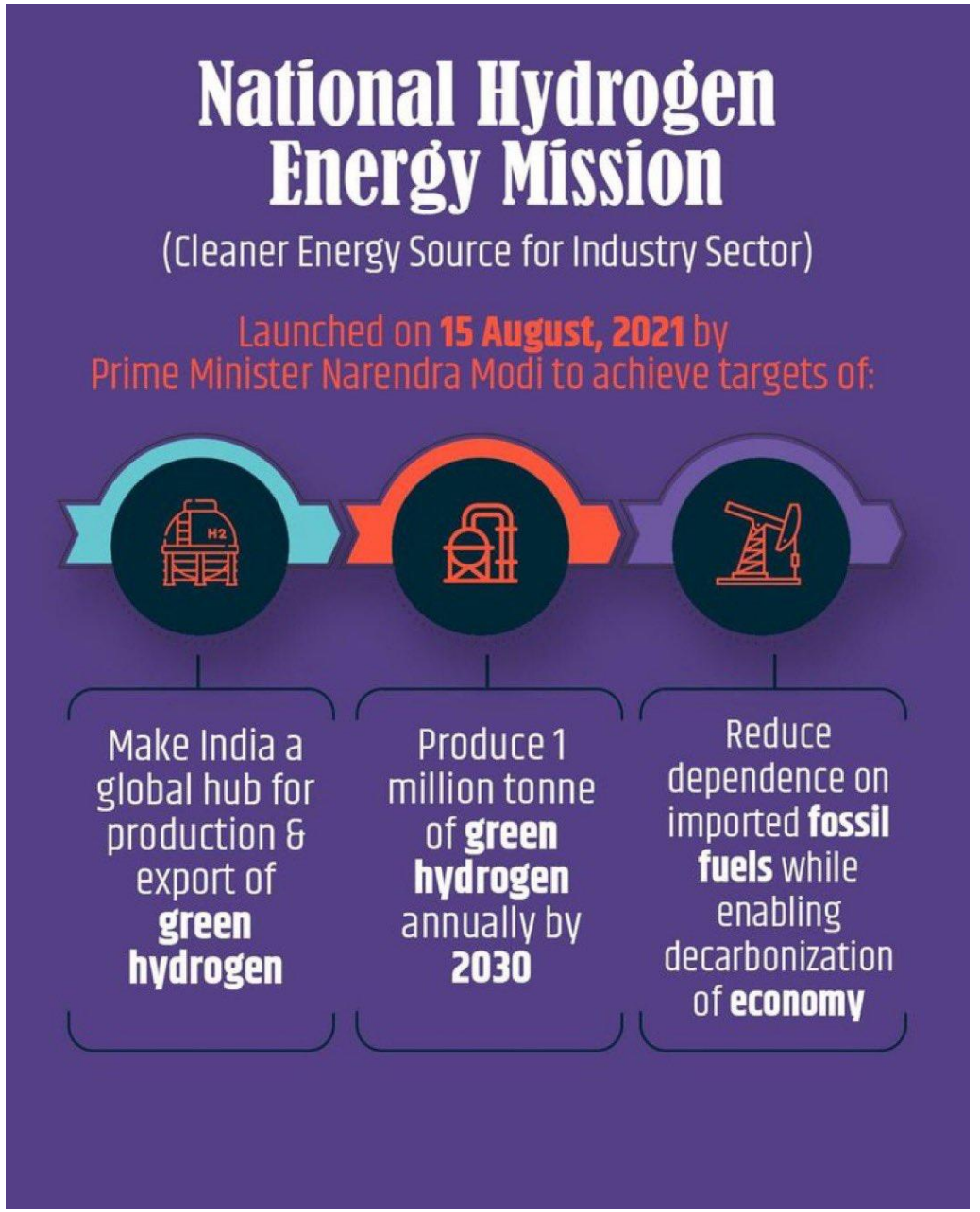
Notification for Hydrogen to be used as Automotive fuel

## Fuel Standards

- ISO 14687:2019 and IS 16061 : 2021 – Hydrogen fuel quality - Product specification
- IS 16735 : 2018 – Cylinders for Compressed Hydrogen as fuel for Automotive Application
- AIS 157 : Hydrogen Fuel Cell Vehicle Safety Standard
- AIS 195: Hydrogen IC Engine Vehicle Standard

# National Hydrogen Mission

# INDIA GREEN HYDROGEN ROADMAP

Energy transition whitepaper prepared by FTI Consulting

## POLICY INTERVENTIONS

4% by 2030

Aspirational H2 energy share

India Green Hydrogen Taskforce

USD 100 mn

India Hydrogen Fund

National Green Hydrogen Policy and Roadmap 2021

Inter-govt H2 Group, fiscal incentives, global harmonisation

## NATIONAL DEMONSTRATION PROJECTS (Proposed)

H2 Bharat Trucking Project on Delhi-Mumbai Industrial Corridor

H2 Bharat Port & Logistics Clusters

H2 Industrial Clusters (Steel, Fertilizer)

Municipal Bio-Gas H2 project

Coal-Gasification H2 project

## DESIRED OUTCOMES BY 2030

**India in Global H2 Supply Chain**
Domestic Manufacturing of Electrolysers, Fuel-Cell stacks, components; Partnerships and H2 India Consortium

**10 National H2 Projects**
Large, demonstration -stage, different use cases

**USD 500 mn**
Expanded Hydrogen Fund (by 2030)

**75,000**
New Hydrogen Economy jobs, potential

**GW-scale**
Electrolyser capacity in India

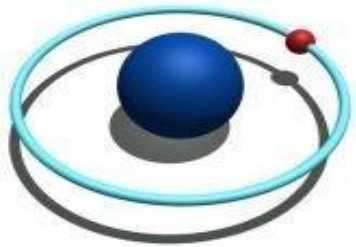
# Hydrogen ($H_2$) – Technology Applicable for Vehicles

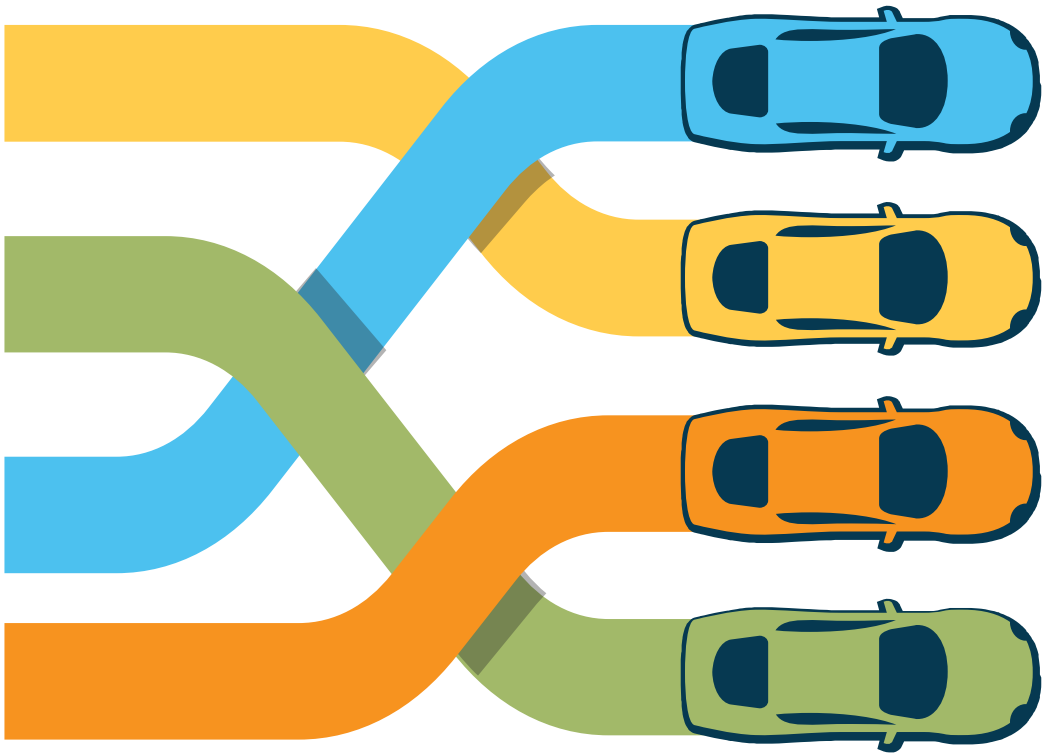
For India, the Hydrogen Fuel technology is best feasible for SI engines for following vehicle categories

Cars / SUVs

3-Wheelers

Buses



**Neat Hydrogen**

**Hydrogen supplementation (Petrol+ hydrogen )**

**Hydrogen + CNG**

**Dual Fuelling (Diesel + Hydrogen)**

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# Hydrogen ($H_2$) – Technical Issues with Hydrogen

- Hydrogen has a wide flammability limits which permit its use under lean conditions
- Due to wide flammability limits, pre-ignition on hot cylinder walls can occur
- Flame speed for $H_2$ is seven times higher than that of gasoline, thus approaching the ideal constant volume cycle.
- Ignition energy is ~1/10 that of gasoline
- It is colorless and odorless so difficult to detect leaks
- Causes metal embrittlement of Iron and Zinc.
- Burns with nearly invisible flame. Hydrogen fires are more difficult to detect than Methane or gasoline fires.
- Backfire may occur due to hot spots (valve, spark plug).
- Low density requires high flow rate injection configuration

# Hydrogen Fuel Cell System

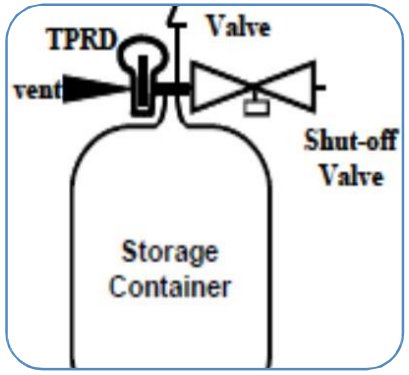
**Reference to various standards to cover various aspects of hydrogen fuel cell vehicles is given in AIS 157**

## H2 Receptacles & Nozzles

**ISO 17268**
Refueling Connection Devices

**ISO 15916**
Hydrogen Safety

**WP2 Hy Approval**
Refueling Station Approval




## H2 Storage System

**ISO 19881**
H2 Cylinders

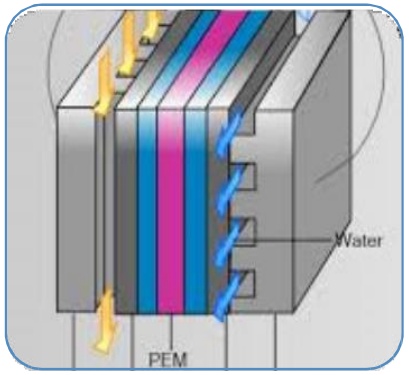
**ISO 12619**
Cylinder valves & Fittings

**EC 79/2009**
Installation Safety

## H2 Fuel System Components

**ISO 12619**
H2 Fuel Components

**EC 79/2009**
Installation Safety

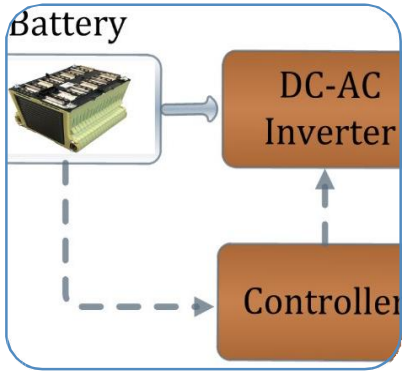



## Fuel Cell System

**GTR 13**
H2 Fuel Cell Vehicles

**UN ECE R134**
Hydrogen Fueled Vehicles

**ISO 27273**
Functional Safety




## Electric Propulsion

**AIS-038(Rev.1)**
Safety

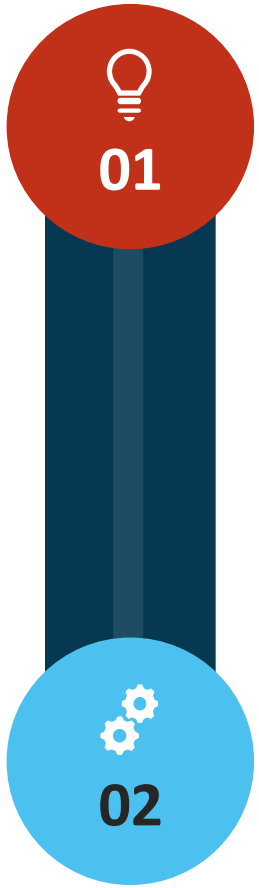
**AIS-039(Rev.1)**
Energy Consumption

**AIS-041(Rev.1)**
Power Measurement

**AIS-048(Rev.1)**
Traction Battery

**AIS-049(Rev.1)**
Type Approval Process

# Hydrogen-CNG (HCNG) – Notifications and Standards




01

## GSR 585 (E) dated 25th Sept 2020

Notification for HCNG to be used as Automotive fuel

02

## Fuel Standards

IS 17314 : 2019 – HCNG as fuel for automotive application

# Hydrogen-CNG (HCNG) – Technology Applicable for Vehicles

For India, the HCNG technology is best feasible for SI engines for Buses

Buses

- HCNG is the general term used to denote varying blends of Hydrogen and CNG and is considered as a transition fuel towards Hydrogen
- The name “Hythane®” signifies a 20 % blend of Hydrogen and Methane (CNG) by volume patented by Frank Lynch of Hydrogen Consultants Inc, USA
- HCNG has advantage of low minimum ignition energy and wide range of flammability limits
- Adding Hydrogen, which has higher flame speed to a low flame speed fuel like CNG, improves the combustion efficiency of the HCNG blend
- HC and CO emissions are lower by 30% for HCNG as compared to CNG. NOx emissions are reduced by adding Hydrogen to CNG.
- HCNG can use existing CNG Infrastructure

**HCNG IS THUS THE FIRST STEP FOR INTRODUCING HYDROGEN AS AN AUTOMOTIVE FUEL**

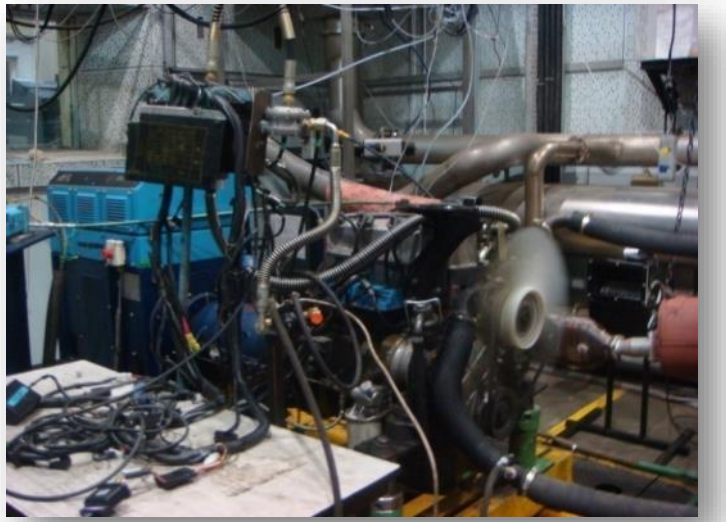
# Hydrogen-CNG (HCNG) – Environmental Benefits

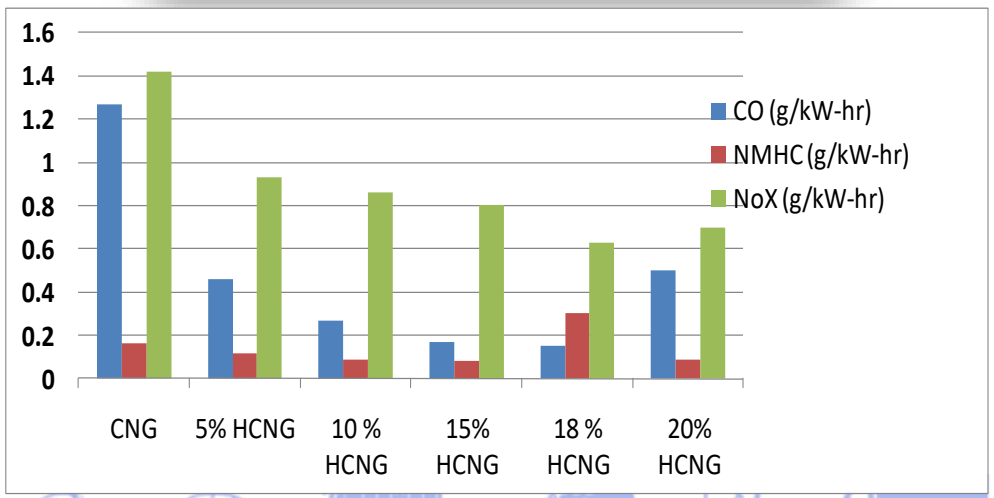
1) Reduction in emissions due to 20 % HCNG blend as compared to CNG is as follows *
    i. CO reduction by 40-50 %
    ii. NMHC reduction by 25-30 %
    iii. NOx reduction by 45-50 %
    iv. $CO_2$ reduction by 7-10 %
2) Improvement in ambient air quality and mitigation of health problems associated with air pollution
3) Creation of a Hydrogen infrastructure thereby promoting the entry of a renewable fuel in the energy market

# Hydrogen-CNG (HCNG) – ARAI Work

## B. BS IV compliant Hydrogen + CNG (HCNG) Engine for Bus Application

- ARAI along with IOCL and OE had partnered for assessment of HCNG blends through compact reforming
- Developed a BS-IV CNG engine optimized for various blends of HCNG - 5%, 10%, 15%, 18% & 20%
- Optimized blend shows
  - ✓ 10% better power than base CNG engine
  - ✓ 5% improved fuel economy, 40% NOx reduction
  - ✓ Low loading CAT than base CNG






**This HCNG Engine was used in Demonstration buses in New Delhi**

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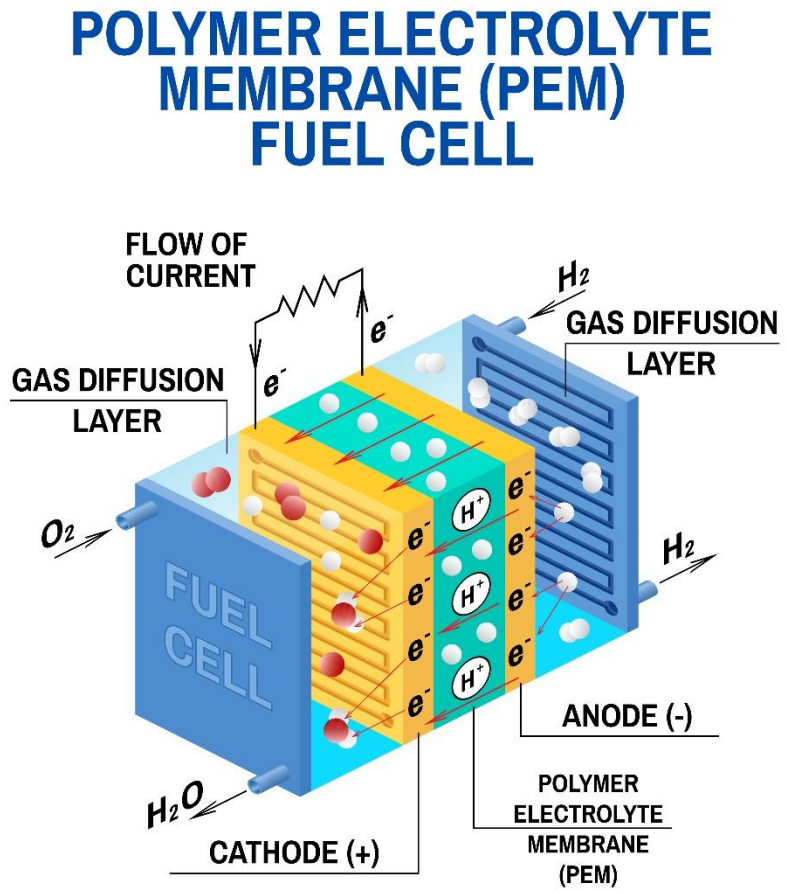
# Hydrogen-CNG (HCNG) Pilot Project in Dellhi

Delhi Transport Minister Kailash Gahlot on 20th October 2020 inaugurated HCNG Plant and Dispensing Station at Rajghat Depot. The 4 Tonne/day Compact reformer- based HCNG production Plant has been set-up by IOCL in collaboration with Transport Department of Delhi. 40 Buses are now run on HCNG

**Ministries Engaged in Hydrogen Program in India**

- Ministry of New & Renewable Energy (MNRE)
- Ministry of Petroleum & Natural Gas (MoP&NG)
- Ministry of Road Transport & Highways (MoRT&H)

# Hydrogen Fuel Cell - Basics




- The fuel is hydrogen
- Charge carrier is hydrogen ion (proton)
- At the anode, the hydrogen molecule is split into hydrogen ions (protons) and electrons
- The hydrogen ions permeate to the cathode
- electrons flow through an external circuit producing electric current
- Oxygen/air, supplied to the cathode, combines with the electrons and the hydrogen ions to produce water

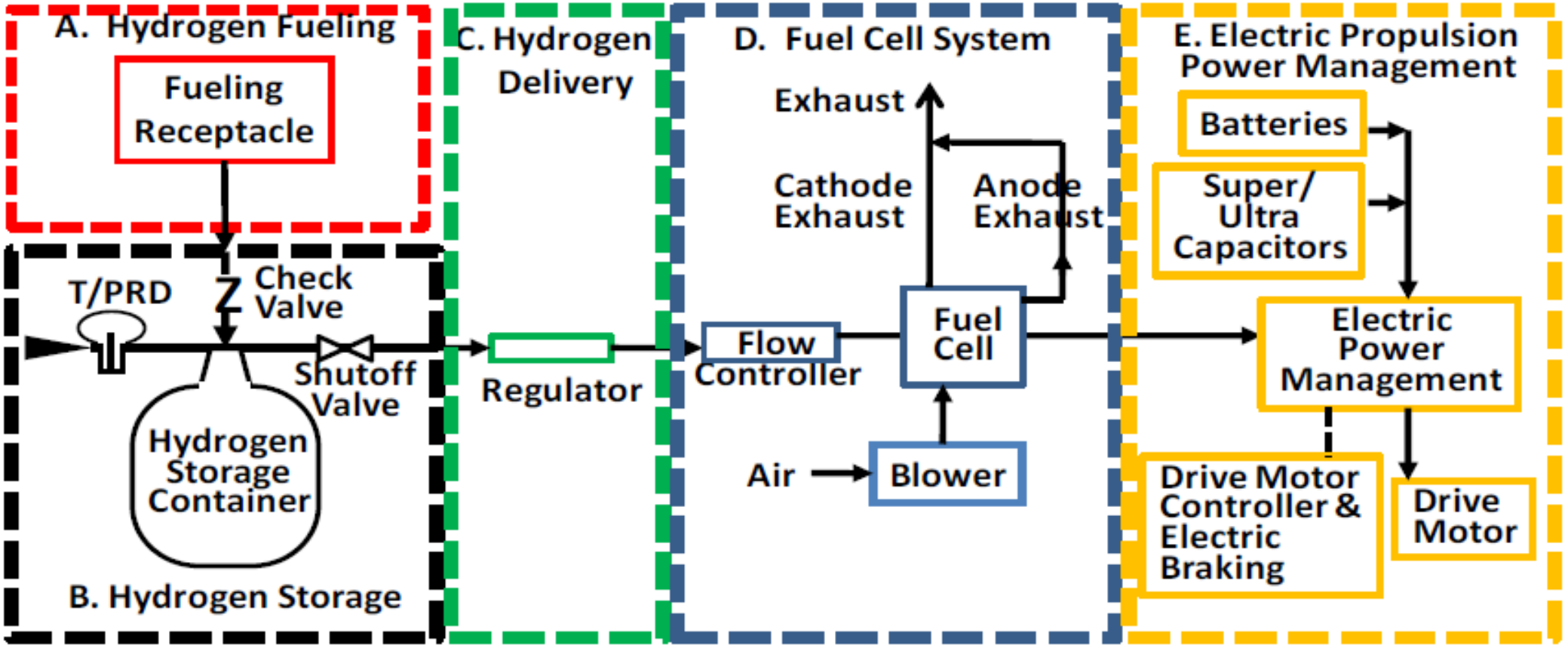
Anode Reactions: $2H_2 \Rightarrow 4H+ + 4e-$

Cathode Reactions: $O_2 + 4H+ + 4e- \Rightarrow 2\ H_2O$

Overall Cell Reactions: $2H_2 + O_2 \Rightarrow 2\ H_2O$

# Schematic Layout of Hydrogen Fuel Cell Vehicles

**Five Aggregates of Fuel Cell Vehicles:**
A) Hydrogen Fuelling B) Hydrogen storage C) Hydrogen delivery D) Fuel Cell System E) Electric propulsion and power management system.



# Hydrogen Fuel Cell Standard (AIS-157)

## AIS-157

### SAFETY AND PROCEDURAL REQUIREMENTS FOR TYPE APPROVAL OF COMPRESSED GASEOUS HYDROGEN FUEL CELL VEHICLES

| GENERAL | REQUIREMENTS | OTHERS |
|---|---|---|
| Scope (M&N Category)<br><br>Reference Standard<br><br>Definitions | Performance & Safety Requirements<br><br>▪ Fuelling Receptacle<br>▪ H2 Storage System<br>▪ H2 Fuel Lines<br>▪ Fuel Cell Stacks<br>▪ Electric Propulsion | Safety Checklist & TA Requirements<br><br>Vehicle Identification Label<br><br>CMVR Specs for H2 Fuel Cell Vehicles |

**MoRTH has issued final notification G.S.R 579 (E), dated 23rd September 2020 to implement AIS 157**

# Hydrogen Fuel Cell Standard (AIS-157)

**Reference to various standards to cover various aspects of hydrogen fuel cell vehicles is given in AIS 157**

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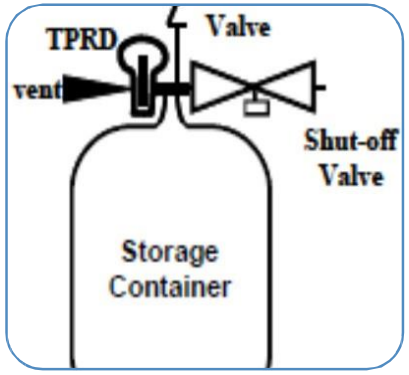


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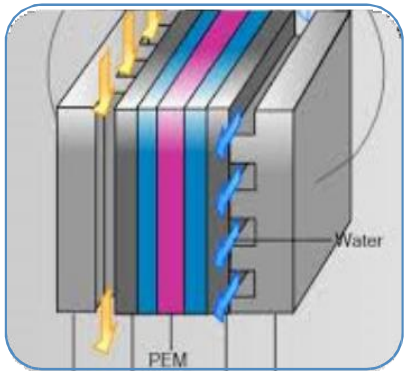


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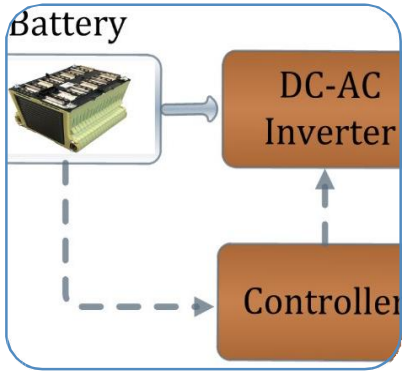


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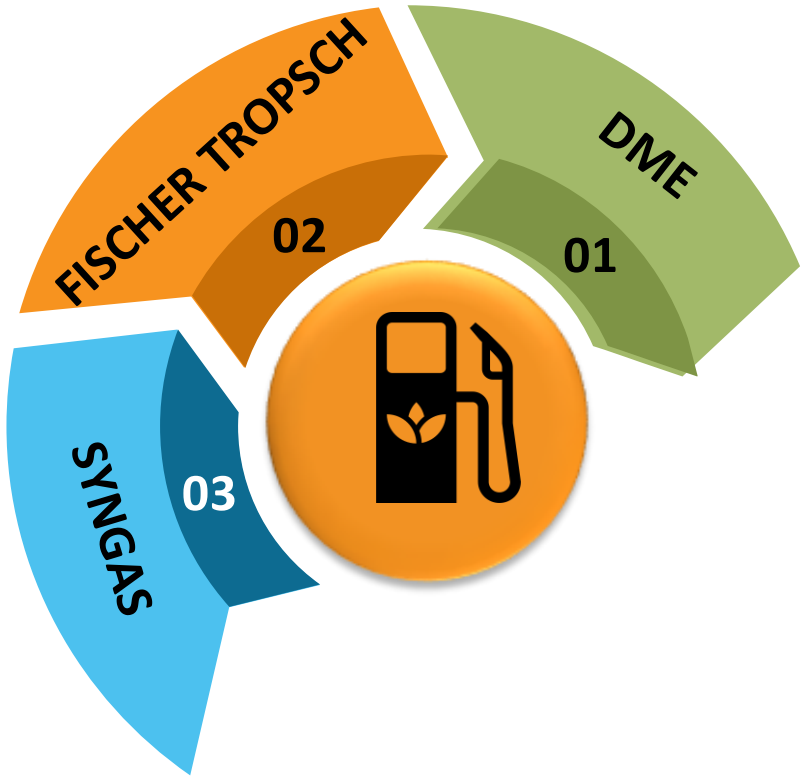
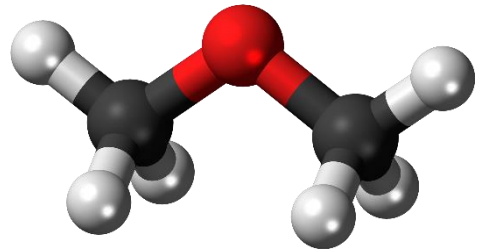
Traction Battery

**AIS-049(Rev.1)**
Type Approval Process

# SYNTHETIC FUELS



# DIMETHYL ETHER (DME)



## 1 SYNTHETIC FUEL

DME can be produced directly from synthesis gas produced from natural gas, coal, or biomass. It can also be produced indirectly from methanol via a dehydration reaction

## 2 DIESEL ALTERNATIVE

It has a very high cetane number. The energy efficiency and power ratings of DME and diesel engines are virtually the same

## 3 GAS AT ATMOSPHERIC CONDITIONS

Under normal atmospheric conditions, DME is a colorless gas. It requires about 75 psi of pressure to be in liquid form. DME's handling requirements are similar to those of propane—both must be kept in pressurized storage tanks at an ambient temperature.

## 4 LOW ON EMISSIONS

DME as an alternative to diesel can virtually eliminate particulate emissions and potentially negate the need for costly diesel particulate filters. However, DME has half the energy density of diesel fuel, requiring a fuel tank twice as large as that needed for diesel.

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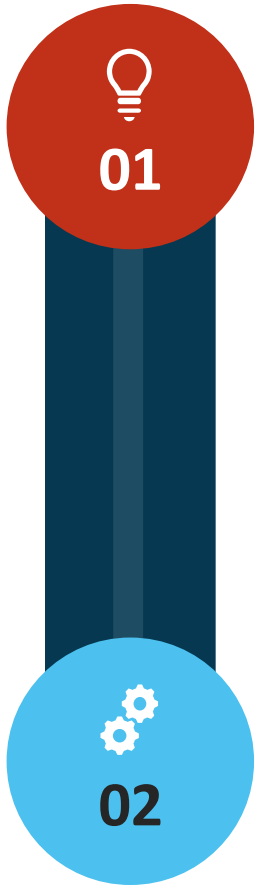
# Di Methyl Ether (DME)– Notifications and Standards




01

## GSR 37 (E) Notified for BS VI

Notification for DME to be used as Automotive fuel

02

## Fuel & Component Standards

- IS 16861 - DME Fuel Specs

# DME : Worldwide Scenario

VOLVO DME Engine, *Source: IDA*


*Volvo DME Truck*

SAIC DME Engine, *Source: IDA*

MAC Truck DME Engine, **the MACK® MP8 engine**

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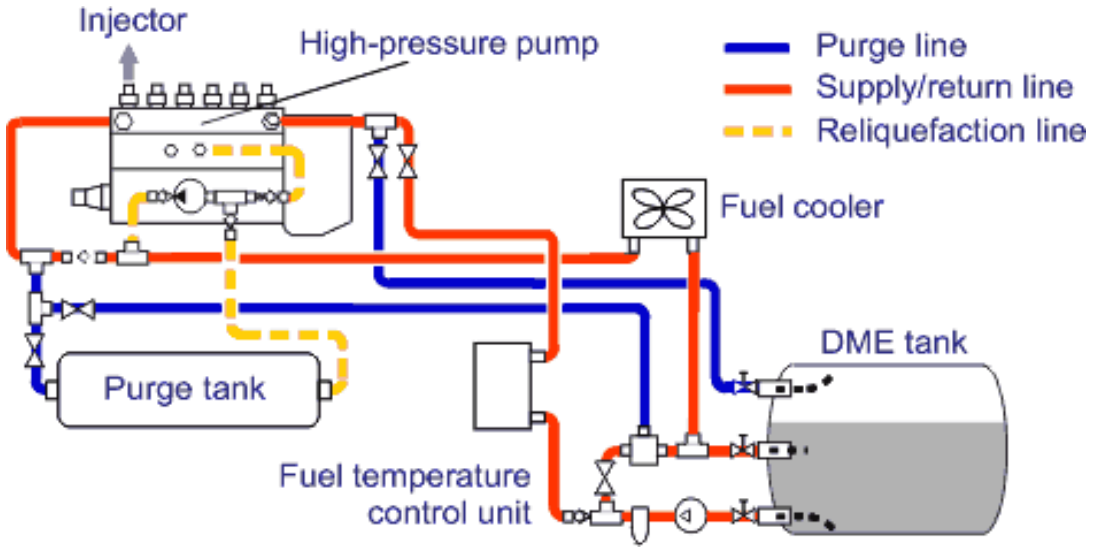
# DME as a CI Engine Fuel

- The cetane number and auto ignition temperature of DME are very favorable to use as a Compression Ignition Engine Fuel.
- Because of its low boiling point temperature and high vapor pressure, Some modifications in the Fuel Injection System are required and those are
  - Major design changes are required in plunger diameter and nozzle through flow area to deliver the more fuel quantity (1.8 times of diesel by volume)
  - Proper sealing is required to avoid the leakage of DME to atmosphere (High vapor pressure (5.1) and low boiling point temperature)
  - Injection Optimization is Required to minimize the Combustion Noise
- Large fuel tanks required to get equivalent range of operation of diesel
- DME is stored at a pressure of 9 bar and this is equal to LPG storage pressure

# DME – Challenges for CI Engines

- Lower Calorific Value
- Low viscosity
- Negligible lubricity
- High vapour pressure (the fuel system needs to be pressurized to maintain DME in a liquid state)
- Seal and gasket material compatibility
- Combustion development

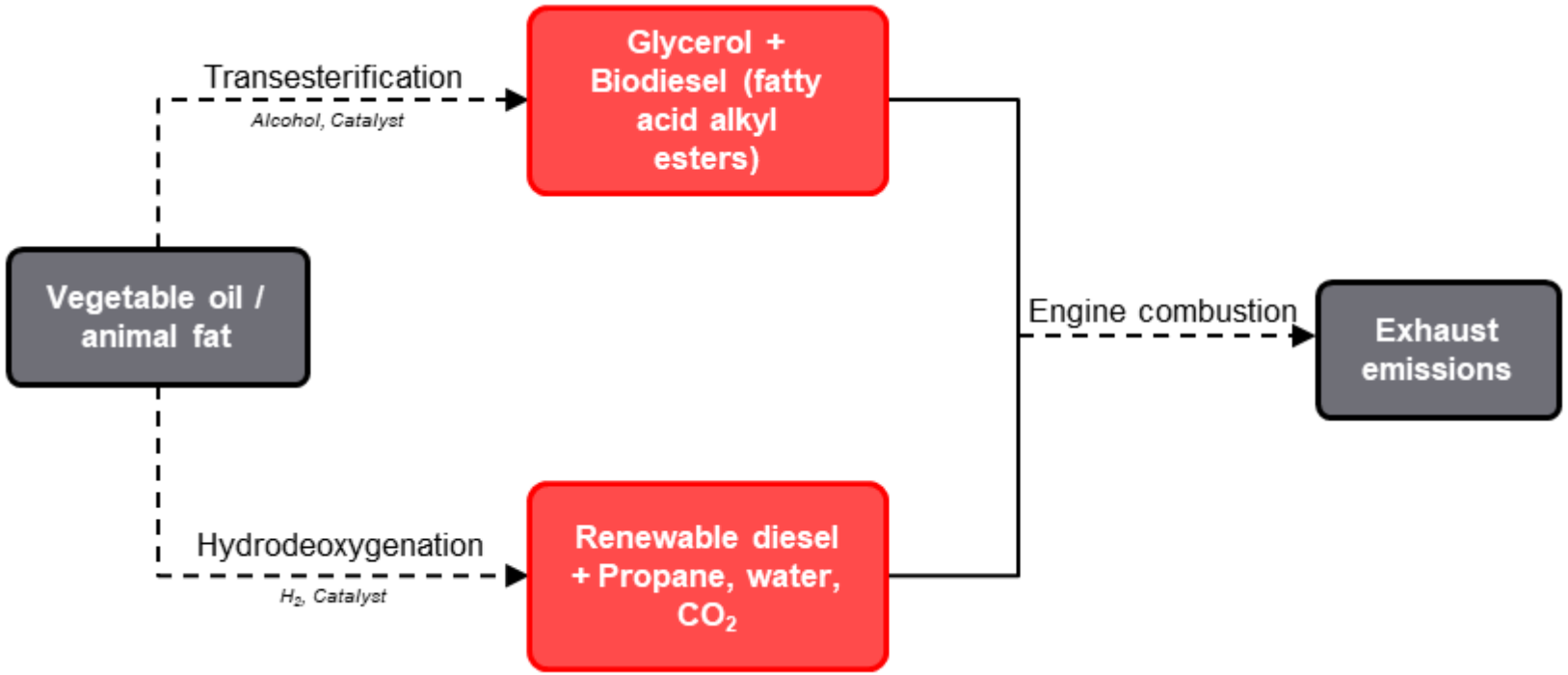


# Renewable Diesel (R-Diesel or Green Diesel)

- **Renewable diesel, previously known as green diesel, is a hydrocarbon produced most often by hydrotreating and other biochemical and thermochemical technologies.**

- **Renewable diesel is a mixture of straight-chain and branched paraffin with typical carbon numbers of C15–C18 and chemically identical to petroleum diesel.**

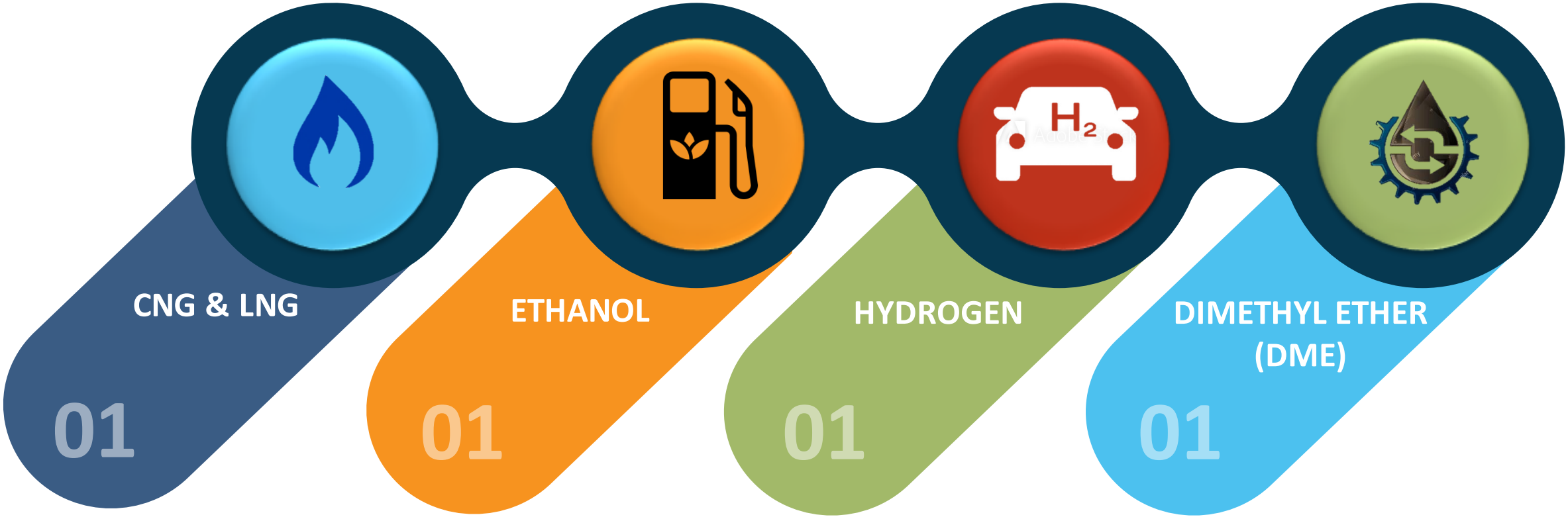
- **Currently R-Diesel is not separately notified for automotive use and separate BIS specification is not available.**



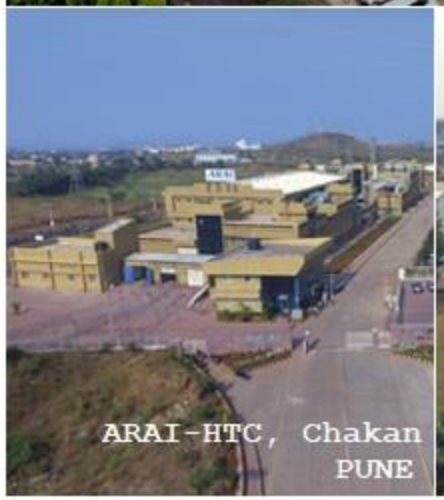
# Renewable Diesel in India

Indian Oil Corporation Limited has rolled out a cleaner and greener ‘XtraGreen’ diesel, which is more fuel-efficient and environment friendly than the regular diesel. The Xtra Green diesel is available at 126 fuel stations across 63 cities in India since November 2021. The fuel is compliant to IS 1460 and also meets BS-VI emission norms

# ALTERNATIVE FUEL CHOICES AT FOREFRONT IN INDIA



# ARAI ROLE IN ALTERNATIVE FUELS



01 R&D PROJECTS ON ALTERNATIVE FUELS

02 REGULATION FORMATION IN CMVR & BIS STANDARDS

03 CMVR CERTIFICATION OF GENSETS & VEHICLES ON ALTERNATIVE FUELS

04 TRAINING & IPR GENERATION ON ALTERNATIVE FUELS

05 CONSULTANCY TO INDUSTRY

ARAI®
Progress through Research

# Alternate Fuel Centre at EDL, ARAI

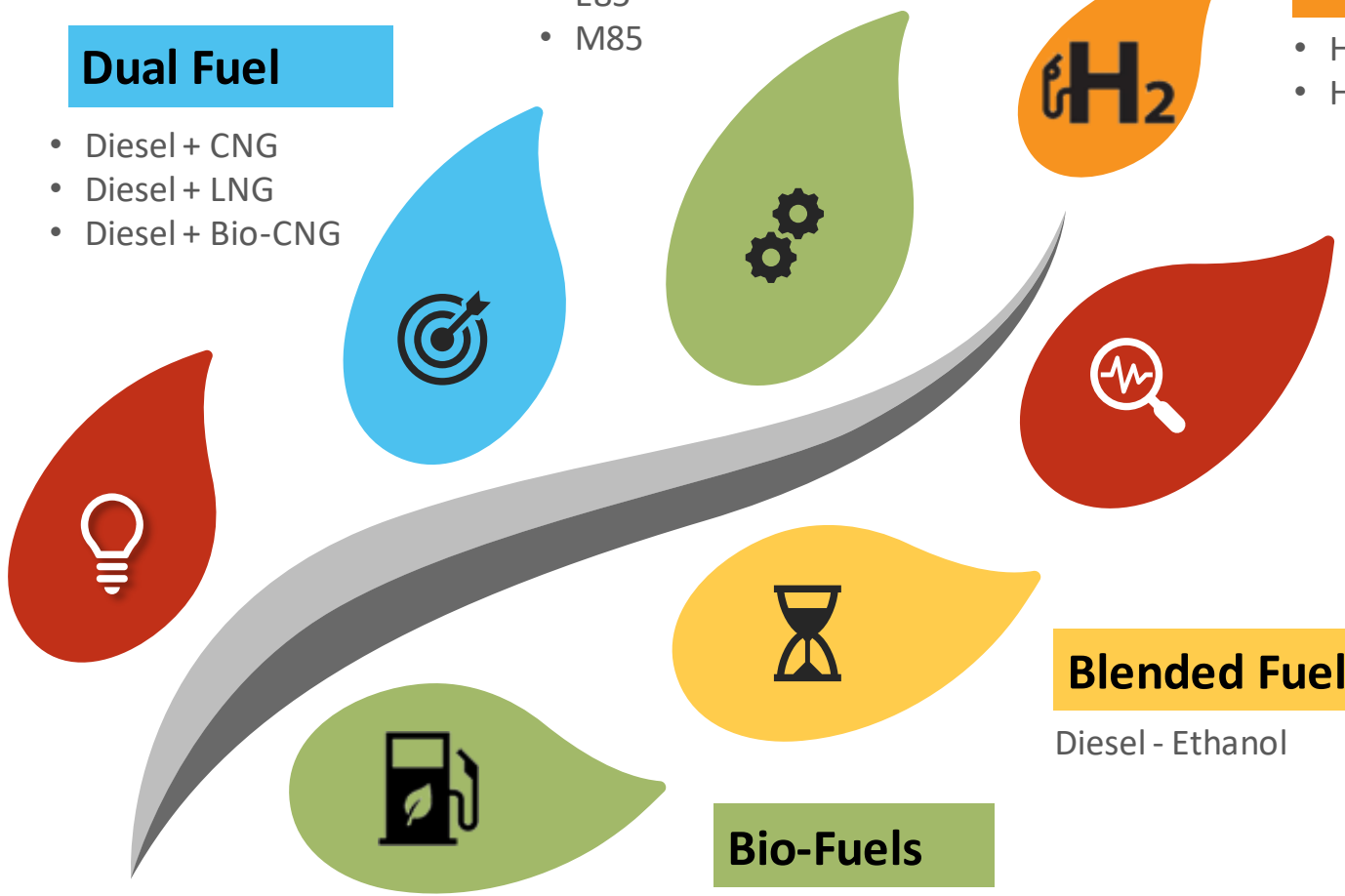
## "All Solutions to alternate fuels under one roof"

**Various Fuels handled by Alternate Fuel Centre**

### Flex Fuel
- E85
- M85

### Dual Fuel
- Diesel + CNG
- Diesel + LNG
- Diesel + Bio-CNG

### Hydrogen
- H2 ICE
- HCNG



### Gaseous Fuels
- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)
- Bio-CNG
- Liquefied Petroleum Gas (LPG)

### Synthetic Fuels
- DME
- DME+LPG

### Blended Fuel
Diesel - Ethanol

### Bio-Fuels
- E10, E20, E100
- M15 M100
- ED95 MD95

# Services offered by Alternate Fuel Centre at ARAI

## Engine Level – Calibration Support

- Alternate fuel engine calibration for emission/power/BSFC
- Alternate fuel engine durability
- Alternate fuel engine development, testing and validation
- Alternate fuel engine combustion and simulation
- Alternate fuel engine component evaluation
- Upgradation of the engine for specific fuel
- Genset Certification and Consultancy

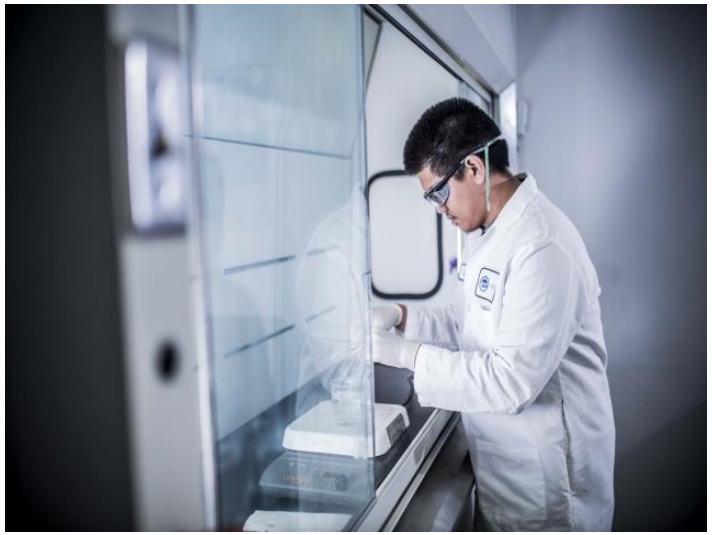
## Vehicle Level - Support

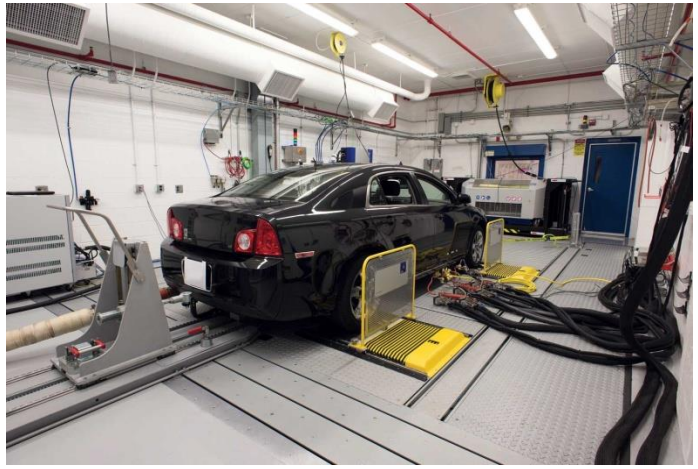
- Safety layout design and review as per AIS
- Vehicle trials

## Other Support Services

- Fuel Characterisation
- Preparation of additive / oil / catalyst and its evaluation
- Material compatibility as per ASTM standards
- Training on alternate fuel engine, vehicle, rules and regulation to RTO & other govt officials, Fuel suppliers, STU's, Academician, Industry personnel, Graduate trainees, etc.
- Consultancy on need basis for specific project / technical support
- OBD demonstration Consultancy
- De-coding of regulation and consultancy
- System verification, review and readiness for any specified notification
- Assistance in new standard development
- Evaluation of additive/ efficiency improvement devices
- Third party inspection

# Research & Development is the Key for Adaptation of Alt Fuels



# Thank You

Questions ?