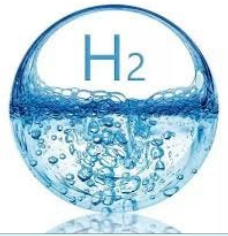
Fuels for Clean and Sustainable Future



IndianOil R&D The Power of Possibilities

50 years of Innovative Excellence

Dr. SSV Ramakumar, Director (R&D),
IndianOil Corporation Limited

ECT 2022– 10th November'2022

Global Megatrends – Sustanability

1

Long-term demand impact of COVID-19 is modest

2

Molecules & Electrons going to co - exist

3

Peaks in fossil-fuel demand continue to occur earlier

4

Change is too slow to reach the 1.5°C Pathway

5

Investment flows in Energy sector remain stable over the next 15 years

Top Energy & Innovation trends in 2022 revolving around 3 pillars

- Decarbonization
- Decentralization
- Digitalization

Executive Action Plan for the Early Warnings for All initiative, introduced in COP 27 for adaptation financing with initial new targeted investments of $ 3.1 billion between 2023 and 2027

Changing Paradigm of Energy Sector

Advanced Energy Transition

"Net Zero targets"

- $125 trillion of climate investment is needed by 2050 to meet net zero
- IndianOil plans to invest Rs. 2.5 lakh crores (Scope I/II)

"All of the above scenario"

Full menu of fossil, nuclear and renewable energy sources will exist– multiple solutions will fit the bill

"Changing locus of Energy Diplomacy"

Focus from "Access to Resources" currently to "Access to Technology"

India's Climate Commitment – Revised INDCs

Disclaimer: Map for illustration purposes only

Total Installed power (2030) – 820 GW

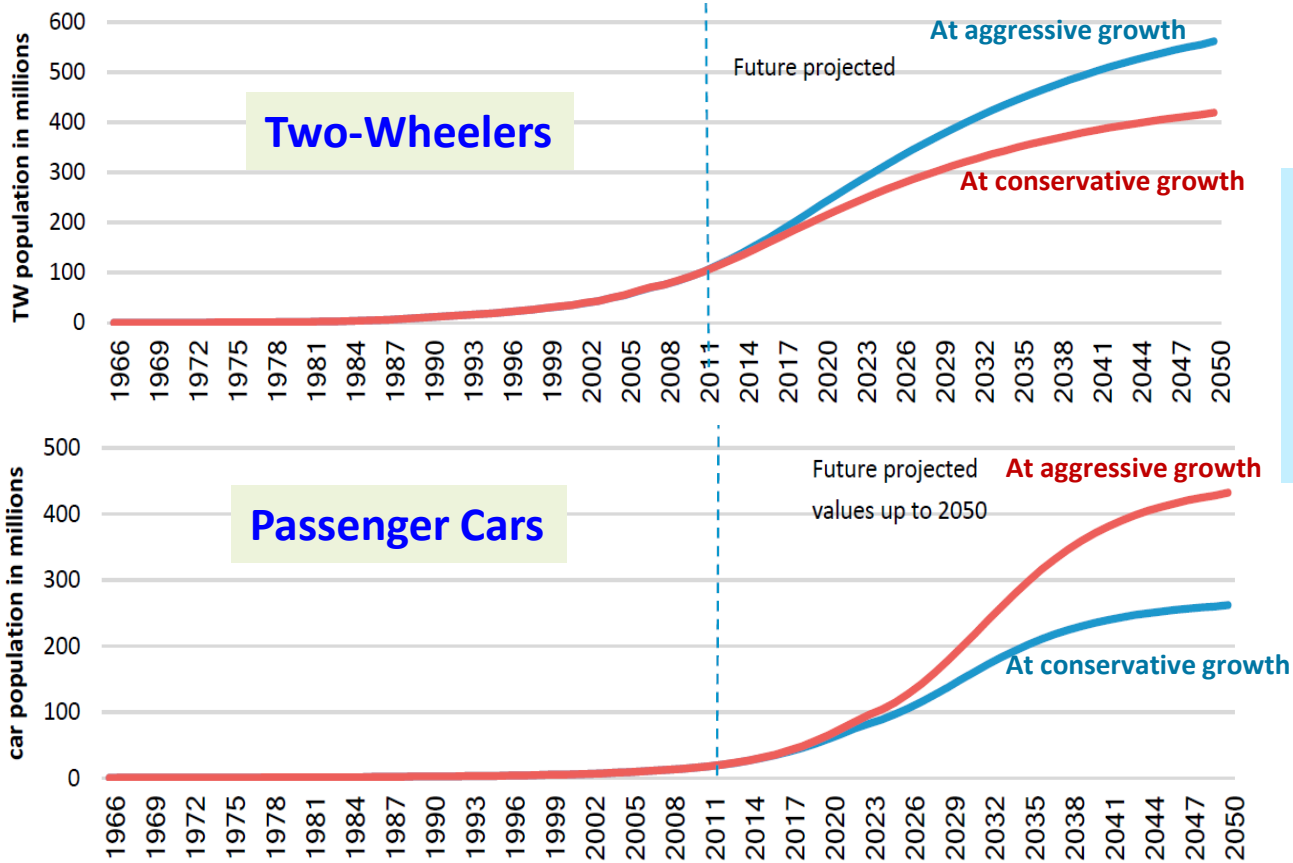
1. 50% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030

2. Reduce carbon intensity of its economy by less than 45% by 2030 (base year 2005)

Achieve net zero emissions by the year 2070

Multiple pathways key to meet the transition

Growth of 2Ws & Cars Park in India

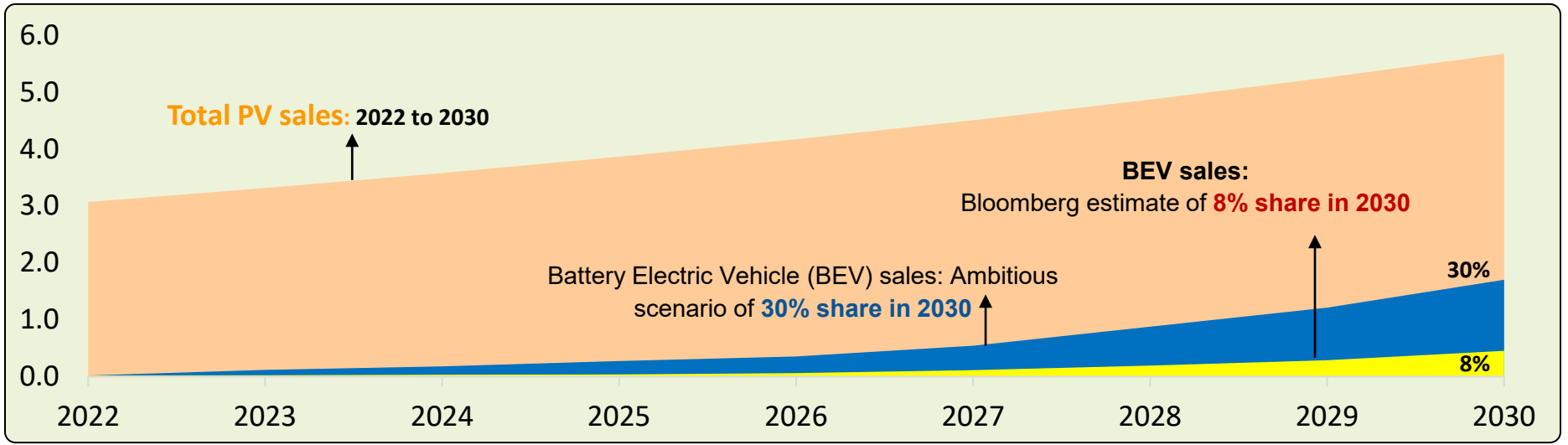


Even under conservative growth,

- 2W Population will double from 2020 to 2050
- Cars population will triple from 2020 to 2050
- No peak seen till 2050

Source:
IIT Bombay 2020,
Transportation Research Procedia
(SIAM Commissioned study)

Share of BEVs & Non-BEVs (PC Case)



Total (Conventional + BEV) Car sales : PV market assumed to grow at 8% CAGR from 2022 to 2030

- Cumulative total Passenger Vehicle sales from FY 2022 to FY 2030 = **38 Mn**
- **Cumulative Non-BEV sales**
  - **As per Bloomberg (BNEF) estimate - 8% BEV penetration by 2030 = 37 Mn (97%)**
  - **As per an ambitious scenario - 30% BEV penetration by 2030 = 33 Mn (86%)**

Significant Non- BEV sales of 86% ~ 97% needs to be addressed

Case of Heavy duty vehicles is also similar

Source : Auto Industry

Segmental Penetration of EVs


Scooter ✓


3-Wheeler ✓


Private Car ?


Intercity Bus ✗


Bikes ?


Taxis ✓


Intracity Bus ✓


Truck Car ✗

Source : Auto Industry

Well to Wheel Emissions: Challenge in the medium term

Generation Source	Power Generation	
	2022	2030
Non-Renewables*(TWh)	1,162	1,465
Non-Renewables* (%)	78%	61%

In India, Hydro electricity is counted under Renewable sources

Source : CEA

Mobility Sector Outlook (2030)

Segment / Technology	BEV	HEV	CNG	LNG	Bio-fuels (E10/E20/FFV)	FCEV
2W						
3W						
Small Passenger Vehicle						
Big Passenger Vehicle						 2030 onwards
Intra city – Bus & Commercial Vehicle						 2030 onwards
Long distance - Bus & Truck						 2028 onwards

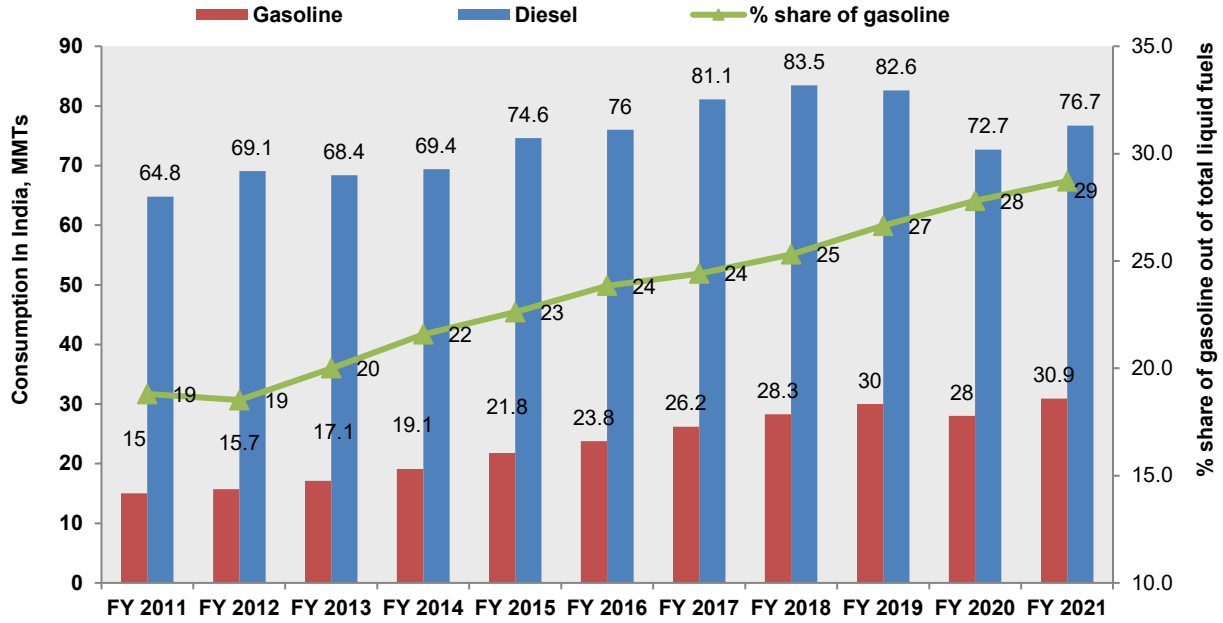
Source : Auto Industry

Imperatives:

- Battery vehicles need Charging and Swapping infrastructure / Need Alternate battery chemistries
- Personalized cars continue to use Gasoline & Diesel
- Demand destruction due to e-mobility will shift the refining slate from Oil to Chemicals
- Shipping sector to explore methanol and ammonia as new energy carriers

Petroleum Fuels – Gasoline & Diesel

Consumption of Liquid Fuels - India



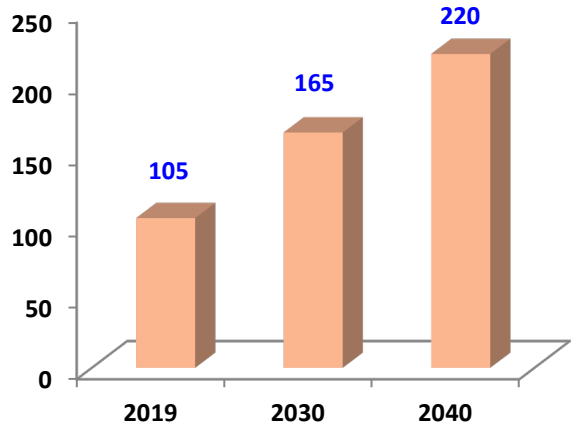
The consumption growth of gasoline is at a faster rate than diesel

Transport sector consumes almost 100% gasoline & 80% of Diesel shown above

Penetration of CNG in heavy duty segment affects the diesel consumption

Forecast

Oil Demand for Transportation (MMTPA)



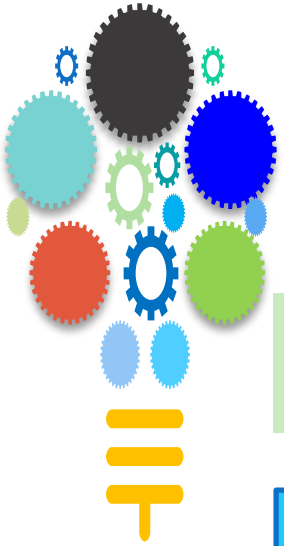
IEA India Energy Outlook 2021

Differentiated Fuels & Lubricants

Differentiated Gasoline

Enhanced fuel economy

Reduced Emissions



Enhanced Performance

Faster Acceleration

Better Drivability & Engine Life

IndianOil XP100 100 octane premium petrol

XP95 95 OCTANE PREMIUM PETROL

Differentiated Diesel

- ✓ IOC differentiated diesel provides average fuel economy benefits of >= 5..0% and significant emission benefits.

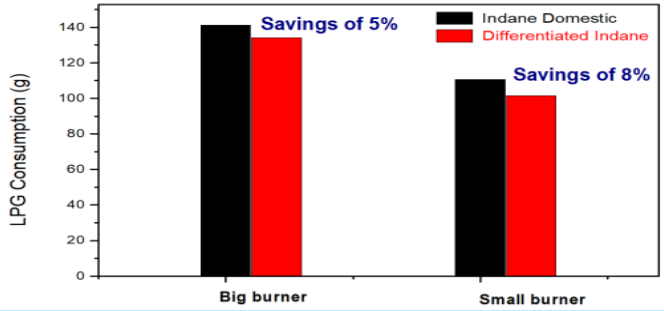
Differentiated Lubricants

SERVO Greenmile - SAE 5W-30 and API SN requirements

SERVO Raftaar - SAE 15W-40 & API CK-4 requirements

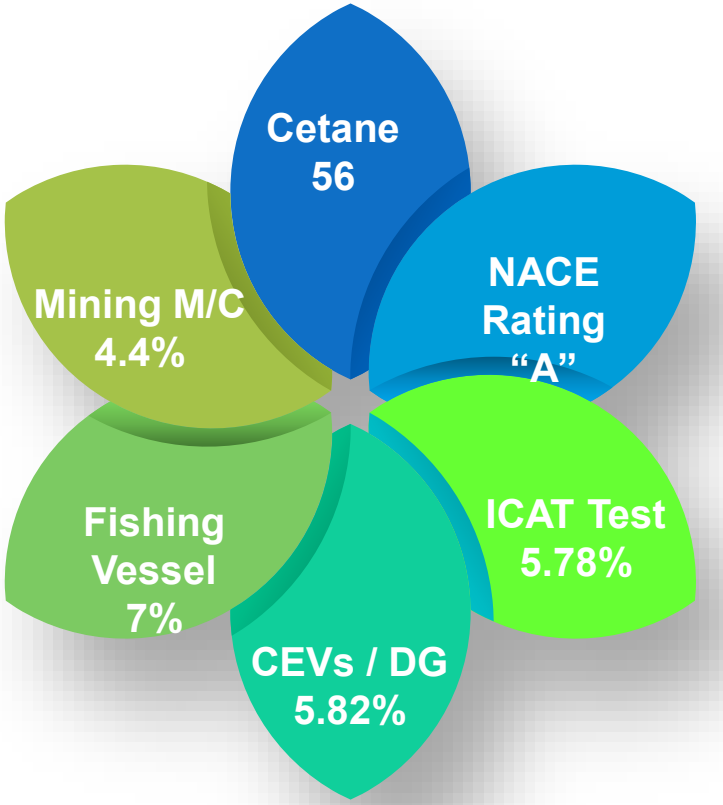
Reduction in carbon footprints by 10%

Differentiated LPG – Xtra Tej



Reduction in LPG consumption: 5%-8%

Differentiated Fuels and Lubricants - Testing & Validations



Lab Evaluations

CFR Test

ASTM D 613 /IS 1448: P9 Method for Cetane No.

Corrosion Test

NACE TM-0172 Method for Corrosion

Accredited Testing Centre

International Centre for Automotive Technology

IS:11921 Based Test on On-road Heavy Duty In-Use Vehicle

International Centre for Automotive Technology

Tests on Off-highway and Stationery Engine by 3rd Party

Field Performances - Govt. Lab / Customer's End

Central Institute for Fisheries Technology

Field Evaluation on Fishing Vessel in Sea with Voyage & Fishing

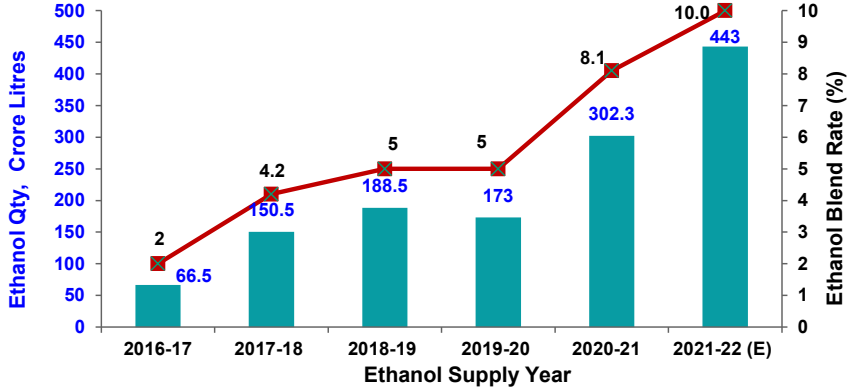
Mining Machinery

Tests on Komatsu Dumpers at TATA Steel Iron Mines

Complete chain of performance evaluation from laboratory to to field performance done

Fuel Ethanol

Present Scenario



All-India Average Ethanol Blending

The Average all-India Ethanol Blending Percentage as on 24.07.2022 = 10.16%

Forecast

Capacity Augmentation (in Crore Litres)

Year	Plant Capacity			Ethanol required for blending
	Grain	Sugar based	Total	
2021-22	300	519	819	443
2022-23	350	625	975	542
2023-24	450	725	1175	698
2024-25	700	730	1430	988
2025-26	740	760	1500	1016

Source: Ethanol Blending Roadmap 2020-25

E20 Roll out from April 2023

Feedstock Options: Sugar cane juice, Sugar, Sugar Syrup, B & C molasses, damaged food grains, FCI Rice, Maize

50:50 mix of grain and sugar based feedstock by 2025-26 can help sustainable supply of ethanol balancing lean & rich sugar seasons

Benefits

- Low-hanging fruit, Eco-system exist for fuel ethanol
- Automotive technology for E20 & FFVs are available
- **2G** ethanol plants can support availability provided there is mechanism for biomass aggregation and PAN India cooperative federalism
- 3G route to be aggressively followed where refinery / industrial off-gases to be valorized to ethanol

Challenges & Opportunities

- If ethanol becomes deficit due to natural calamities like extreme drought, then protection grade of min. E10 fuel with 95 RON can suffice all automotive requirements
- Surplus ethanol to be used for blending with diesel (ED5)– Research work started, Trials for use of ethanol in SAF route to begin.

ED5 (5% Ethanol – Diesel blend)

IS 1460 allows 7% biodiesel blending.
Lack of biodiesel availability is a concern.

Possible Composition of ED5:

- 5% v/v ethanol
- BS VI Diesel
- Coupler
- Corrosion Inhibitor
- Cetane Improver
- Lubricity Improver

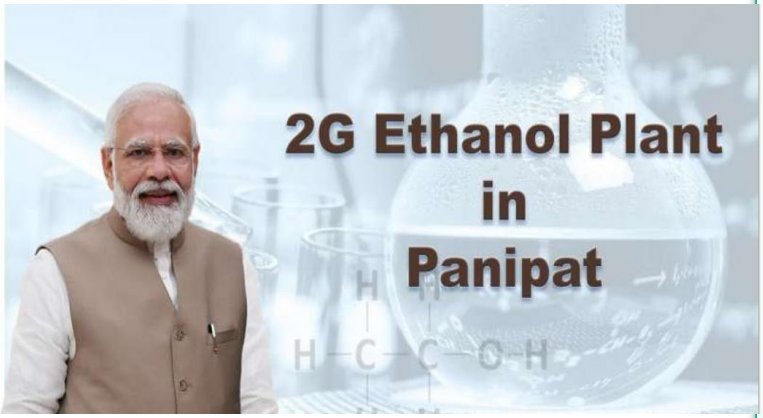
S.No	Property	IS:1460	Remarks
1.	Flash point (Abel), ^{0}C	35 min	**It is expected below 35.** Product category may change from Class "B" to Class "A" of PESO, if flash point is below 23 ^{0}C for ED5.
2.	Water content, PPM	200 max	**May be higher than 200 PPM** as Ethanol is hygroscopic and contains around 2000 PPM water content
3.	Cetane Number	51 min	**Cetane improver is required**

Highlights of KSRTC trials (2006-2011)

- **7.7% blending of ethanol blended with diesel and a solubilizer additive used to improve blend stability**
- **Trials expanded to include 21 Depots over 8 KSRTC divisions, involving BS-2 & older buses having in-line fuel pumps.**
- **Total km of buses covered with EBD = 5.15 Cr**
- **Total ethanol consumed = 8.44 lakhs litres**

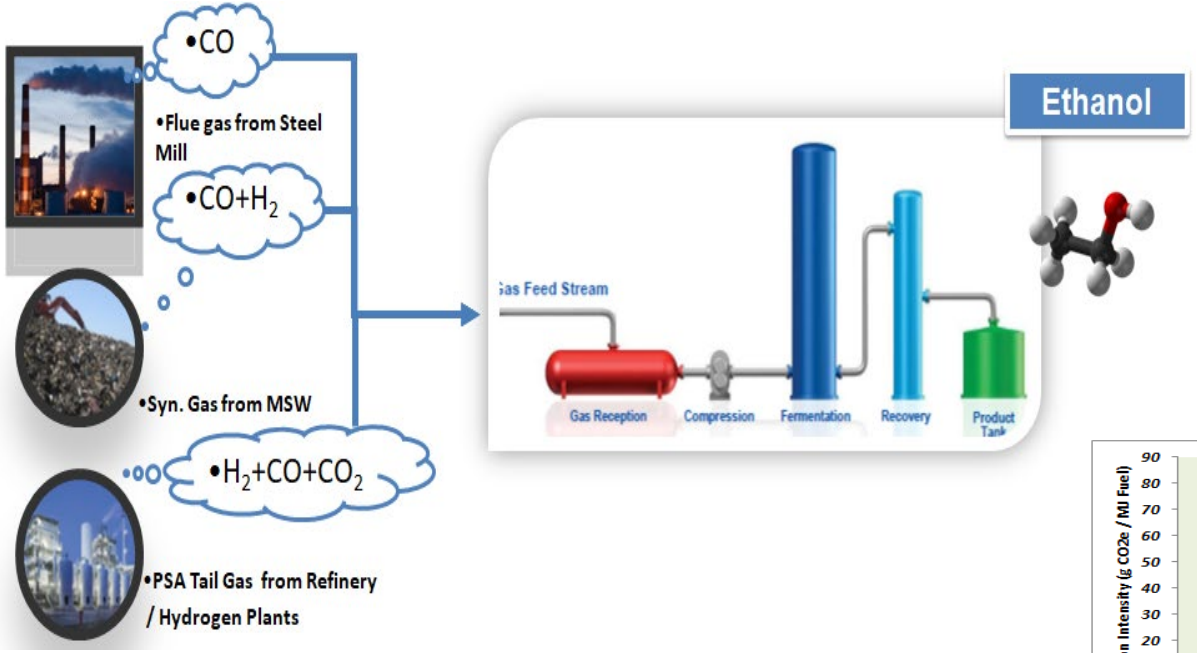
Onstreaming – 1st 2G Ethanol Plant

PM dedicated India's 1st 2nd Generation Ethanol plant in Aug'22 at Panipat Refinery

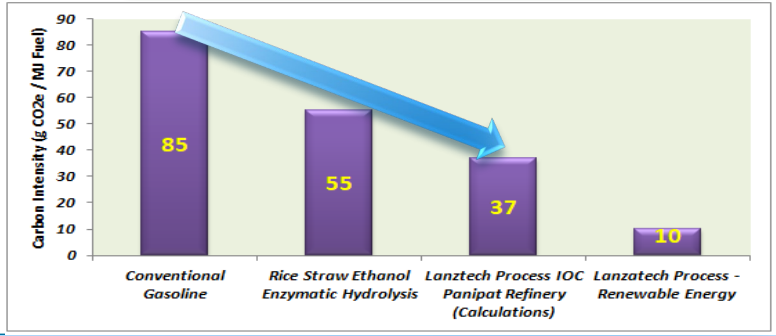


- Built at an estimated cost of Rs. 900 crore by IOCL
- Would utilize 2 lakh tonnes of rice straw (parali) annually
- To generate around 3 crore litres per annum Ethanol
- Empowering farmers by creating end-use market for agri-crop residue
- Reduce 3 lakh tonnes of CO_2e emissions per annum (equal to replacing nearly 63,000 cars annually on the country's roads)
- Commercial production of 2G ethanol to commence soon

Waste Gases to Ethanol (3G)



- Fixes **CO_2 apart from ethanol production - >60% GHG reduction**
- Low Capex and opex compared to cellulosic 2G Ethanol
- Low Water foot print per ton of ethanol
- Flexibility of producing other chemicals like Isopropanol, Acetone, 1,3 butandiol etc in the same fermentor
- Endorsed by USTDA with a grant of 5 million USD towards feasibility studies



IOC setting-up World's 1st Demo plant for PSA Off-gases to Ethanol
: 33,000 t/annum – *Mainstreaming in December 2022*

SAF Demand Projections- India

India needs to comply with CORSIA emission norms from 2027 onwards

SAF requirement projection under different blend scenarios for Total Aviation (TMTPA)

FY / Blending %	1%	5%	10%
2023 - 2024	95	475	950
2024 - 2025	100	500	1000
2025 - 2026	103	515	1030

2.47 $MtCO_2e$ Carbon/ annum mitigated (10% scenario)

SAF requirement projection under different blend scenarios for International Aviation (TMTPA)

FY / Blending %	1%	5%	10%
2023 - 2024	33.5	167.5	335
2024 - 2025	35	175	350
2025 - 2026	37	185	370

0.88 $MtCO_2e$ Carbon/ annum mitigated (10% scenario)

SAF Demand (By 2025) :

- ❑ **International: 100 TPD production @ 1% SAF Blending**
- ❑ **International + Domestic: 300 TPD production @ 1% SAF Blending**

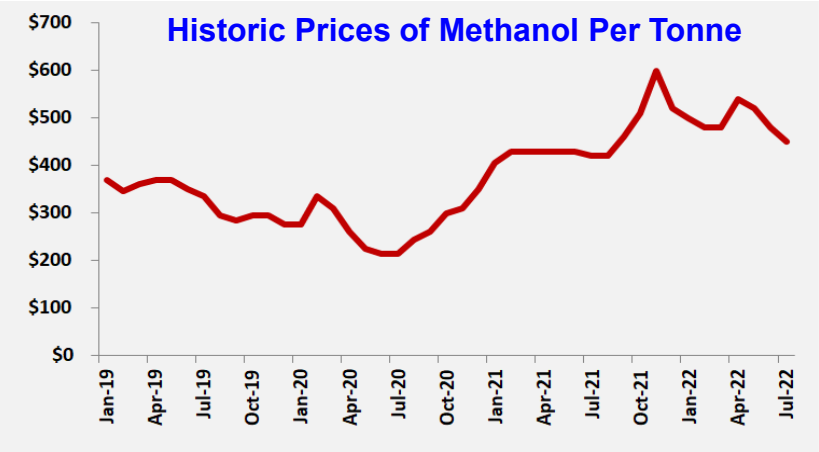
Source – Expert Committee Report on Bio-ATF

IndianOil in process of setting two Biojet plants in northern and western part of India

Methanol as a fuel

Methanol Scenario

- Estimated current demand: ~ 2.4 MMTPA
- Domestic production capacity: ~ 0.47 MMTPA
- Domestic methanol production ~0.272 MMTPA
- Methanol import: 2.16 MMTPA
- Cost of Methanol - $450/ton
- Cost is the main factor triggering methanol imports



Feedstock Options: Natural Gas, Coal (Indian High Ash Coal), Bio-mass, Municipal Solid waste and CO2.

Setting up of New Indian coal-based methanol plants is essential. Technology demonstrated.

Benefits

- 15% substitution of diesel can save the crude import bill of approx. 53,000 Crores
- Methanol blending can significantly decrease the Particulate matter (PM) emissions

Challenges

- The large-scale availability of methanol for fuel purpose is a major hurdle in embarking on methanol economy
- Price competency of indigenously produced methanol
- Substitution of diesel by 15% would require ~11.5 MMT of methanol (2021)

CNG / LNG

CGD Network Coverage:

(after completion of 11 A Bidding round)

- 295 Geographical Areas (GAs)
- 98% of the population and
- 88% of total geographical area
- around 630 districts in 28 states/UTs

CNG stations

- At Present - 4629
- By 2030 - 17,700

(Source: PIB, Jul'22)

Domestic Production of NG is 23 MMTPA which is 53% of total consumption

NG Demand for Transport Sector: 3.5 MMT (2019), 7.02 MMT (2030)

(Source: Derived from WEO 2021, IEA)

Benefits

- Cleaner low-carbon fuel, Vehicle technology exists and vehicle park will ramp up as the availability increases
- Viable alternative for LPG (cooking) and Diesel (automotive)

Challenges

- Infrastructure requirement is huge & require capital intensive equipment for handling
- May struggle in view of Net Zero Commitments – CBG can supplement partially

LNG Terminal	Capacity	Capacity (MMTPA) 2025
Dahej	17.5	17.5
Hazira	5	5
Dabhol	5	5
Kochi	5	5
Ennore	5	5
Mundra	5	5
Dhamra	-	5
Jafrabad	-	5
Jaigarh	-	4
Chhara	-	5
Kakinada	-	4
Kukrahati	-	3
Krishnapatnam	-	1
Gopalpur	-	1
Karaikal	-	1
Total Capacity (MMTPA)	42.5	71.5

Source: PPAC / PNGRB / MoPNG

CBG or Bio-CNG

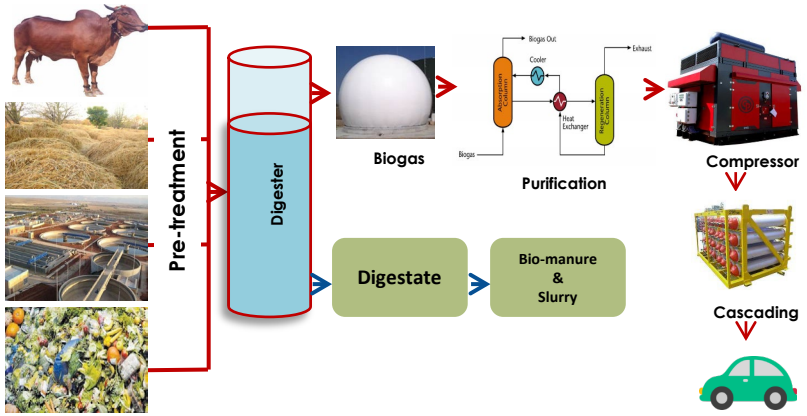
SATAT Scheme

Initiative by Government – Rolled out in 2018

5000 CBG Plants by 2023

15 MMT of CBG

50 MMT of Bio-Manure



Feedstock Options: Organic waste / bio-mass sources like agricultural residue, cattle dung, sugarcane press mud, municipal solid waste and sewage treatment plant waste, etc.

30 CBG/biogas plants have been commissioned under SATAT initiative so far. (3497 LoIs issued / CBG sold – 9019 tonnes)

Benefits

- Production technology is matured and available
- Guaranteed off-take by OMCs and Eco-system exist
- No change in vehicle technology required (CNG and CBG qualify same fuel quality standards)

Challenges

- Aggregating the feedstock at affordable cost – Cooperative Federalism will aid in
- Cost of delivered CBG at RO
- Awareness among the entrepreneurs

Aluminum-Air Battery

- **Anode** - Aluminum
- **Cathode**- Air Electrode
- **Electrolyte** - Aqueous

Vehicle Category	Battery energy (KWh)
Commercial Vehicles (Bus/Truck)	700
Passenger Vehicles (Car)	50
Three Wheelers (Auto/e-rick)	15

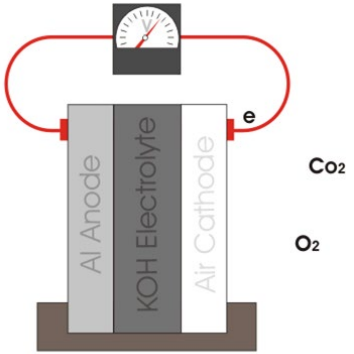
USPs

- ✓ High energy density (8000 Wh/Kg) compared to 400 Wh/kg
- ✓ No need for electric charging & stations
- ✓ Replacement of aluminium plates required
- ✓ Long range
- ✓ Better recycling compared to Li-ion
- ✓ Uncompromised performance at varying weather conditions
- ✓ Lower cost compared to Li-ion as there is no noble metal used

Technology Availability

- Commercial trials are in progress with three-wheelers and passenger cars
- Discussions underway with Heavy duty OEMs

EV with Al-Air battery system



1680 MW batteries expected to be deployed in 3W/4W by 2030 (Aspirational Scenario)

Battery as a Service

Battery Swapping stations by OMCs – 61
EV Charging stations - 3609

38	Number of live battery swapping stations at IndianOil retail outlets
22	Number of swapping stations in Delhi-NCR
15	Number of cities covered by IOCL SMPL Battery Swapping Network
8 Lakhs	Battery Swaps at IndianOil outlets till date (~75K Battery Swaps every month)

Other Active Players (BaaS)
Ola Electric / Bounce-BPCL / Jio-BP / VoltUp / Lithiun Power / Esmito / Numosity / ChargeUp / Amar Raja

An e-Auto in Chandigarh has covered 1.5 lakh+ KM distance so far with Battery Swapping

IndianOil & Sun Mobility

SUN MOBILITY

- Sun Mobility is one of the most prominent players in Indian Battery Swapping Domain with more than 80 Swapping Stations
- Bosch and Vitol have become strategic investors in this company in last 2 years

- **MOU Signed with Sun Mobility**
- **Pilot Project underway - To understand the technical and operational aspects**
- **Due-diligence completed; negotiation process underway**

Hydrogen Enriched CNG (HCNG)

HCNG

- Spiking of hydrogen in CNG can help better combustion in IC Engine
- CO, HC and PM emissions decrease significantly with HCNG compared to CNG
- Fuel economy improves by 4-5% with nominal increase in fuel cost

Green H2 commitments

Blending of 18% green hydrogen in CNG can be cost-effective

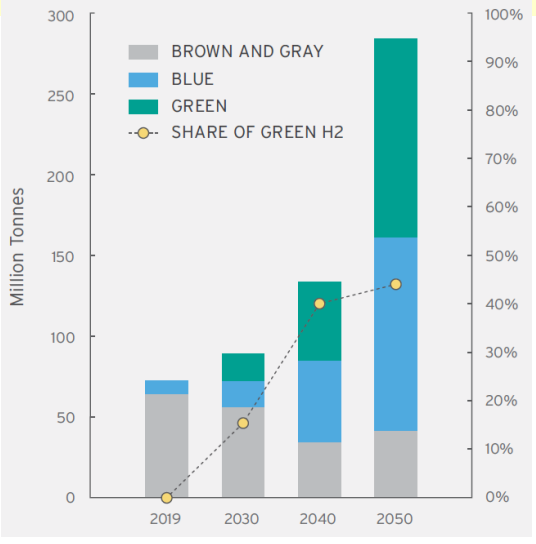
Kick-start use of green hydrogen in transport sector before the commercial roll out of 100% H2 ICE or FCEVs

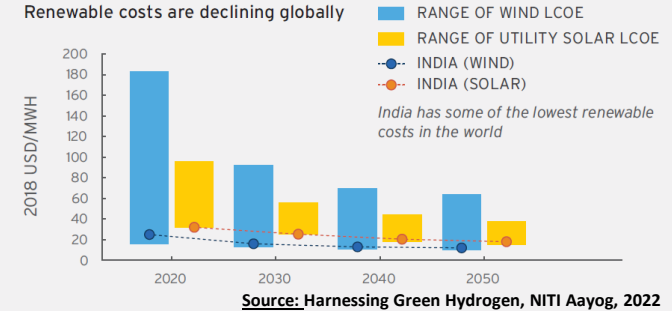
HCNG for Transportation Sector

- Green H2 required for blending: 0.15 MMT
- Can be used in Passenger Cars, Buses and Trucks – ***Blue or Green doesn't make any difference for automotive usage***

NITI Aayog Report on "Harnessing Green Hydrogen" indicates blending of Green H2 10% by 2025 and 20% by 2030 in City Gas Distribution (CGD) as pilot.

Global H2 Production Outlook





Source: Harnessing Green Hydrogen, NITI Aayog, 2022


THANK YOU