Holistic Assessment of Alternate Powertrains for Passenger Vehicles in India

NRI

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Nomura Research Institute Consulting & Solutions India Pvt. Ltd.

20th January, 2021

Objective, Focus and Approach

❑ Objective

This study presents, through a **holistic WTW (Well to Wheel) analysis**, pragmatic insights derived from the comparison **of alternate powertrains (ICE, Ethanol, EV, Hybrid and CNG)** to help shape future powertrain roadmap strategies for Government, testing agencies, OEMs and component suppliers. Basic detailing of other powertrains (Methanol, Hydrogen fuel cells) has also been covered in the study.

❑ Focus

- The focus of the study is on **Passenger Vehicles** because it is the most complex segment driven by consumer choices and price sensitivity, and there is an imminent need to find the right pathway for sustainable development

❑ Approach

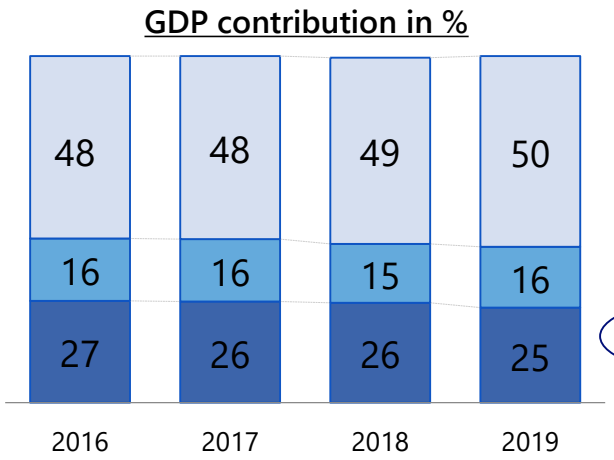
- With this background, the study strives to holistically evaluate alternate powertrains in the current and future scenarios from the perspective of
  1. **Import Dependency**
  2. **Carbon Emission (WTW)**
  3. **Economic Impact Analysis**
- The analysis comprehensively addresses the linkages between the above issues to assess the effectiveness of various alternate powertrains in reduction of fossil fuel consumption and carbon emissions. Also a cost benefit analysis from Government's point of view has been provided.

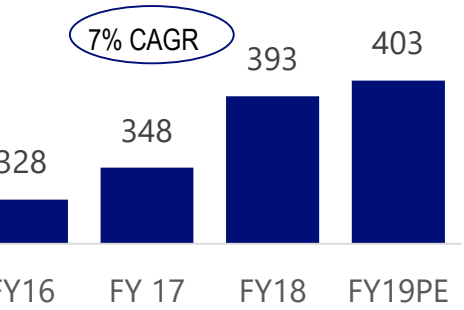
Contents

Importance of Automotive Sector

Automotive sector is a key driver of the India's Economic growth and a key medium to accelerate Make in India program

India GDP Contribution by Sector





Make in India Initiative

Auto Sector Contribution to Indian Economy

2019 (~)	2026 (Target)
~7.5% of Total GDP	>12% of Total GDP
~18.32% of Manufacturing GDP	40% of Manufacturing GDP
37-40 Million Employment	+ 65 Million Emp. Addition
~$75 Bn in Revenues	~$300 Bn in Revenues
~31% Comp. Imports	~9% Comp. Imports
~ 26.31% Auto Exports	~40% Auto Exports

✓ 'Automotive Sector' will continue to remain one of the most important focus area for Indian Government

Source: Statista

Need for Alternate Powertrains in India

Energy security, import dependency & carbon emissions are key issues driving the shift towards adoption of alternate powertrains

1 Energy Security

- Oil Import - 87% in 2019
- Oil Import Bill -$111 Bn
- **Transport Sector consumes ~40% of the Oil**

2 Import Dependency

- **Import of raw material and components used for manufacturing of vehicles: USD 17.7 Bn in FY19 (31% of total)**

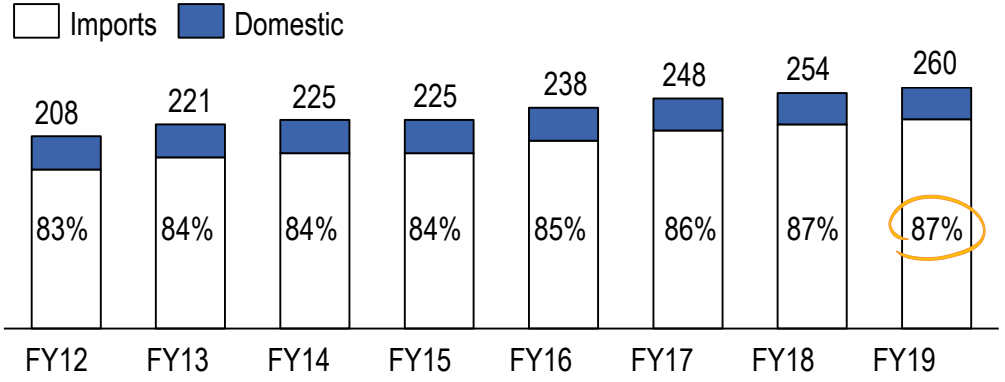
3 Carbon Emission

- 4th Largest CO_2 emitter
- **Transportation - 10% contribution to CO_2 emission in India**

1 Energy Security - High dependence on imported oil

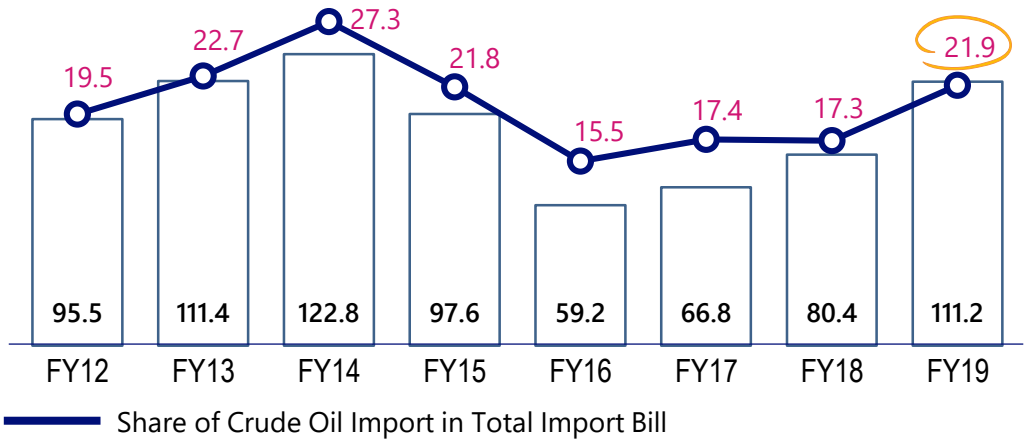
22% of the entire import bill (111 Billion USD) worth of oil is imported annually

India's Crude Oil Consumption [MMT]



(%)- % Contribution of Import in Total

India's Crude Oil Import [in USD Bn.]



Share of Oil in Total Import Bill [FY19]

Crude Oil import in FY19	111 Billion USD
Total import bill in FY19	507 Billion USD
Share of Oil in Total Import Bill	22%

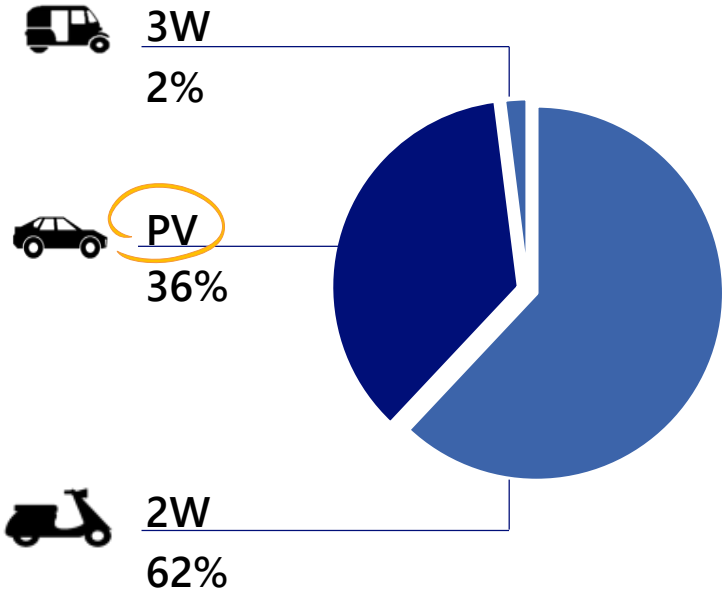
- India has been spending a lot of money on crude oil import
- Crude oil import is a major source of foreign exchange outflow for India and has considerable impact on the Current Account Deficit (CAD)
- Crude Oil Contributed to 22% of India's Total Import bill in FY19

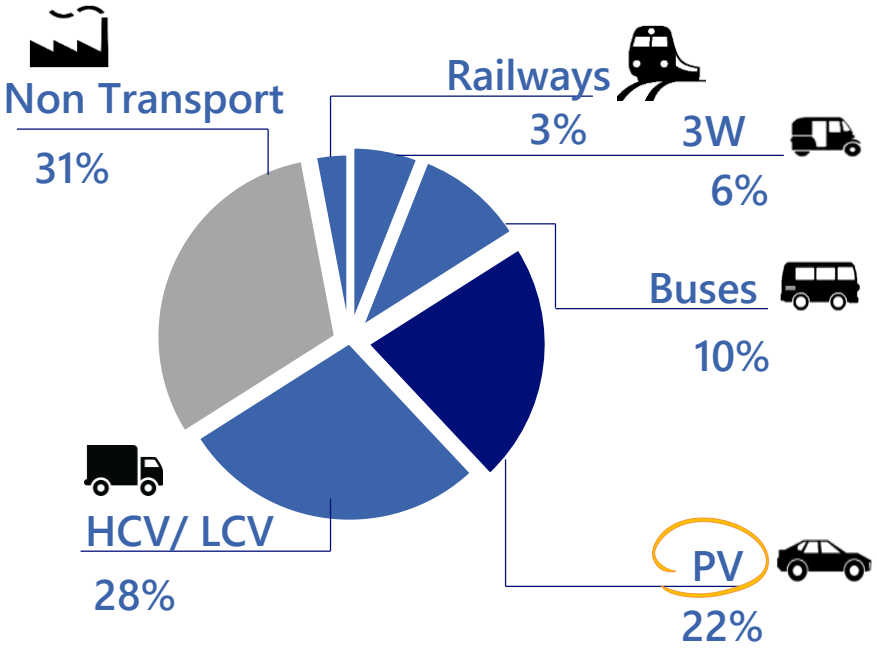
Source: SIAM, PPAC, NRI analysis

① Energy Security - High dependence on imported oil

Passenger Vehicles account for 36% of petrol and 22% of total diesel consumptions

Share of Crude Oil Consumption in India [FY18]



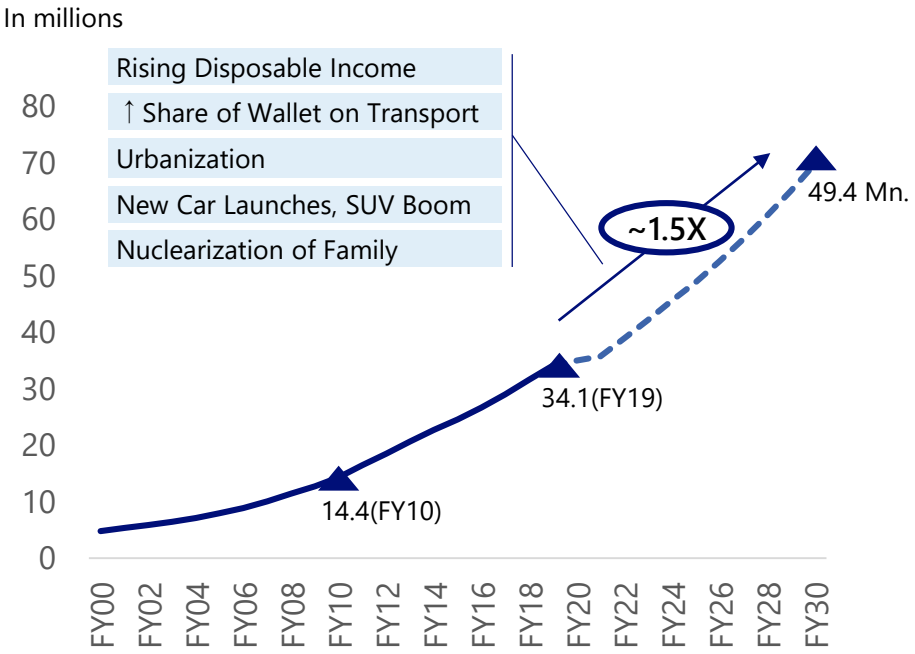


Source: SIAM, PPAC, NRI analysis

1 Energy Security - High dependence on imported oil

As passenger Vehicle UIO is expected to grow at a rapid rate, this might pose a threat to India's vision of Crude Oil import reduction

PV UIO Growth Potential



– Rising disposable income and urbanization is expected to drive vehicle sales. Total Units in Operations is expected to be 50 Million by 2030

**Non Exhaustive Trends*

Five Strategies for 10% Oil Import Reduction

On 27th March 2015 at URJA Sangam

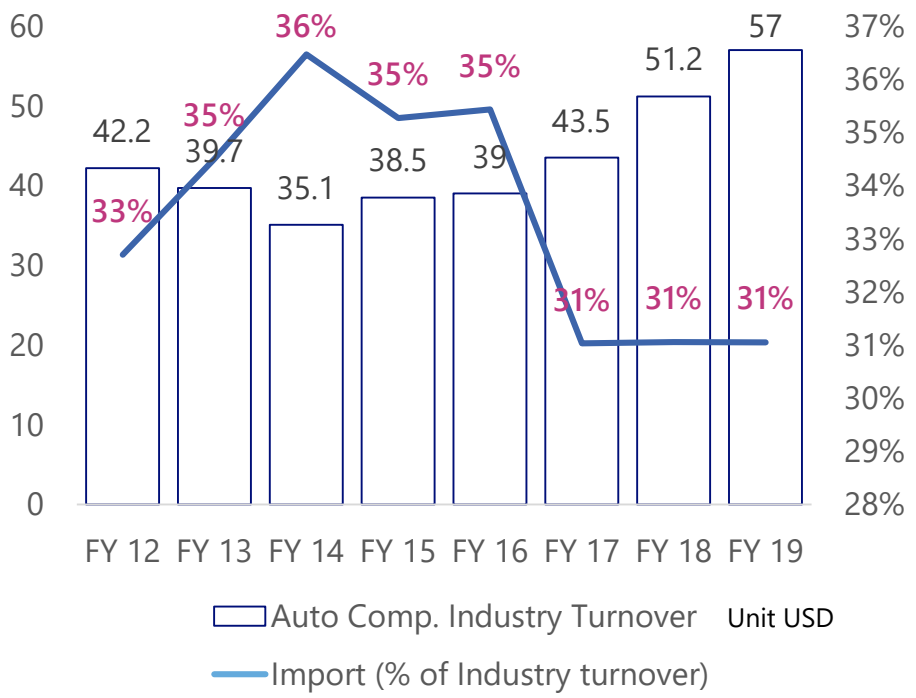
We currently import around 77% in energy sector, in oil, gas and petroleum sector. We can **reduce this import by at least 10% by 2022**.

1. Increase Domestic production of Oil & Gas
2. Promote energy efficiency and conservation measures
3. Give thrust to demand substitution
4. Implement measures for refinery process improvements
5. Capitalize untapped potential in **Biofuels and other Alternate powertrains/renewables**

② Manufacturing Import Dependency

In spite of localization efforts by OEMs, there is still a dependency on imports for auto manufacturing. India imported $17.7 Bn worth of raw materials and components in FY 19

Strong Dependency on Component Import



- 27% of component import is from China in FY19
- Economy and Industry are trying to minimize their reliance on imports post covid and Indo China tensions

Import Dependency on China

Components	China's Share in Indian Imports
Chassis Systems	78%
Road Wheels	44%
Steering Wheels	36%
Suspension Systems	21%
Aluminum Plates	84%
Stainless Steel Tubes	84%

- Strong Dependency on China for Import of Automotive Parts and Components

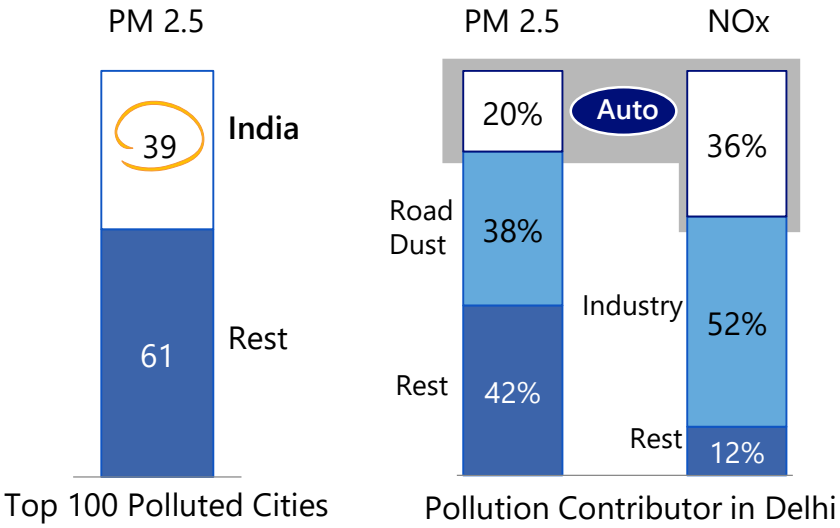
Source: ACMA, Press Articles

Note: Industry turnover includes supplies to domestic OEM's, aftermarket & exports

3 Emissions – CO_2 and PM2.5 Emissions

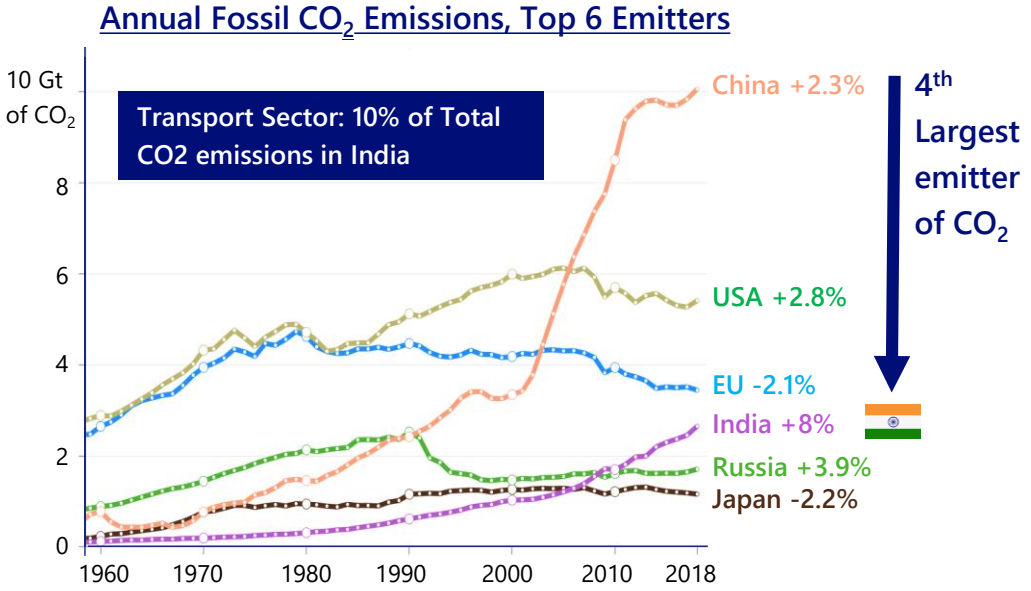
India is the 4th in order in terms of CO_2 emissions and is known for its poor air quality compared to other countries. Transport sector is a key contributor to CO_2, PM2.5 & NOx

PM 2.5, NO_x Emissions



- Air pollution costs India equivalent of 8.5% of GDP – WB estimates
- Significant Reduction in PM and NOX from BS3 to BS6, but it does not address CO_2 Emissions

Annual Fossil CO_2 Emissions



- The top six emitters in 2018 covered 67% of global emissions
- India Contributes 7% of total global emissions.
- Transport contributes 10% of Total CO_2 emissions in India

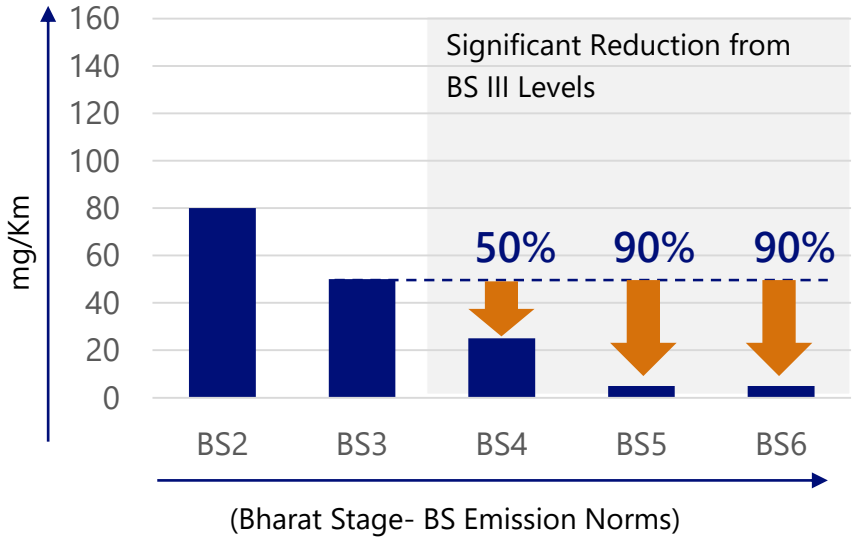
Source: XXX

❸ Managing PM 2.5 Emissions

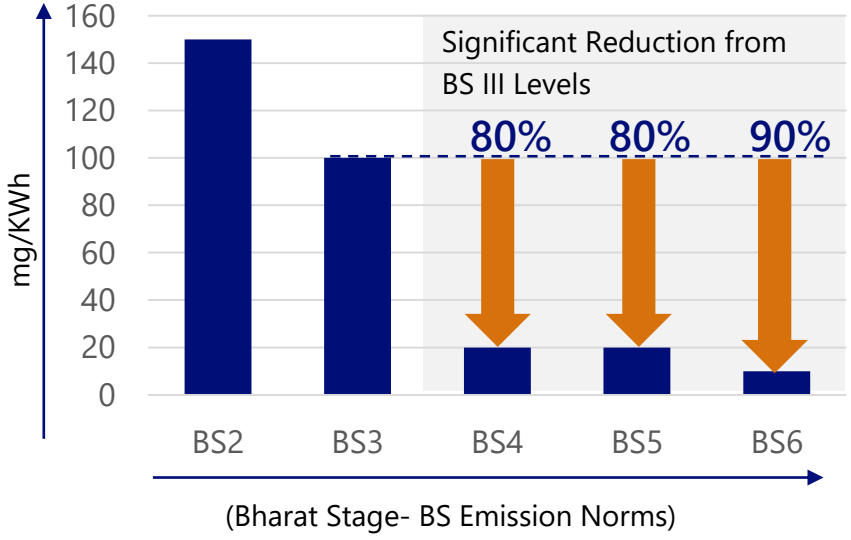
Particulate emissions have been addressed to a good extent thanks to the leapfrog to BS-VI last year. This lead to a 90% reduction in PM2.5 emissions for diesel vehicles

PM 2.5 Emission Reduction Post BS VI

4W Passenger Car (Diesel)



Heavy Duty Commercial Vehicle



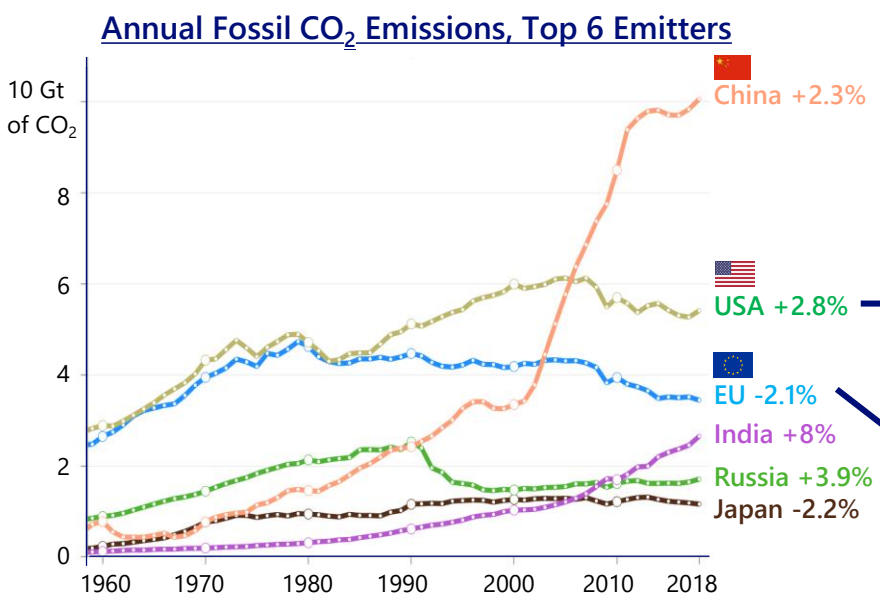
- Diesel Vehicles have been maximum contributors to PM 2.5 and NOx emissions
- With BS-VI transition, there is atleast 90% Reduction in PM 2.5 Levels as compared to BS III
- Thus the **issue of PM 2.5 emissions have been addressed by BS VI.**
- **But it does not address CO_2 Emissions**

Source : MoRTH Notifications

3 Emissions – India's INDC Commitments

Top 3 emitters (China, Europe, US) have expressed to be carbon neutral by 2050-60 and there is further onus on India to reduce GHG emissions

Annual Fossil CO_2 Emissions



Policy of Top 3 Emitters

China

- Pressure on countries for carbon emissions going to be intense in next 4-5 years
- China going carbon neutral by 2060

USA

- Joe Biden expressed wish to make America carbon neutral by 2050

EU

- EU wants to become carbon neutral by 2050
- Plans to reduce GHG emissions to 50-60% of 1990 levels by 2030

India Contributes 7% of total global emissions. Transport contributes 10% of Total CO_2 emissions in India.

3 Emissions – India's INDC Commitments

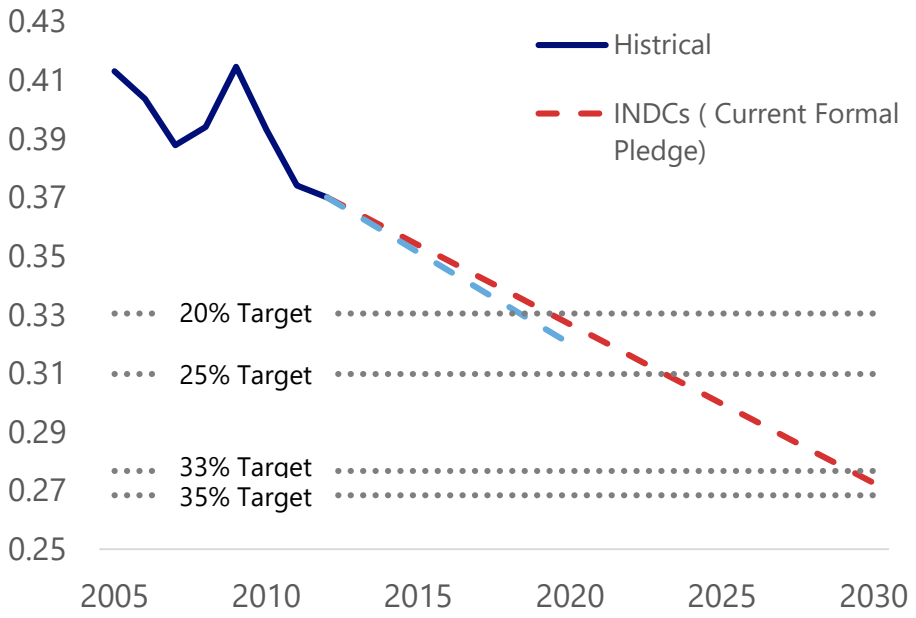
Even the Indian Govt. through INDCs, has made 5 pledges and 2 of them are aimed towards reducing CO2 emissions

India's INDCs regarding Energy Mix

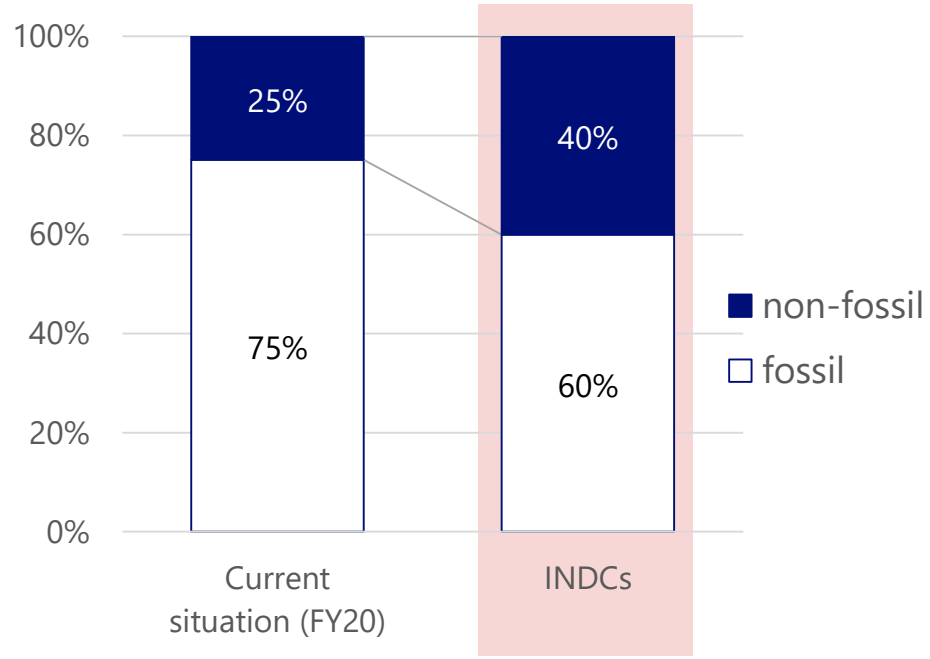
1 Reduce the emissions intensity of its GDP by 33-35% by 2030 from 2005 level

2 Archive 40% of electric power installed capacity from non-fossil fuel by 2030

Carbon Intensity (tCO2/US$ current PPP)



Share of Non-Fossil Fuel in Power Installed Capacity



Source: EIA, World Bank

Alternate powertrain options

There are multiple alternate powertrain options which have potential to address energy security, manufacturing import dependency and carbon emission related issues

Fossil Fuel Based Technology

	Component Import Share	Local procurement Possibility
Ethanol	Same as ICE	High
CNG	ICE+	High

Core technology common across vehicle types

Electrification Based Technology

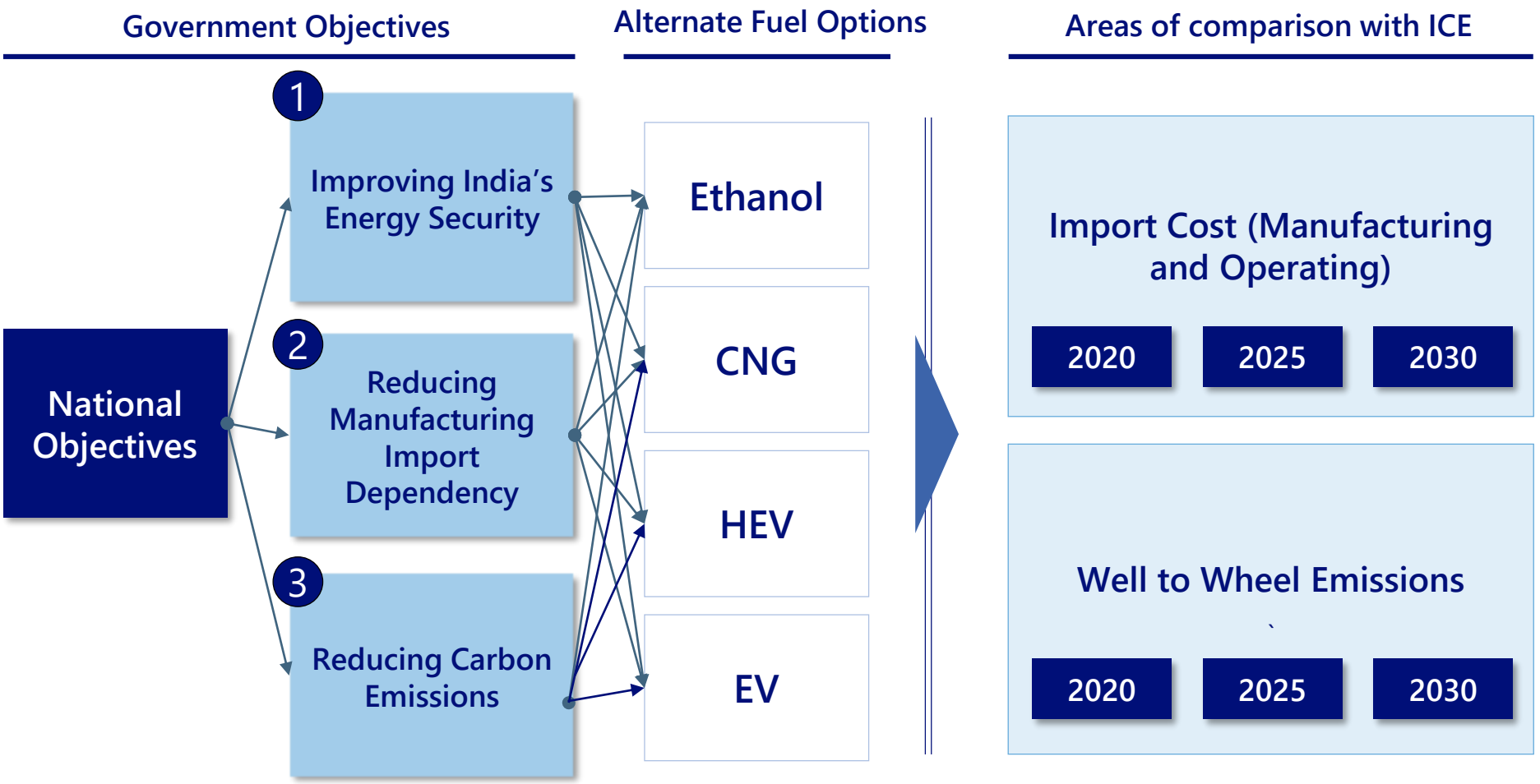
HEV	ICE++	Mid
EV	ICE+++	Low

Core technology common across vehicle types

– Other than these, there are emerging technologies like Methanol and Hydrogen Fuel Cell

National Objectives: Impact of Alternate powertrains

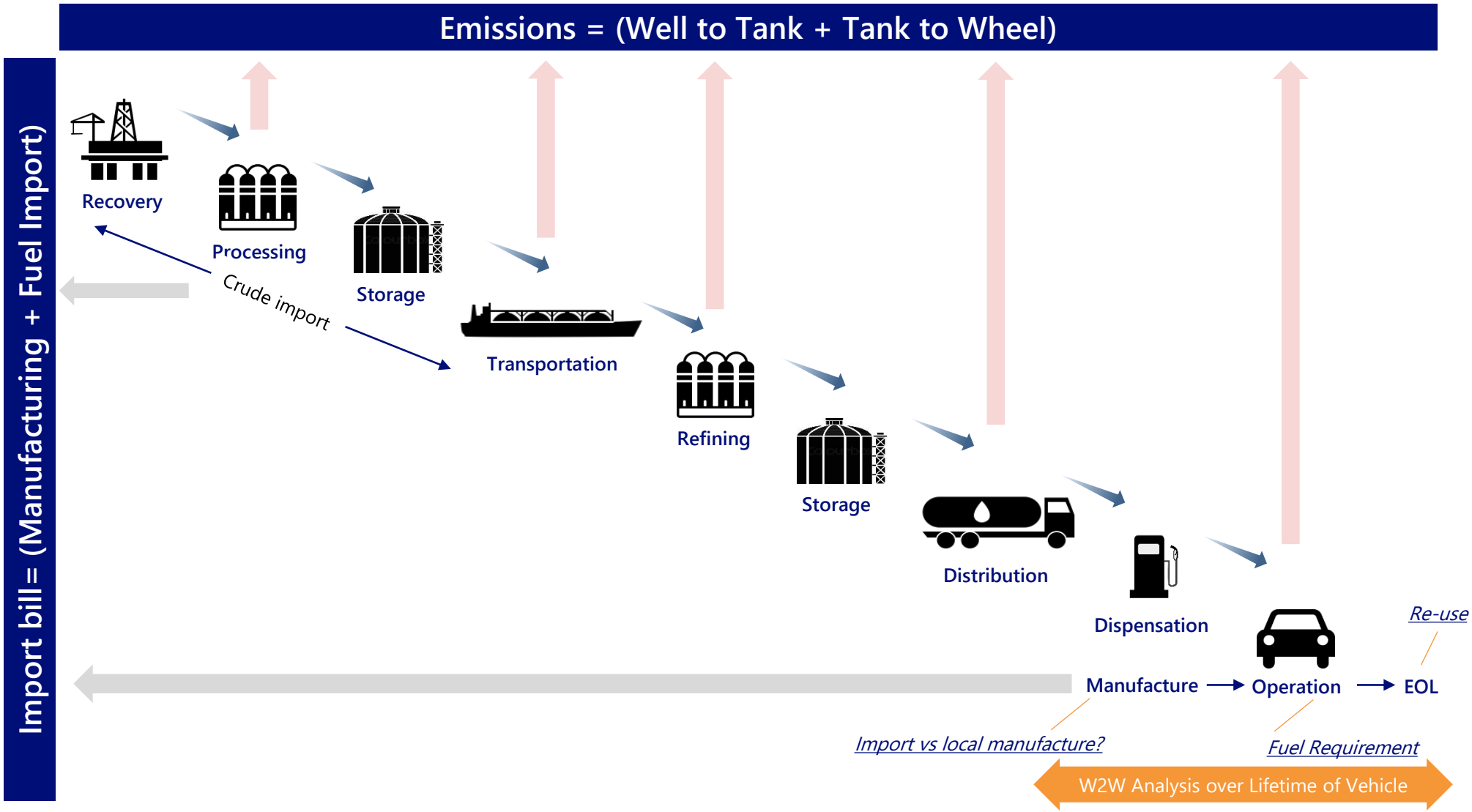
This reports strives to numerically analyze the impact and effectiveness of various alternate powertrains in addressing the national objectives



– Trend analysis of other futuristic powertrains (Methanol/ Hydrogen Fuel Cell) have also been included

Approach – Emission and Import Calculation for Fossil Fuel Based Technology

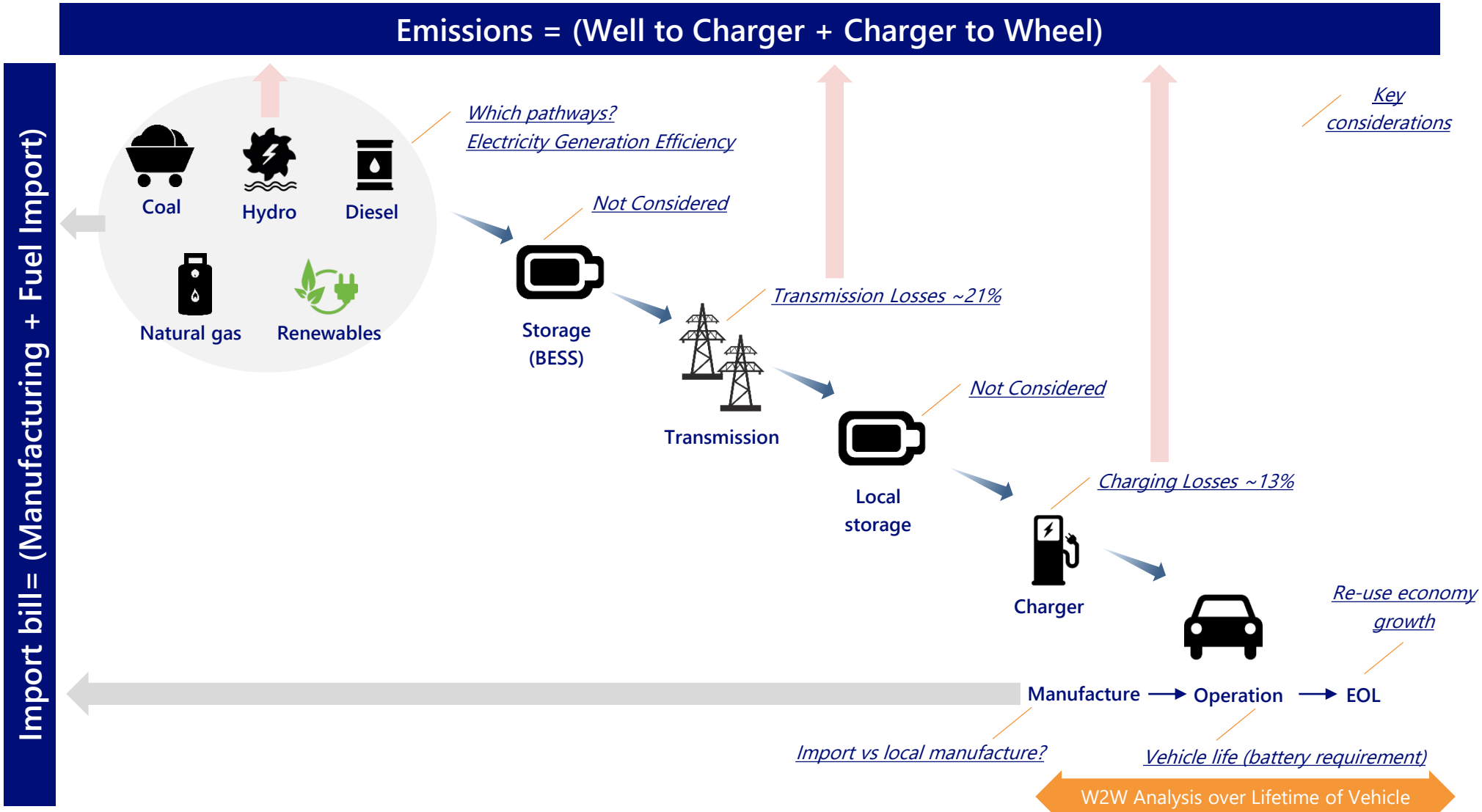
Overall emissions (well to tank and tank to wheel) have been considered along with fuel and manufacturing imports to evaluate fossil fuel based technologies



Source: NRI Analysis

Approach – Emission and Import Calculation for EV Technology

For electrification technologies, Emissions and Losses in Well to charger and Charger to Wheel along with import costs have been considered



Source: NRI Analysis

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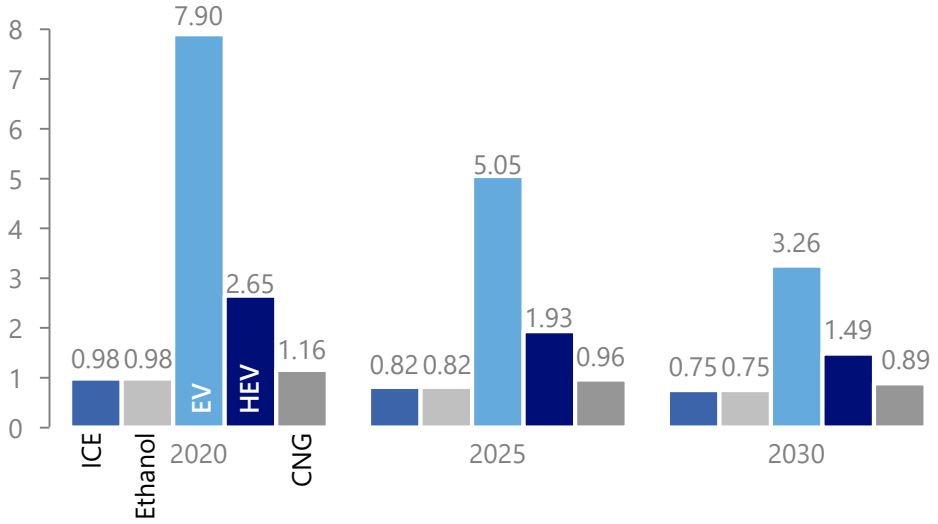
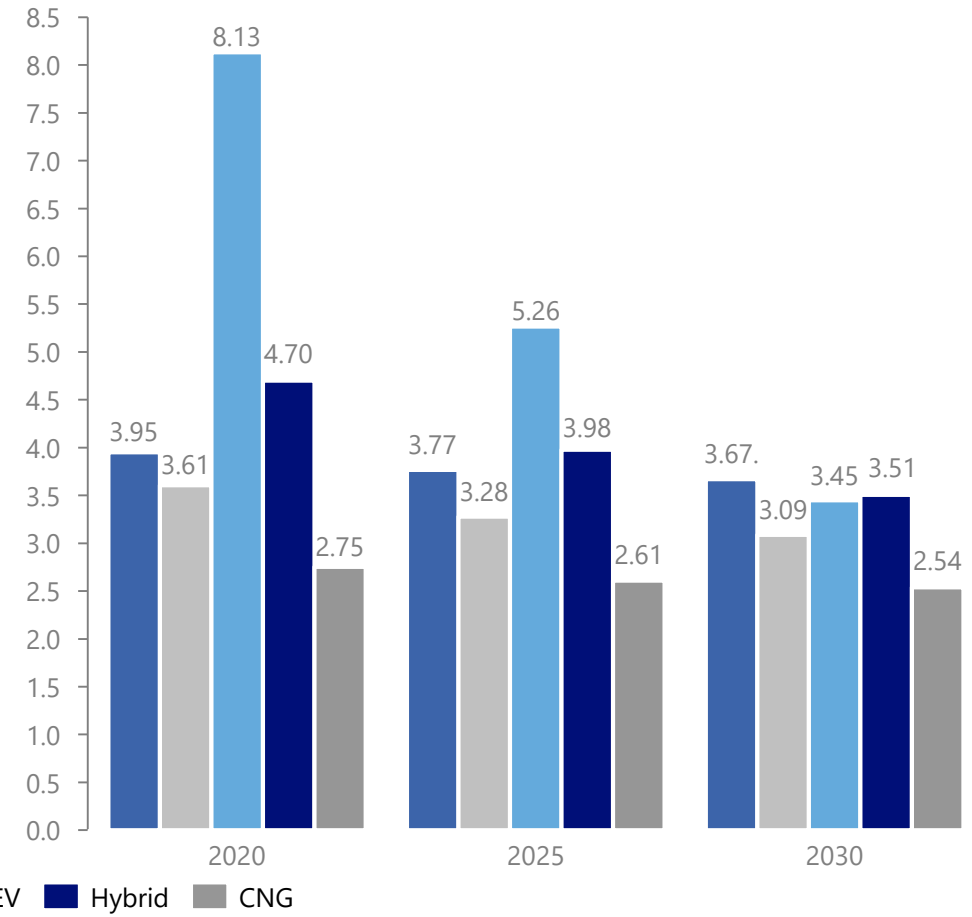
Summary: Import Cost Analysis

All powertrains (including EVs) will become equally competitive towards 2030 though currently the variation is high on account of component imports

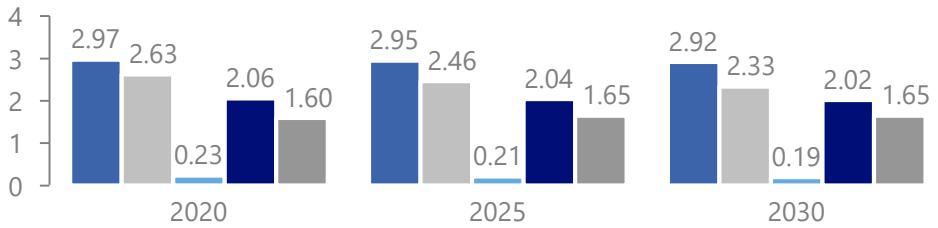
Manufacturing Import Cost (INR Lakh per car)



Total Import Cost (INR Lakh per car)



Operating Import Cost over vehicle lifetime (INR Lakh per car)



Assumptions on Localization %

1. ICE: current net localization is at 71.4% and increasing to 78% in 2030
2. EV: 20% battery localization is assumed for 2020, 60% for 2030

Note: 1) Average vehicle lifetime is considered to be equal to vehicle registration life of 15 years
2) Average annual VKT (Vehicle Kms Travelled) is considered 12,024 km
3) Life of single battery in case of EV is assumed to be 8 years

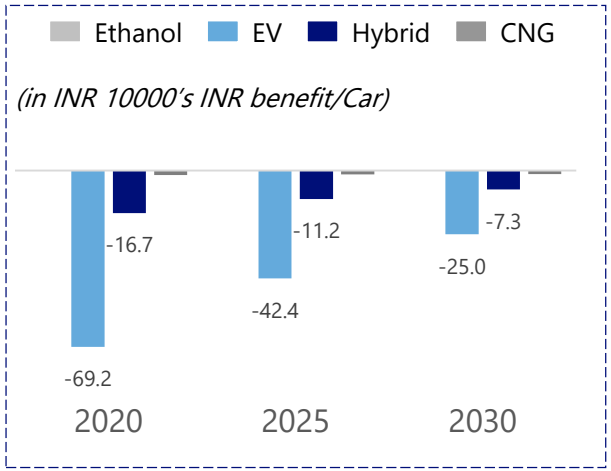
Source: NRI Analysis

Summary: Import Savings of alternate powertrains (relative to ICE)

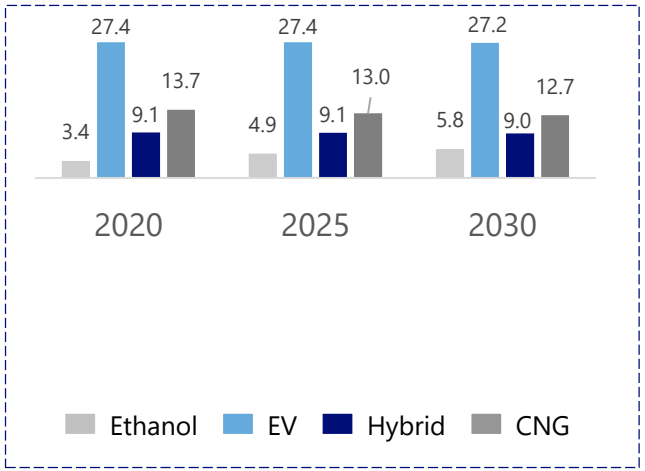
Alternate powertrains like CNG, Ethanol & Hybrid can help pave the way for EVs

Effective savings on import over vehicle lifetime w.r.t ICE

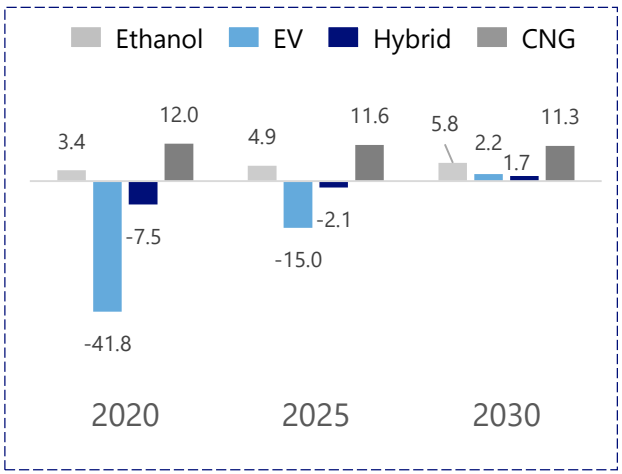
Manufacturing Import Cost



Fuel Import Cost



Total Savings



INR benefit/ Car	Manufacturing Import Cost		
	2020	2025	2030
ICE	-	-	-
Ethanol	0	0	0
EV	(6,91,996)	(4,23,511)	(2,50,238)
Hybrid	(1,66,663)	(1,11,766)	(73,317)
CNG	(17,500)	(14,568)	(13,438)

+

INR benefit/ Car	Fuel Import Cost		
	2020	2025	2030
ICE	-	-	-
Ethanol	34,475	48,976	58,360
EV	2,73,652	2,73,907	2,72,351
Hybrid	91,496	90,944	89,889
CNG	1,37,399	1,30,347	1,26,609

=

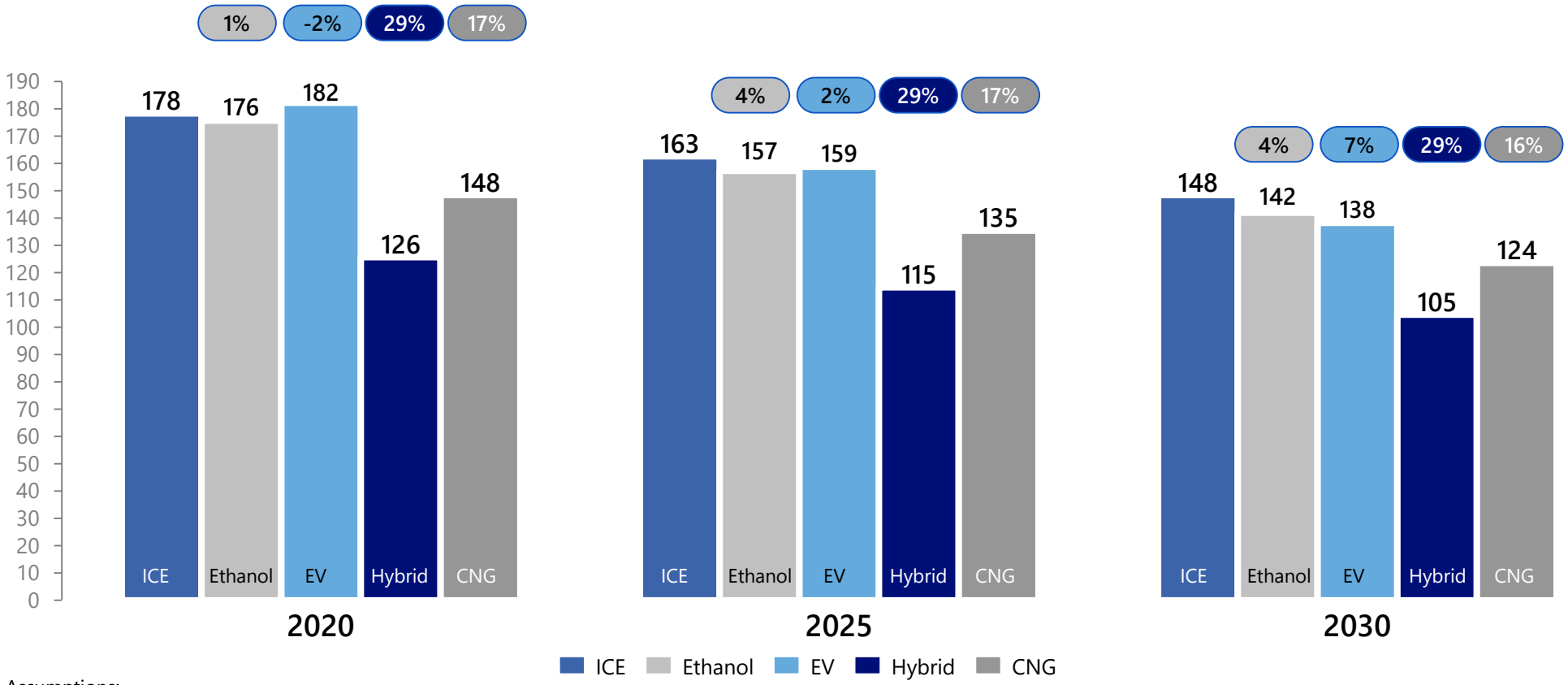
INR benefit/ Car	Total Savings		
	2020	2025	2030
ICE	-	-	-
Ethanol	34,475	48,976	58,360
EV	(4,18,344)	(1,49,604)	22,112
Hybrid	(75,138)	(20,823)	16,572
CNG	1,19,899	1,15,780	1,13,170

Note: ICE has been taken as the base case to calculate benefits on a per car basis across powertrains

Summary: Carbon Emissions Analysis

Hybrid & CNGs can provide substantial emission reduction compared to other powertrains in the current and future scenarios

■ Well-to-Wheel Emissions (gCO_2/km)



Assumptions:
1. Fuel Improvement factor: of 1.85% till 2030
2. **Renewable Energy**: Renewable sources are expected to generate 25% of India's electricity demand by 2030; fossil fuels share 75% by 2030 (71% from coal) [source: IESS]
3. Major losses come from T&D losses; currently at 21% and decreasing to 19% by 2030

Ethanol Timeline & Mileage

Mileage (2020 - 2024) - E 5	16.6	kmpL
Mileage (2025 - 2029) - E 10	-2.0%	kmpL
Mileage (2030 onwards) - E 20	-6.5%	kmpL

Source: NRI Analysis

Economic Impact / Cost Benefit analysis (Government's Perspective)

Government Income

INR / car	2020	2025	2030
ICE	-	-	-
Ethanol	-	-	-
EV (w/o FAME incentives)	-86,467	-1,05,200	-1,27,992
EV (with FAME incentives)	-3,66,653	-4,00,508	-4,65,151
Hybrid	1,38,167	1,68,101	2,04,521
CNG	15,950	19,406	23,610

Govt. Income = Taxes - Incentives (relative to ICE)

Economic benefit*

Import cost savings (lifetime)

INR / car	2020	2025	2030
ICE	-	-	-
Ethanol	34,475	48,976	58,360
EV (no incentives)	-4,18,344	-1,49,604	22,112
EV (with incentives)	-4,18,344	-1,49,604	22,112
Hybrid	-75,138	-20,823	16,572
CNG	1,19,899	1,15,780	1,13,170

Emissions savings (lifetime)

Kg CO2/ car	2020	2025	2030
ICE	-	-	-
Ethanol	472	973	1167
EV (no incentives)	-706	695	1,834
EV (with incentives)	-706	695	1,834
Hybrid	9,497	8,665	7,906
CNG	5,387	4,916	4,485

Based on the cost benefit analysis considering tax, incentives & emissions, It has been observed that the Government would still be earning on Hybrid followed by CNG in addition to benefits in terms of import cost and emission savings

Source: NRI Analysis

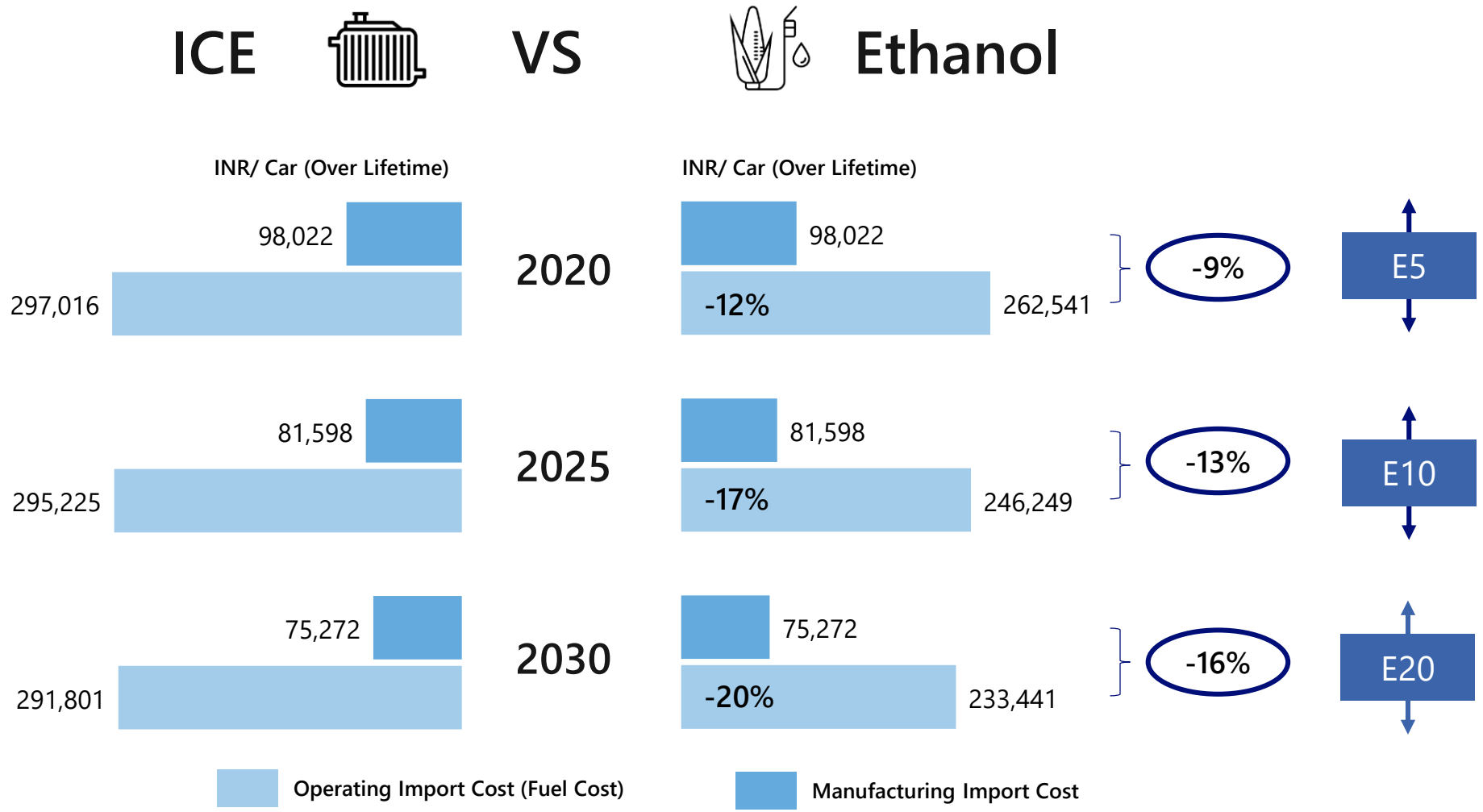
Note: ICE has been taken as the base case to calculate benefits on a per car basis across powertrains

Contents

Ethanol

Import Cost Comparison: ICE Vs Ethanol

Ethanol blending can potentially reduce the fuel import cost by 16% by 2030



Assumptions:

1. Up to 20% blending can be achieved through domestic production
2. It has been assumed that additional products required for blending can be procured domestically

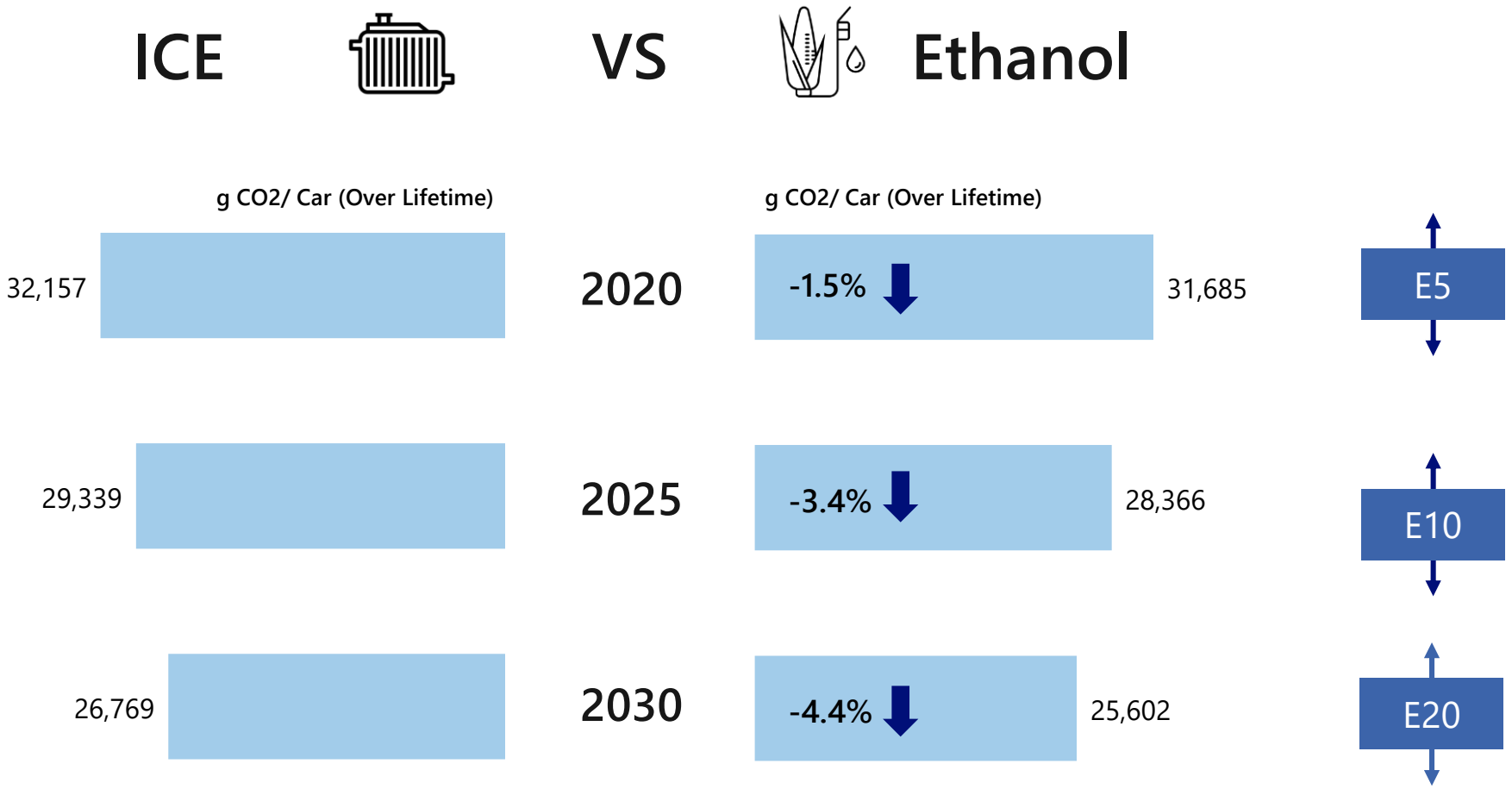
Ethanol Timeline & Mileage

Mileage (2020 - 2024) - E 5	16.6	kmpL
Mileage Drop (2025 - 2029) - E 10	-2.0%	kmpL
Mileage Drop (2030 onwards) - E 20	-6.5%	kmpL

Source: SAE International paper on Systematic Evaluation of 20% Ethanol Gasoline Blend (E20) as a Potential Alternate Fuel

Carbon Emission Comparison: ICE Vs Ethanol

On the other hand, emissions savings impact by ethanol blending is limited



Assumptions:
1. Zero emissions considered in the production and transportation of Ethanol (Source: EIA)
2. T2W emissions: The calculations for Ethanol are based on ICE and not gasoline (If it is done basis Gasoline data then Ethanol emissions will be higher than ICE till 2025)

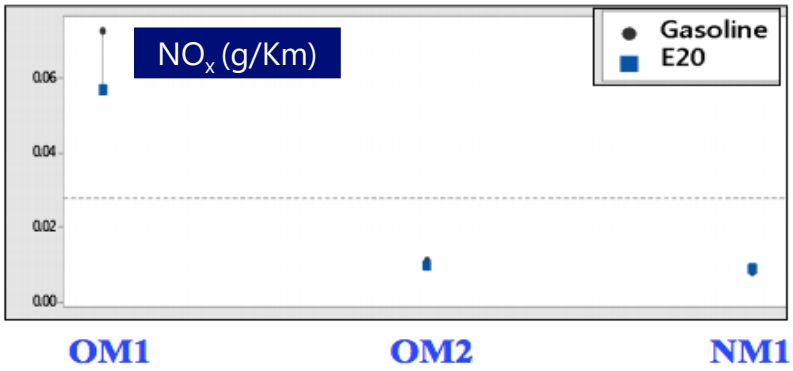
Ethanol Timeline & Mileage

Mileage (2020 - 2024) - E 5	16.6	kmpL
Mileage Drop (2025 - 2029) - E 10	-2.0%	kmpL
Mileage Drop (2030 onwards) - E 20	-6.5%	kmpL

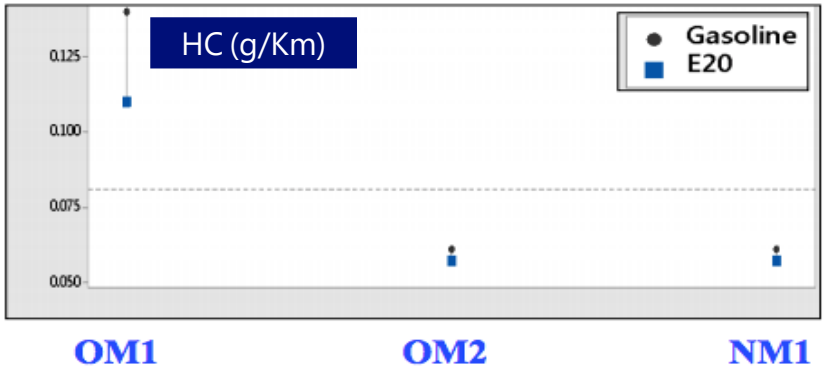
Source: NRI Analysis

Ethanol Blending: Emissions Benefits for other Gases

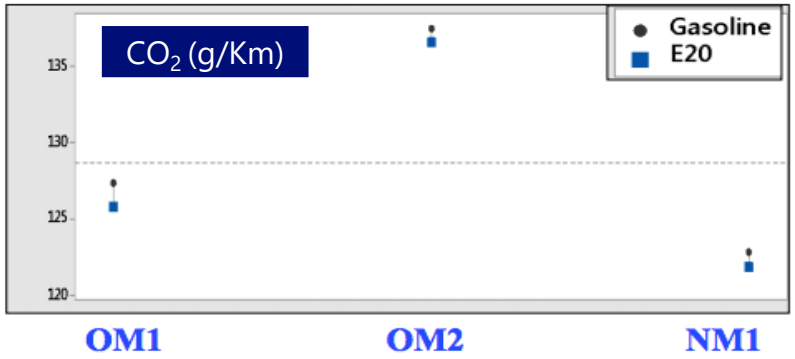
Apart from savings in CO2 emissions, a significant reduction in CO is also observed with 20% ethanol blending



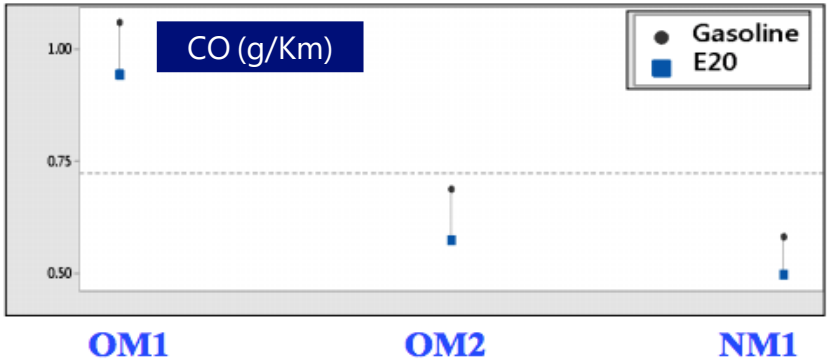
- **No Significant Trend** in NO_X Emissions
- Mean Difference = 0.005 g/km



- **Minor Reduction** in HC Emissions
- Mean Difference = 0.012 g/km



- **Significant Reduction** in CO_2 Emissions
- Mean Difference = 1.143 g/km



- **Significant Reduction** in CO Emissions
- Mean Difference = 0.106 g/km

Source: ARAI Analysis
(Systematic Evaluation of 20% Ethanol Gasoline Blend (E20) as a Potential Alternate Fuel)- Oct. 2017

OM1 & 2: Old Model 1 &2, NM: New Model

Ethanol Blending – Policy Developments

National Biofuel policy 2018 was launched to promote ethanol blending specially for the use as transportation fuel

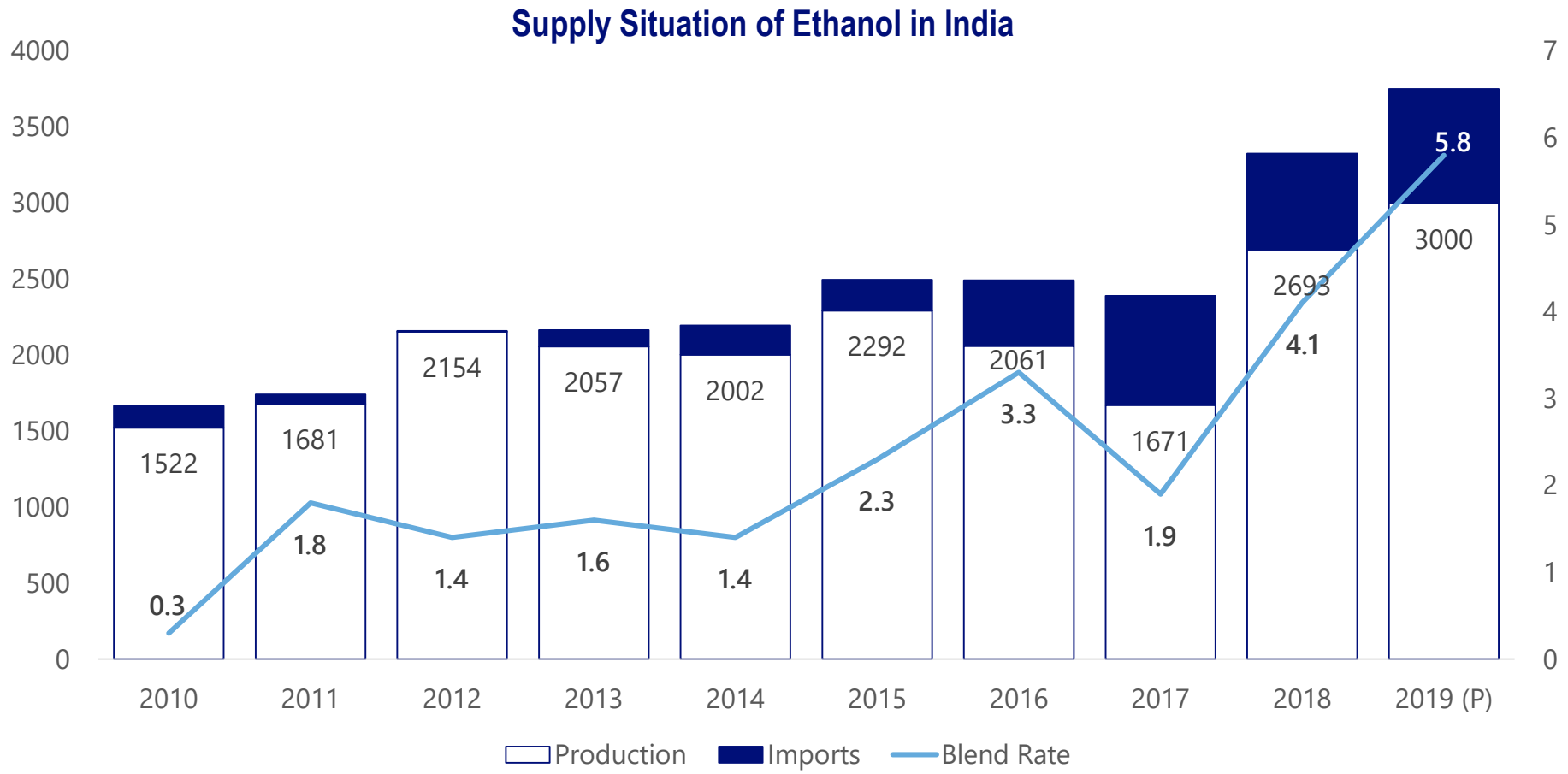
Policy developments in Ethanol blending

2003	• Mandated 5% ethanol blending 13 states and UTs
2006	• 5% universal blending
2008	• 10% blending pan India in 2008
2009	• National Policy on Biofuels - 20% blending of ethanol by 2017
2013	• Mandated 10% mandatory blending to achieve national average of 5%
2013	• Mandated 10% mandatory blending to achieve national average of 5%
2015	• Notified use of flex fuel E85 and ED95 for vehicles
2018	• National Biofuel Policy released, E20 fuel by 2030
2019	• OMCs to sell 10% EBP or any percentage as per BIS, from 1st April 2019

OMC: Oil Marketing Companies

Ethanol Supply Situation – Overall

Despite policy push, achievement of ethanol blending has been low mainly due to supply constraints from domestic production



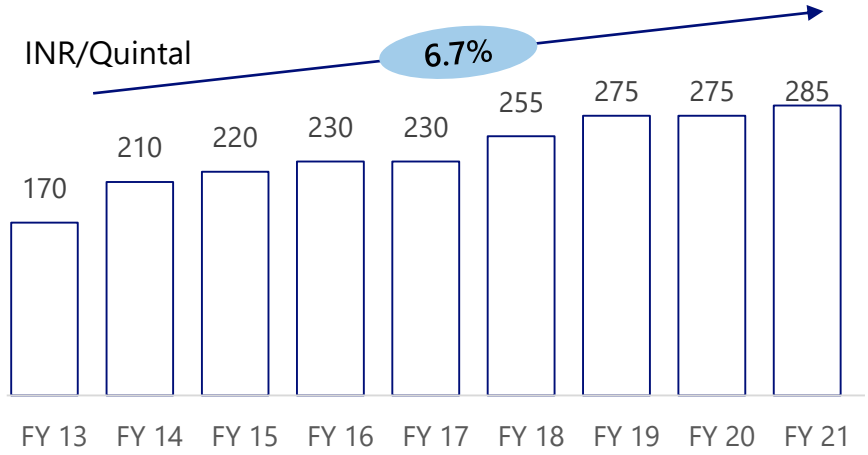
- A surplus sugar season coupled with a stronger financial incentive to convert excess sugar to ethanol should help the OMCs procure upwards of 2.4 billion liters in 2019 and hep India achieve its highest fuel ethanol market penetration

Source: USDA GAIN

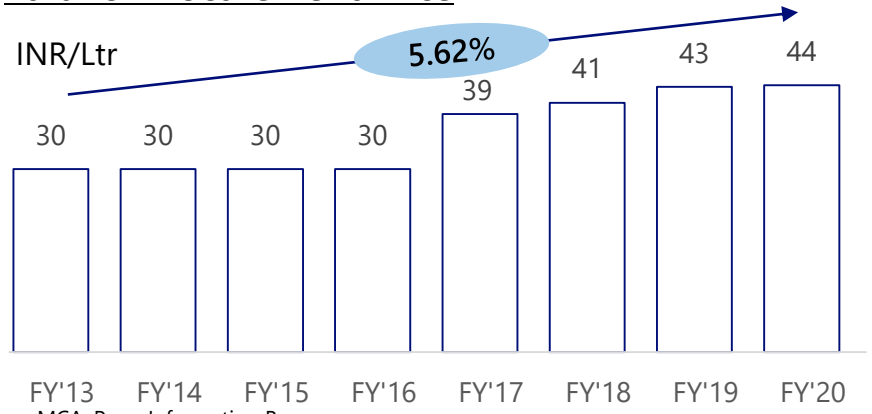
Ethanol availability can be increased by improving the supply from existing sources and identify alternate sources of production

1 Improving Supply from Current Sources

Fair and Remunerative Price (FRP) of Sugarcane

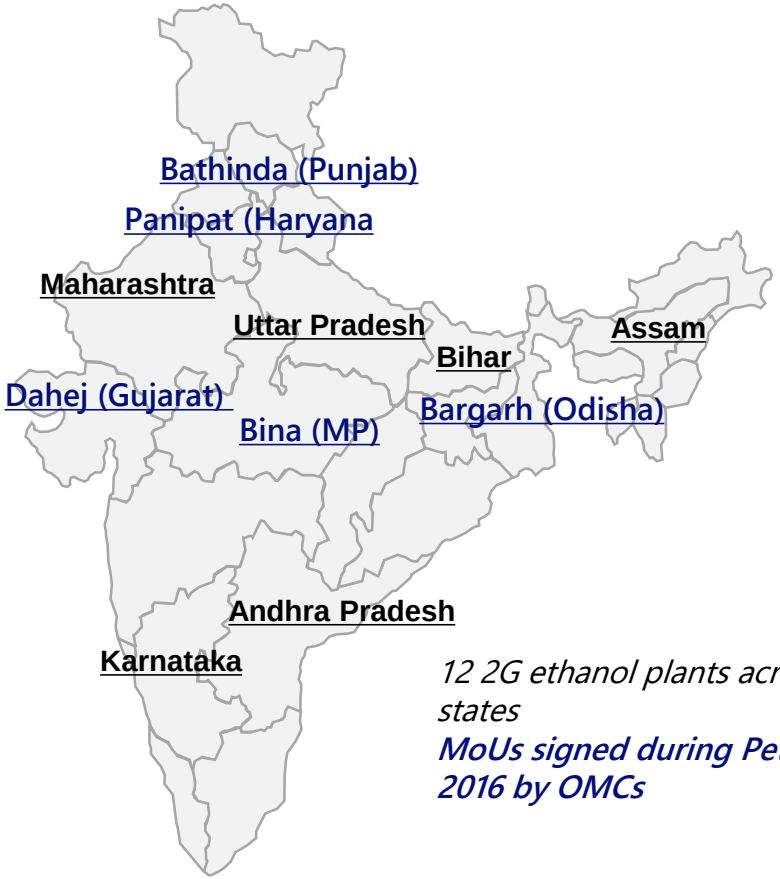


Ethanol Procurement Price



Source: MCA, Press Information Bureau

2 Identifying Alternate source



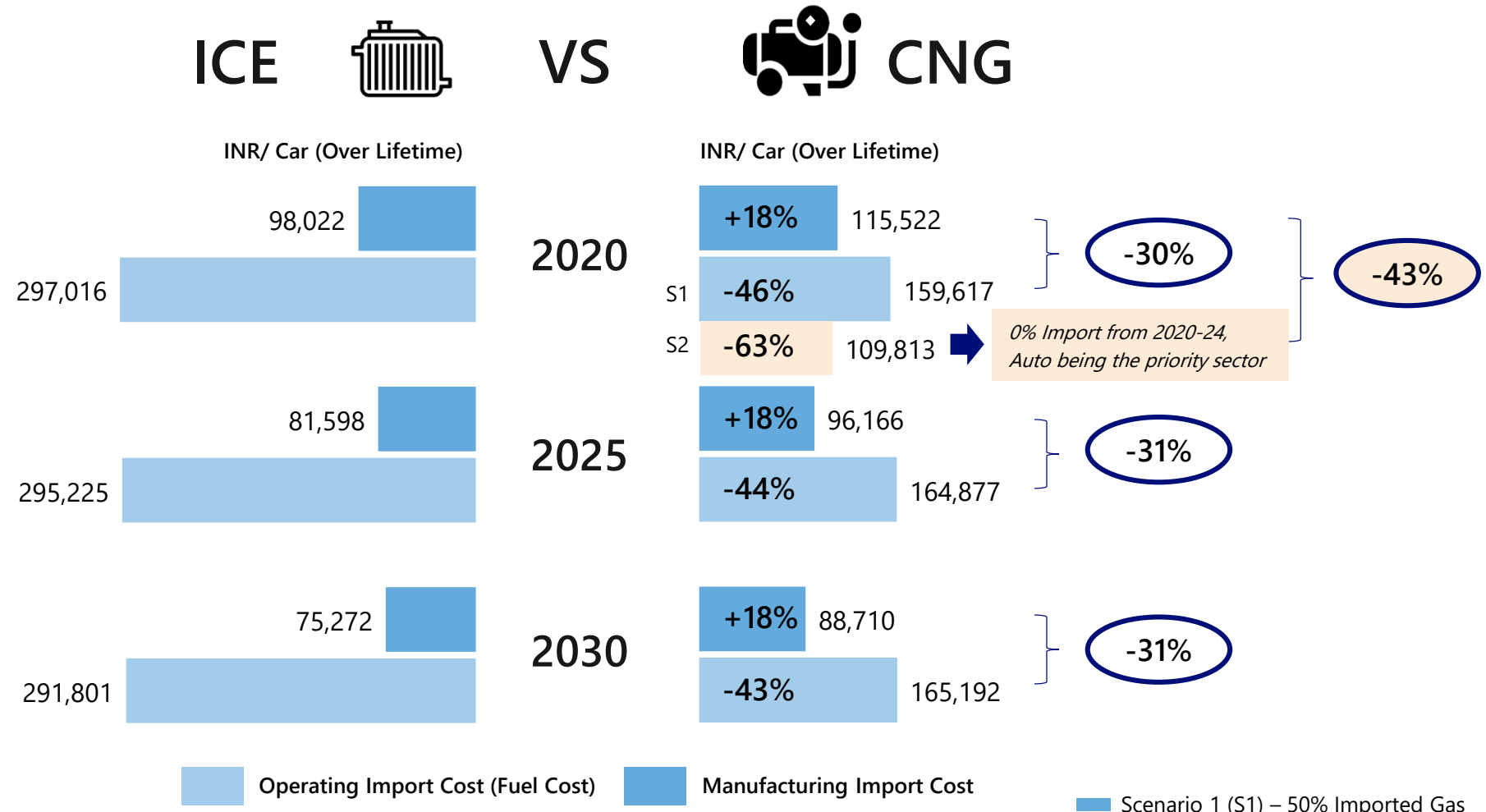
12 2G ethanol plants across 11 states

MoUs signed during Petrotech-2016 by OMCs

CNG

Import Cost Comparison: ICE Vs CNG

CNG can provide direct savings between 46%~63% on fuel imports even currently and even with 18% higher component import cost, a net benefit of 31% in 2030



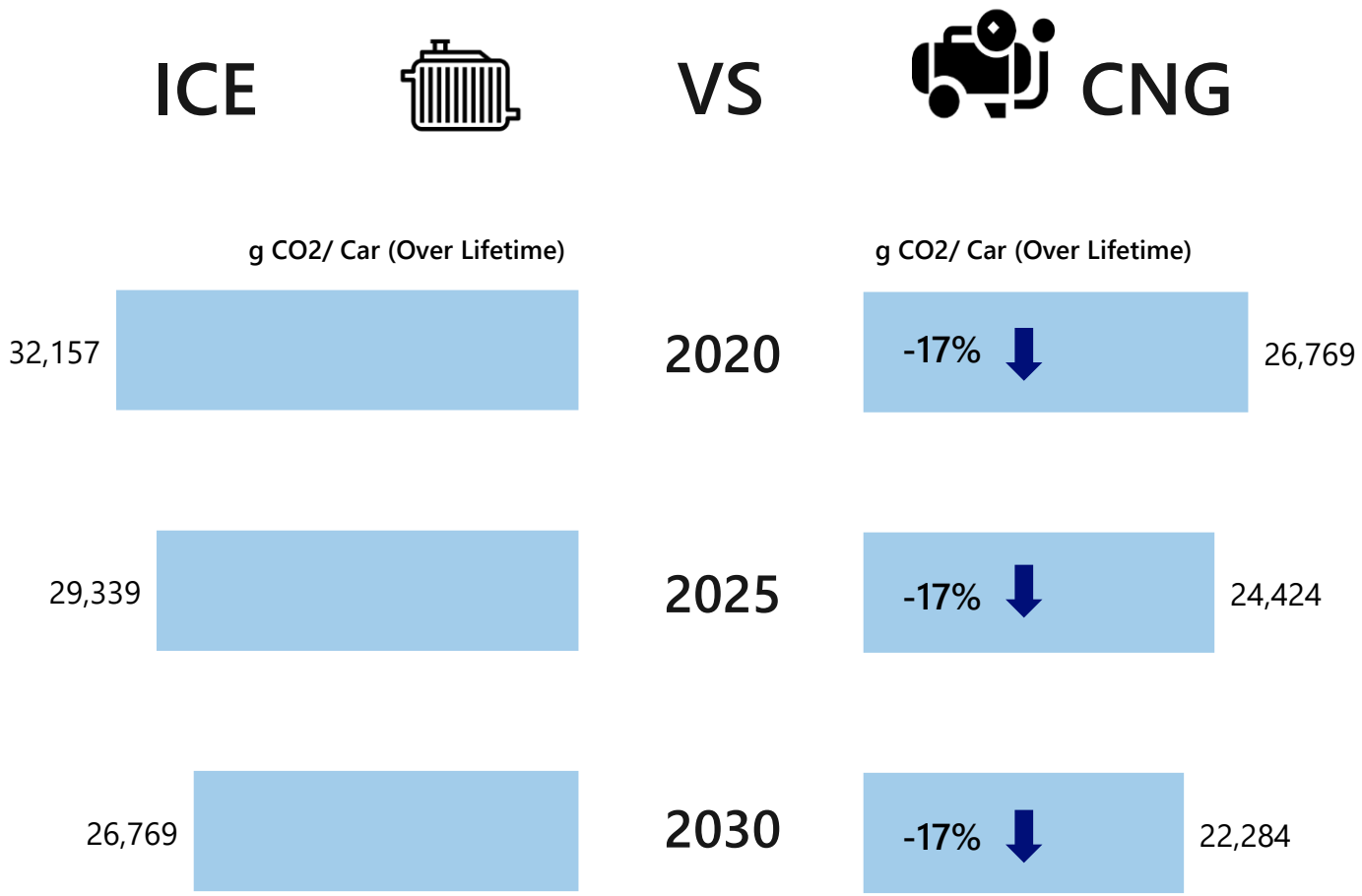
Assumptions:

- A CNG kit costs around Rs. 50k import % is currently 35%
- Localization criteria is considered to be same as ICE localization assumptions; there is potential for 100%
- For fuel import cost, it is assumed as 50% imported is going into auto sector [Scenario 1] and 100% [Scenario 2}

Source: NRI Analysis

Carbon Emission Comparison: ICE Vs CNG

CNG vehicles could give significant emission reduction of as much as 17% primarily due to better fuel efficiency of CNG and other properties of CNG



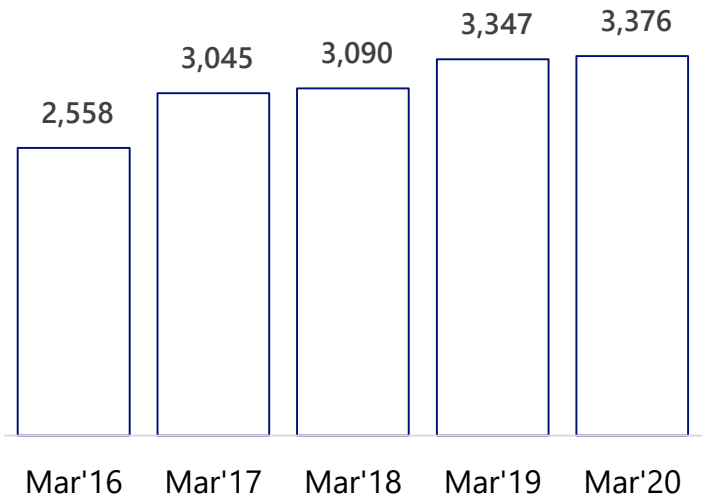
Assumptions:
1. The CNG mileage considered is 19 kmpl and the fuel improvement factor is 1.85% YoY

Source: NRI Analysis

CNG overview

Though CNG vehicles are concentrated in a few states, increasing focus to curb vehicular pollution is expected to boost CNG adoption all over the country

CNG Vehicles in India [000's, Mar'16 – Mar'20]



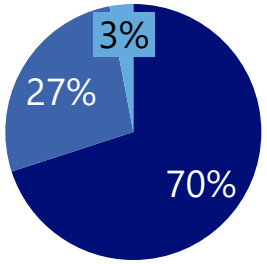
7%

CAGR in Past 5 Years

CNG Vehicles by Type [000's, Mar'20]

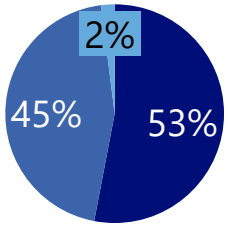
Delhi NCR

1,127



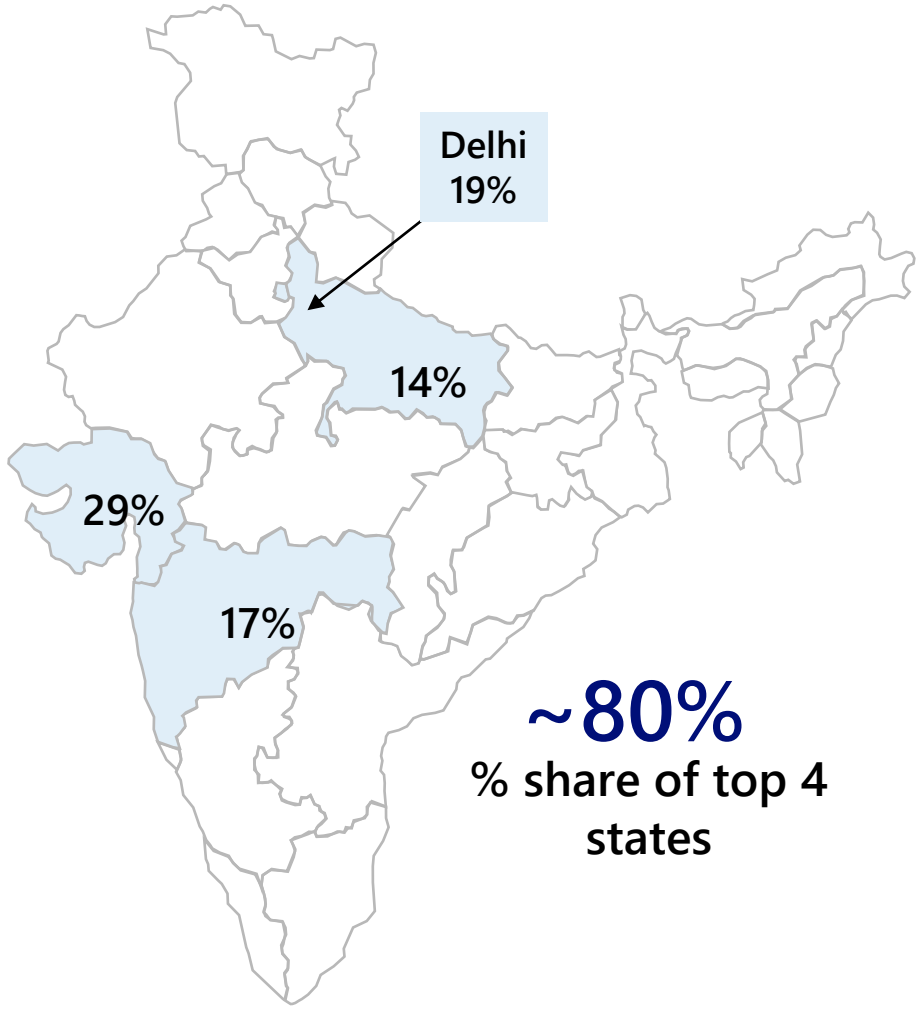
Greater Mumbai

750



Cars/Taxi Auto/LTV/RTV Buses

State-wise CNG Vehicles in India [Sep' 2020]



~80%

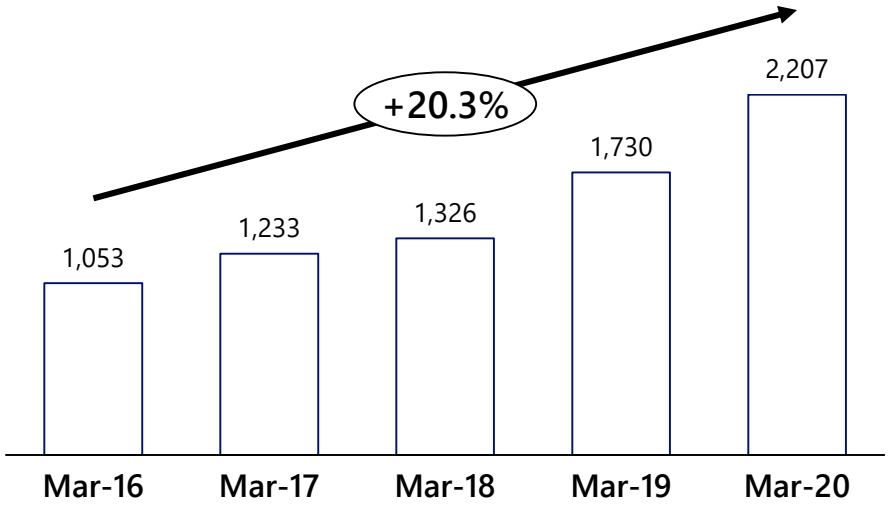
% share of top 4 states

Source: PPAC, IGL and MGL Investor Presentations

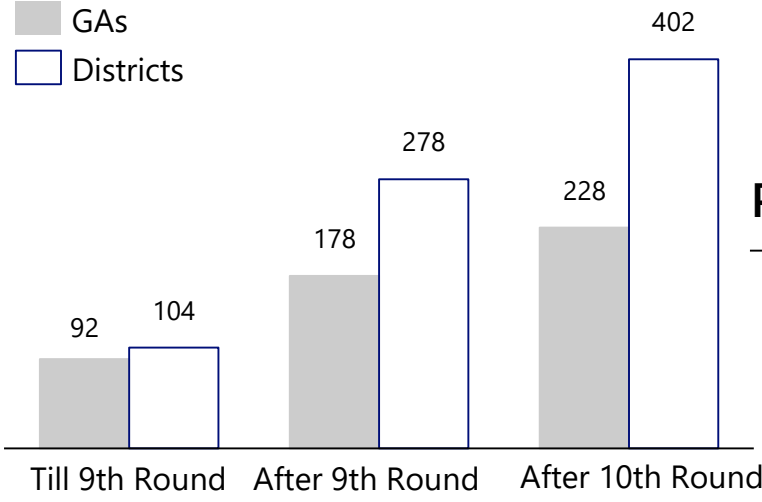
CGD Infrastructure

After 9th & 10th CGD round, 70% of India's population and 52% Area will come under the coverage of Natural gas infrastructure by 2030

■ CNG Stations in India [000's, Mar'16 – Mar'20]



■ Development of CGD Infrastructure



The CNG stations will be increased to 4 times the current figure in ten years, could potentially mean that country may save over INR 2 lakh crore if prospective buyers transition to CNG vehicles

Industry has invested over INR 70,000 Cr. for 9th Round and another INR 50,000 Cr. For 10th Round in setting up of CGD network

- *10,000 CNG stations to be set up in 10 years*
- *India to see INR 4 lakh crore investment in gas infrastructure*

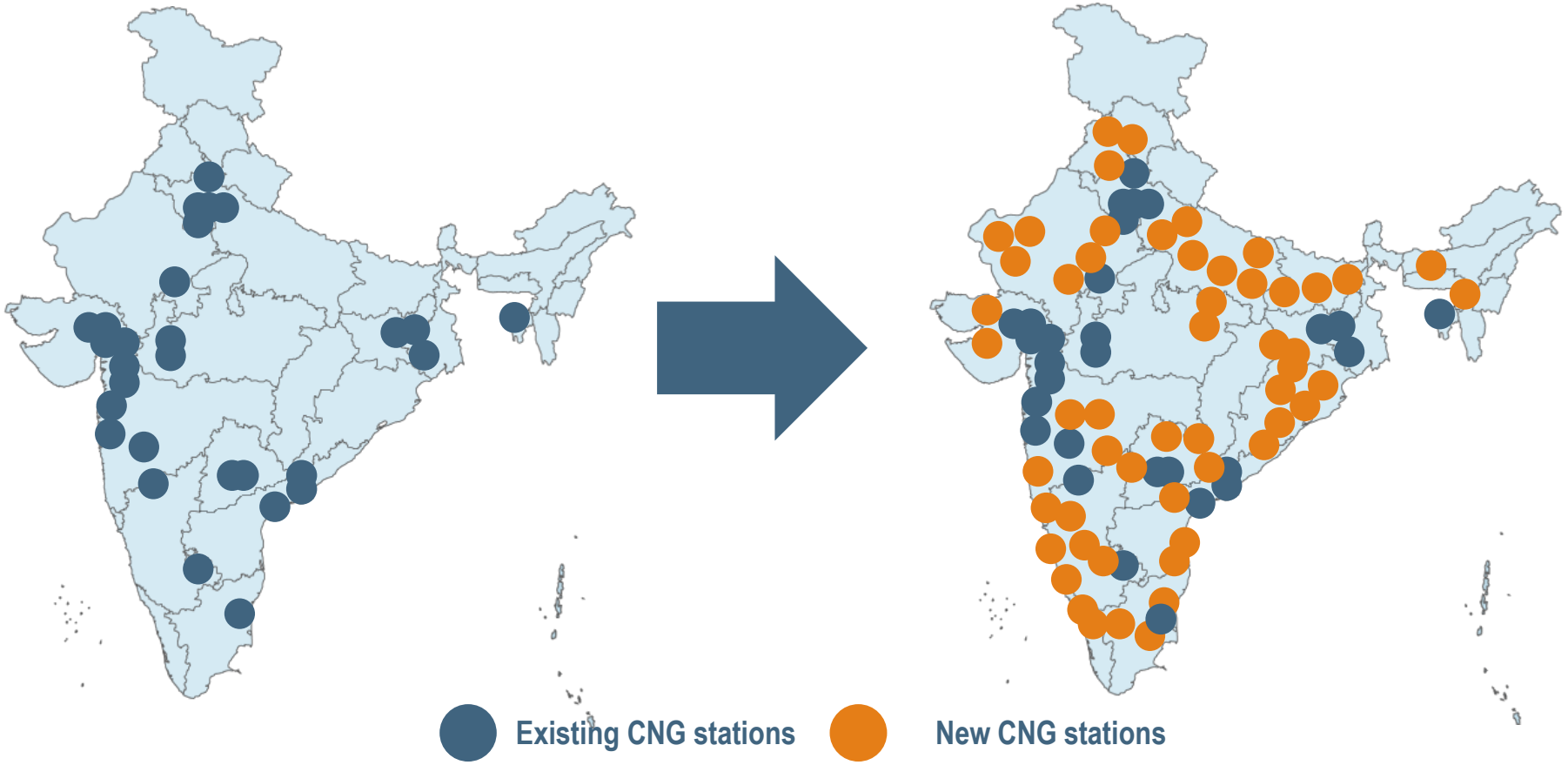
- Dharmendra Pradhan,
Cabinet Minister of Petroleum & Natural Gas

Source: PNGRB, Secondary Research

Expansion of CNG station network

The Government aims to increase the number of CNG Stations in India to 10,000 by 2030

2,207 CNG stations* **TO** **10,000** CNG stations



As of March'20

Source: Google Maps, PNGRB for upcoming GAs

Developing CNG Corridors

So that it does not get limited to city usage, there are plans to develop CNG corridors on major inter-city highways with the setup of CNG stations every 50 km

■ Green Corridors (CNG)

- MoPNG has planned to run inter-city buses on CNG fuel as part of its initiative to make public transportation cleaner and push CNG usage
- Pilot for running CNG buses from Delhi to other cities had been planned in Feb 2019 by DTC (Delhi Transport Corporation)
- 8 CNG buses (Range-700 kms per refill) have been procured from Ashok Leyland and are in final stages of regulatory approvals
- The pilot appears to have met with operational delay currently

Green Corridors Under Construction

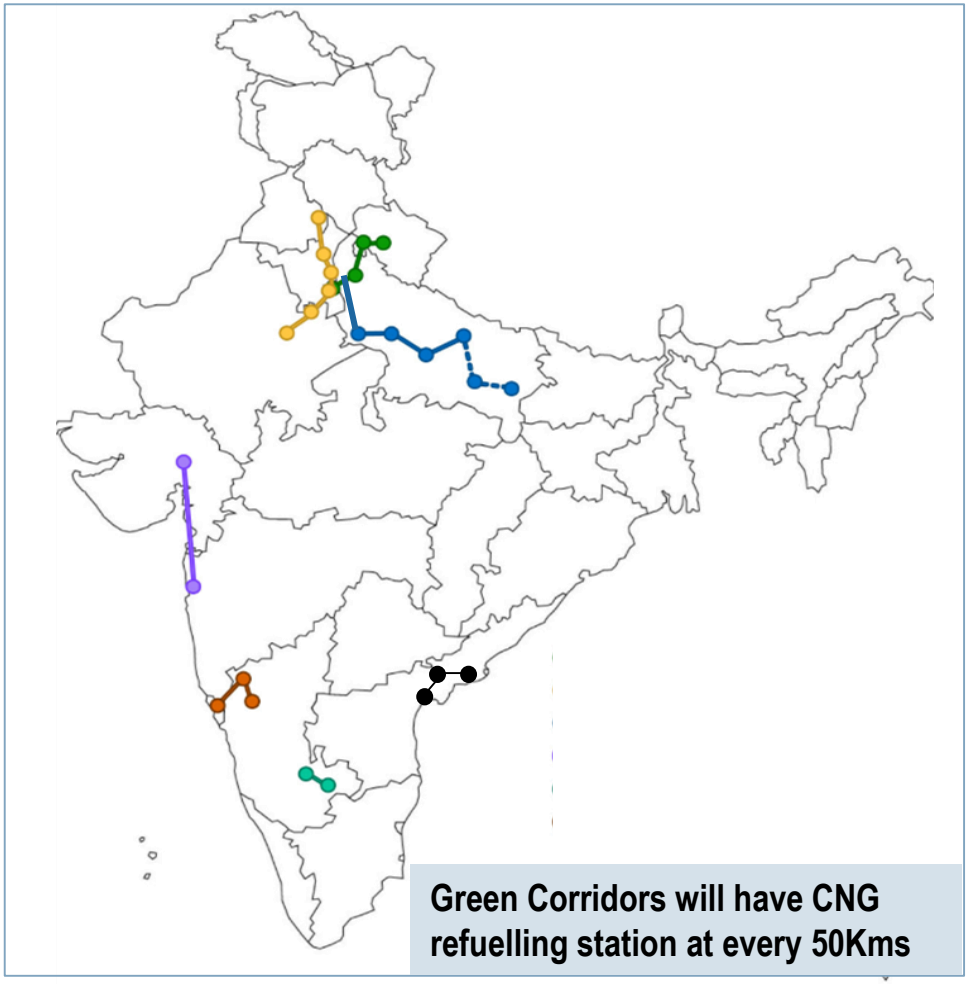
- Vishakhapatnam – Kovuur - Vijayawada
- **Delhi-Agra**–Firozabad–Kanpur–Lucknow–Allahabad–Varanasi

Planned

- **Delhi – Meerut – Roorkee – Haridwar**
- **Chandigarh – Panipat – Sonipat – Delhi – Neemrana – Jaipur**
- Ahmedabad – Mumbai
- Hubbali – Belgavi - Goa
- Bengaluru – Tumakuru

Trial Corridors

■ Green Corridors (CNG)



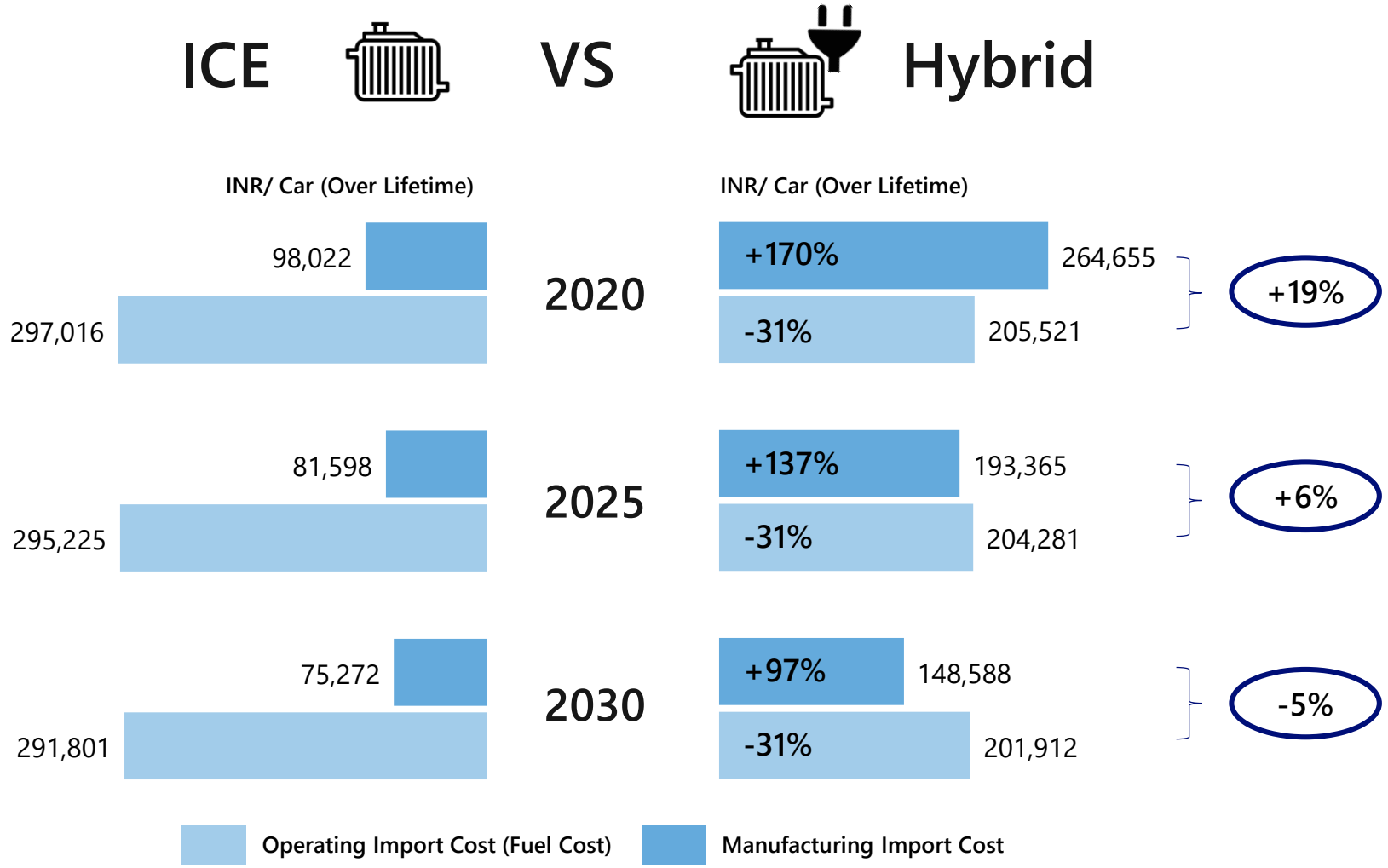
Green Corridors will have CNG refuelling station at every 50Kms

Source : GAIL, MoPNG, Secondary Research

Hybrid

Import Cost Comparison: ICE Vs Hybrid

Hybrids can reduce fuel consumption by 31% but component import cost is 170% higher. Towards 2030, hybrids can potentially give savings of upto 5% with localization



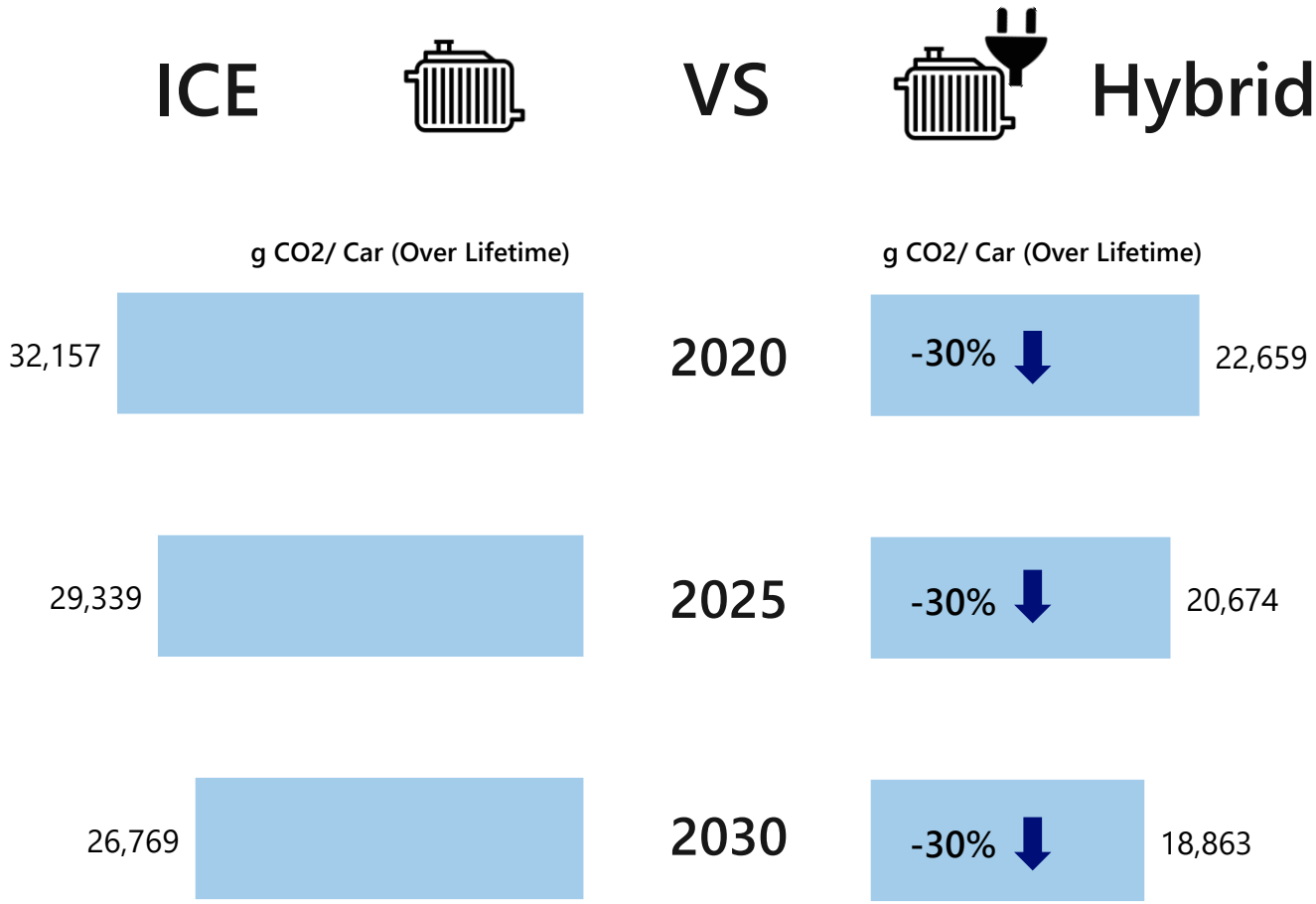
Assumptions:

1. Fuel Efficiency (Gasoline, Hybrid : 16.42, 23.73 kmpl)
2. Degree of localization in HEV components is considered similar to EV case
3. Additional components import cost for battery, motor & inverter has been covered

Source: NRI Analysis

Carbon Emission Comparison: ICE Vs Hybrid

In terms of Emissions, Hybrids are the clear winner with as much as 30% reduction in emissions because of the mileage factor



Assumptions:

Current Hybrid Mileage is considered as 23.73 kmpl

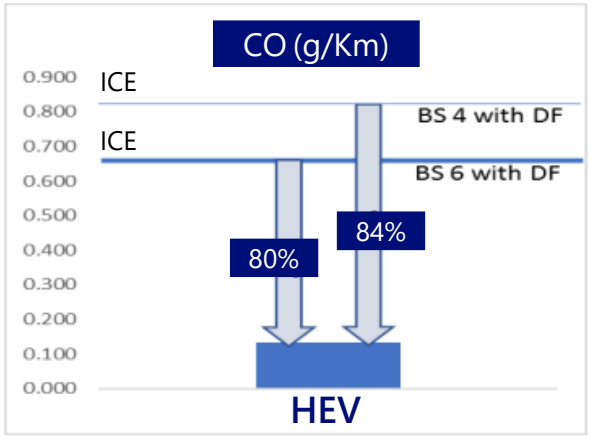
Source: NRI Analysis

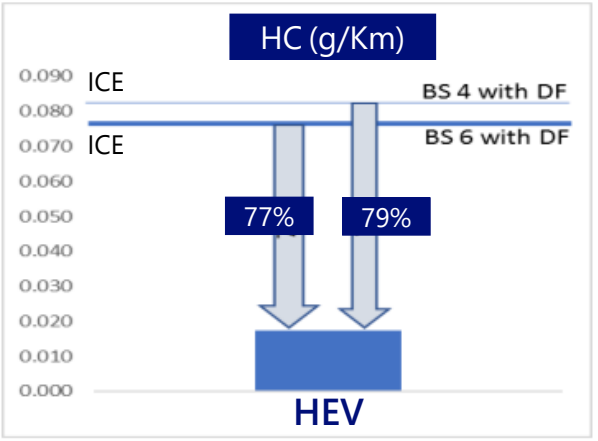
Hybrid: Emissions Benefits for other Gases

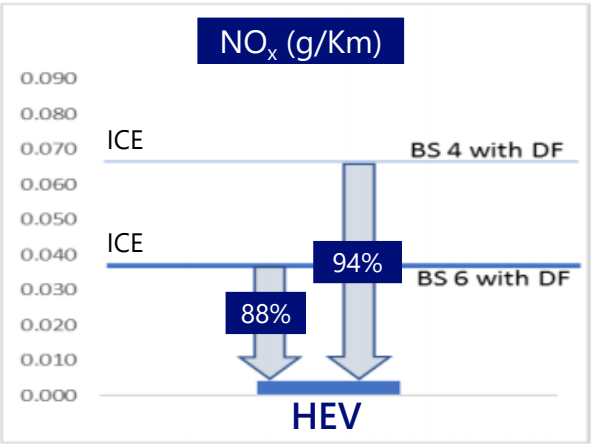
In addition to savings in CO2 emissions, CO, HC and NOx emissions are also observed to be ~80% lower for HEV's in MIDC drive cycle compared to a BS6 ICE vehicle

Parameter	HEV	ICE
Wheelbase (mm)	2,550	2,550
Engine Displacement (cc)	1,496	1,496
Vehicle Mass (Kg)	1,365	1,580

Note- All are 4 Cylinder vehicles







– 80-84% Reduction in CO emissions

– 77-79% HC reduction

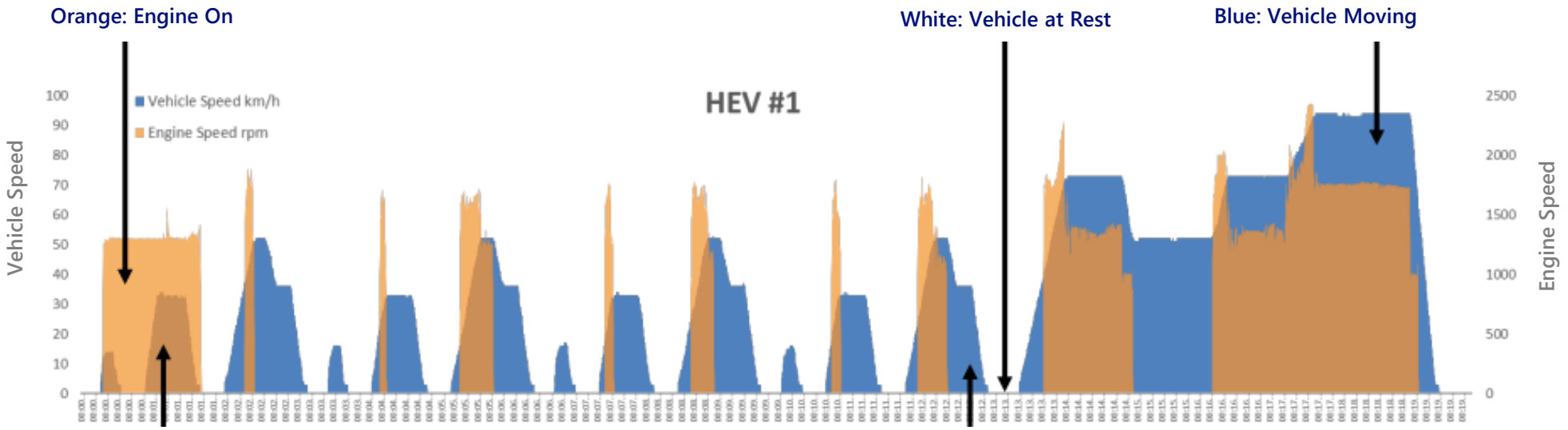
– 88 to 94% NOx Reduction

Note- All calculations done in MIDC Drive Cycle, DF-

Source: Affordable and Energy Efficient Mobility Solution Report presentation in Nugen Mobility Summit 2019 at Icat

HEV: Operation Benefits

Significant Fuel Efficiency improvement is observed in HEVs over ICE from the test results in different cycles of MIDC, Urban and IRDE



1

Fuel efficiency improvement with HEV's over ICE

- 30-50% on MIDC cycle
- 160-195% on MIDC urban cycle (Higher improvement due to higher idling conditions experienced in city driving)
- 40-80% in IRDE cycle

2

Low on Regulated Pollutants

- 60-80% lower with respect to BS6 limits (Co, HC, Nox)
- 30-50% less CO2

3

Predominant mode of energy is electric in Hybrids

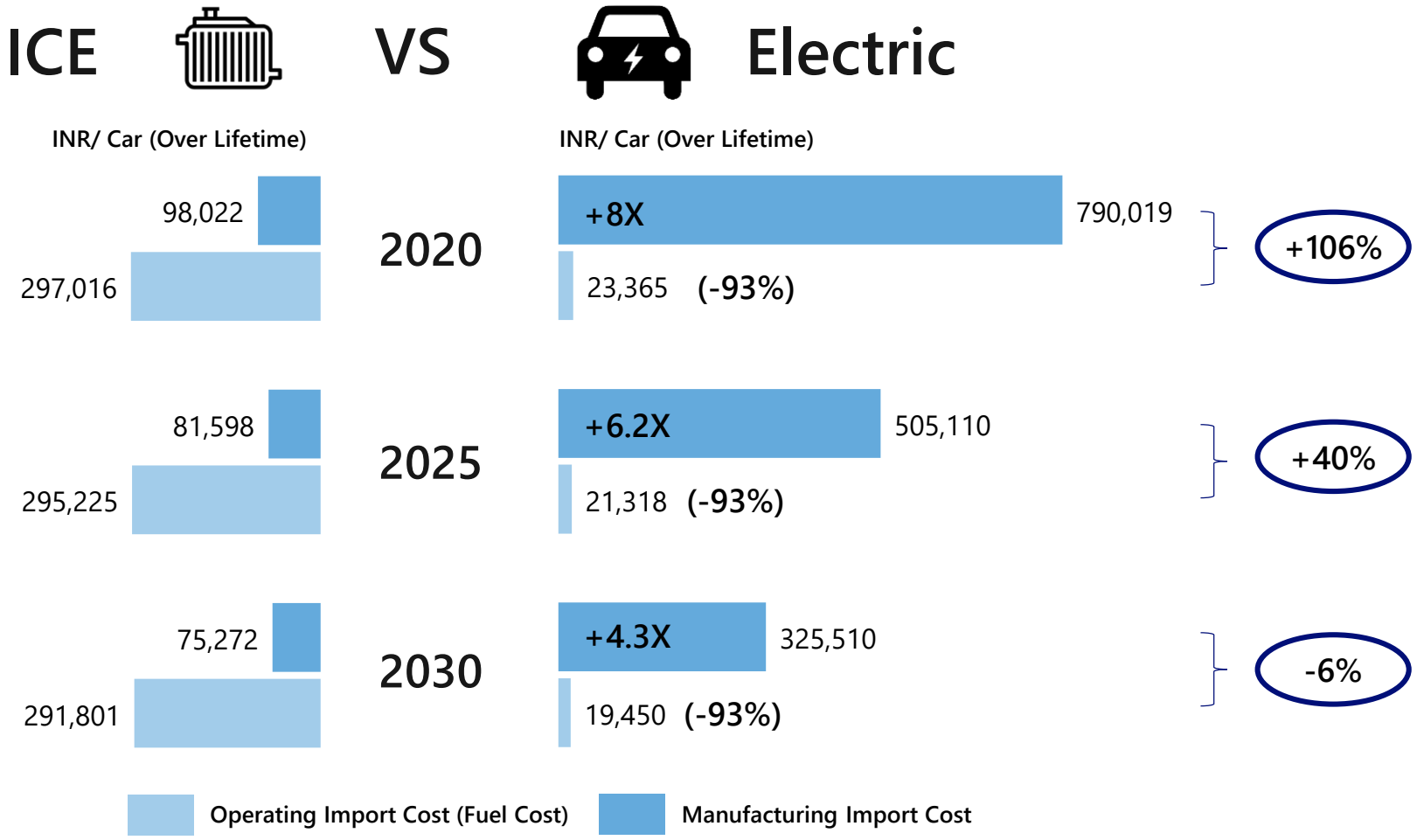
- 60% of time, e-drive observed in MIDC testing

Source: Affordable and Energy Efficient Mobility Solution Report presentation in Nugen Mobility Summit 2019 at Icat

Electric Vehicle

Import Cost Comparison: ICE Vs Electric

Total Import cost for EV is 106% higher than ICE in current situation but may result in 6% savings by 2030



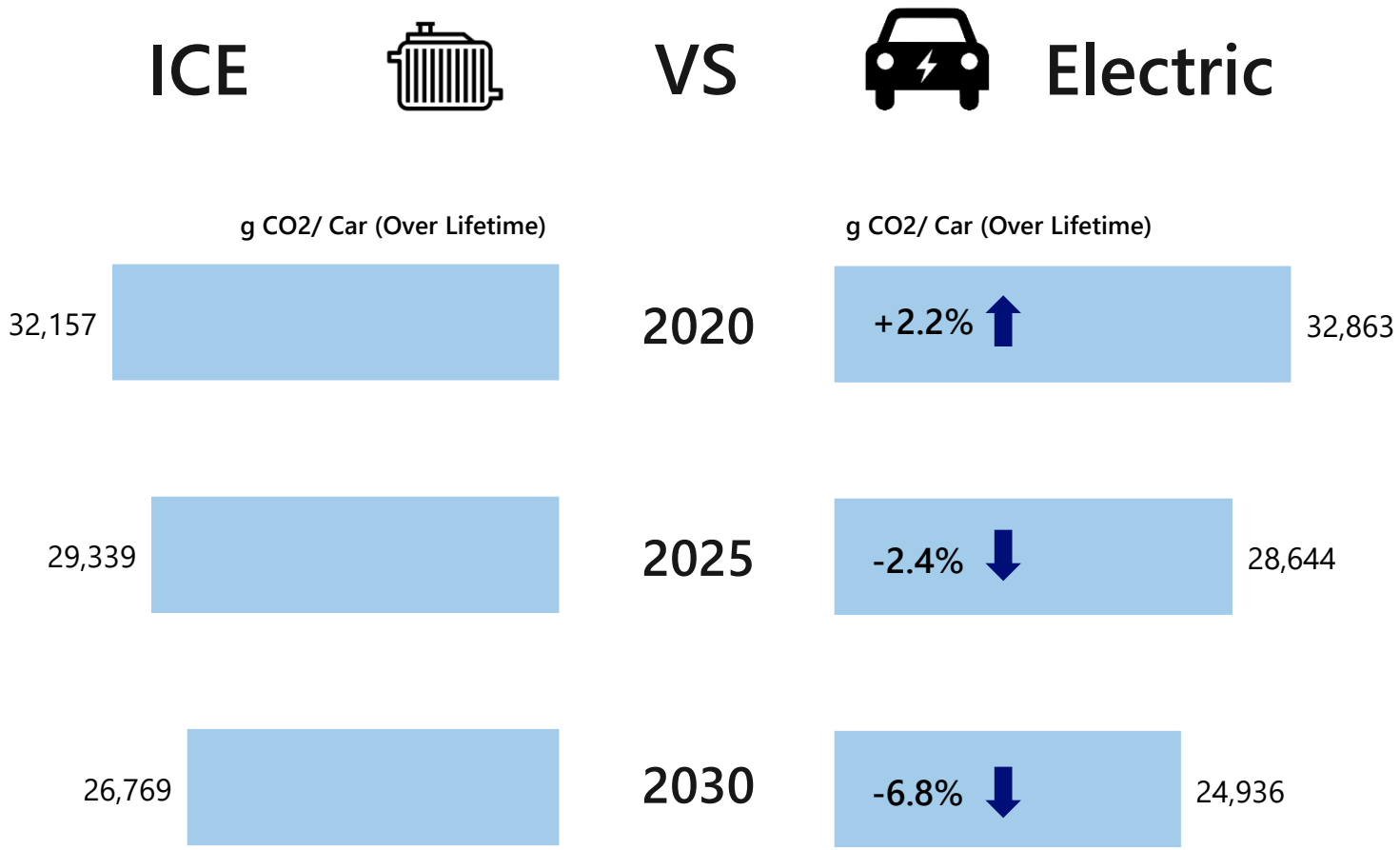
Assumptions:

1. 20% battery localization is assumed for 2020, 60% for 2030
2. 0% Motor+Controller localization for 2020, 50% from 2025
3. 30kW battery has been considered

Source: NRI Analysis

Carbon Emission Comparison: ICE Vs Electric

In terms of CO2 emissions the benefits of EV will start showing in 2025 and beyond when we are able to generate more than ~21% our energy through renewable sources.



Assumptions:

1. Well to Charger Transmission & Distribution Losses:
2. Major losses come from T&D and T&D losses decrease gradually reaching 19% by 2030,
3. Renewable Energy: Renewable sources are expected to generate 25% of India's electricity demand by 2030 (Source: IESS)

Source: NRI Analysis

Current Localization Scenario: HV-PV [30 KWh >72V System]

In order to get the real benefits of EVs faster, India needs to accelerate the development of local supply chain. Net localization levels are currently very low.

	Critical EV Component	Deadline	Net Localization (%)	Approx. Value Addition in India
	Battery (LFP, Air cooled, 21kWh)	July'19	~20-25%	• Local Pack Assembly (from module) • BMS, thermal mgmt. integration
	Power and control wiring harness along with connectors	Oct'19	45-50% (LV) 15-20% (HV)	• Wiring Harness made in India • Connector Imported & assembled
	AC Charging Inlet- Type 2	Apr'21	35-40%	• Inlet, Connector Import • Assm. with Cable/Connector in India
	DC-DC Converter	Apr'21	0-10%	• 100% Hardware imported • Testing, CAN Integration support
	Vehicle Control Unit	Apr'21	0-5%	• HW Import • Software dev. Testing
	On Board Charger	Apr'21	0-5%	• Hardware imported • Testing, CAN Integration support
	MCB, Circuit Breakers, Electric Safety device (Power Electronics)	Apr'21	30-35%	• Some Child parts made in India • System Assembly & Testing
	Electric Compressor	Apr'21	0-5%	• System Import • Some OEMs planned Assm. Line in India
	DC Charging Inlet	Apr'21	15-20%	• Inlet, Connector Import • Assm. with Cable/Connector in India
	Traction Motor & Controller	Apr'21	0-10%	• Majority import • Indian Supplies have low power capability

- Suppliers are importing Critical child parts (some non-critical child parts are locally sourced from India)
- Although invoicing and final assembly is being don't in India, most child parts, raw materials are imported resulting in low net localization

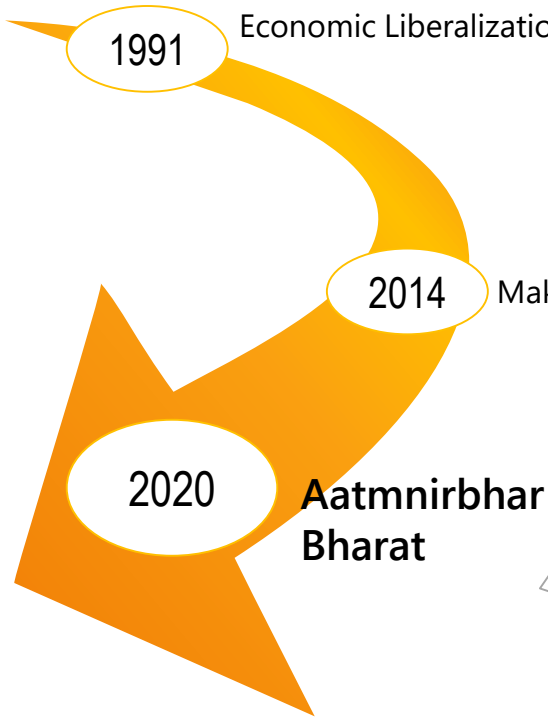
Note- Net Localization = Value of Raw Material/ Child Part Sourced from India + Assembly Value Addition done in India

Source: NRI Estimates, Analysis of Company Reports, NRI Analysis

Government Vision of Local Manufacturing Ecosystem Development

Through Aatmnirbhar Bharat, India is targeting reduced Import Dependency, local manufacturing and export promotion for EVs

Government's Local Manufacturing Vision



Mr. Narendra Modi

Self Reliant India by Reducing Import Dependency and focusing on Make in India

Aatmnirbhar Bharat is a graduation from Make in India to Make for the World

Anything manufactured in India by Domestic as well as Global MNCs would be considered Local

Policies for Automotive Industry

- Stricter Implementation of **FAME**
- **Phased Manufacturing Program of EV Components** (graded import duty structure)
- Revised Corporate Tax to 25%
- Revised **FDI Policy to curb Chinese Investment**
- **MSME Benefits-** Ease of availing incentives due to re-classification, Collateral free loans etc.
- **Production Linked Incentives (PLI)** of INR 145,980 Crore with focus on xEV Battery, Auto Components, Electronics etc.

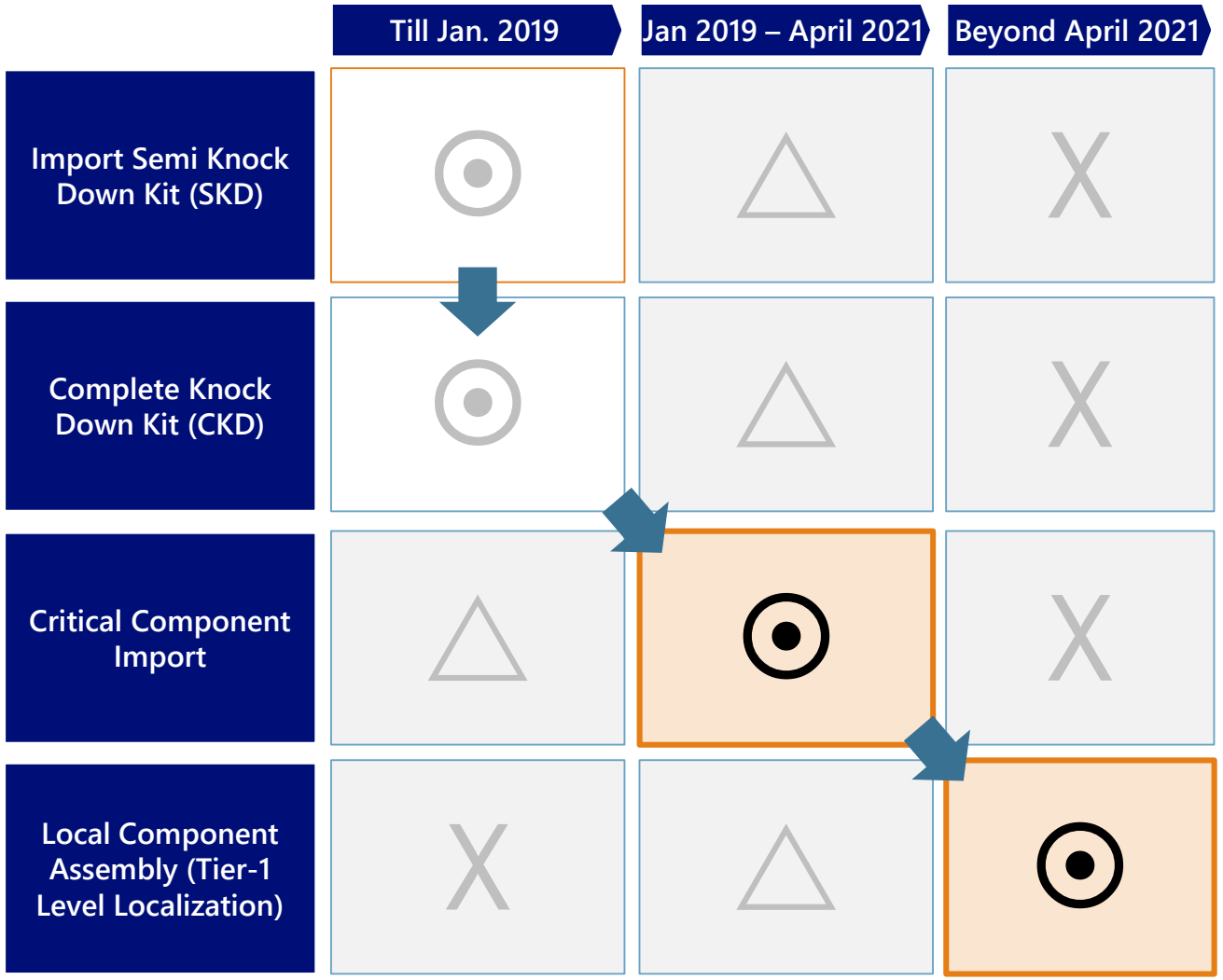
Policies for Electronics & IT industry

- Modified Special Incentive Package Scheme (**M-SIPS**)
- Scheme for Promotion of Manufacturing of Electronic Components and Semiconductors **(SPECS)**
- Modified Electronics Manufacturing Clusters (**EMC 2.0**) Scheme
- Electronics Development Fund **(EDF)** policy

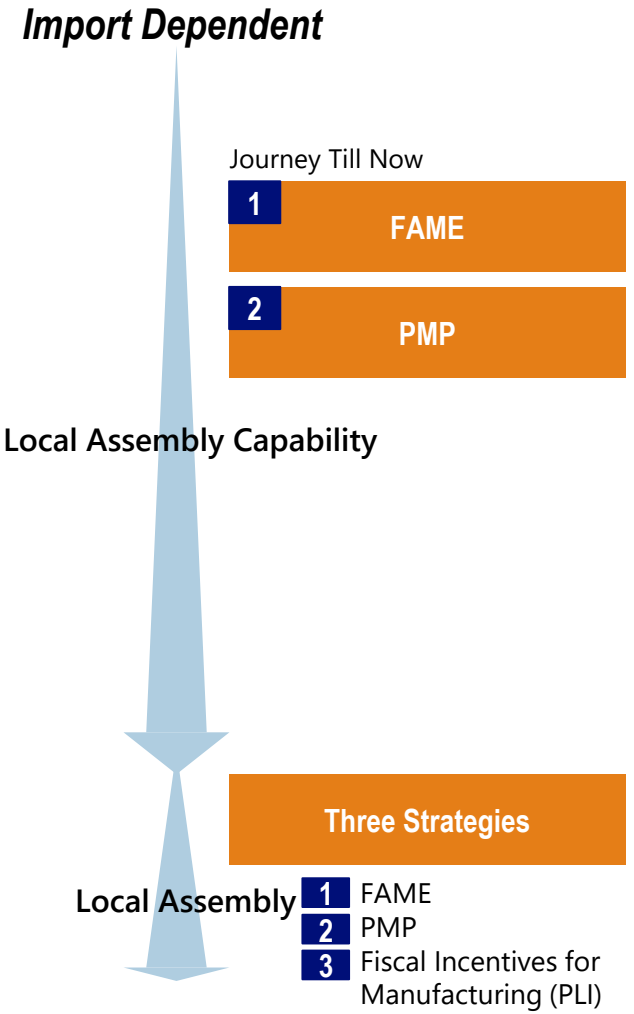
Source: Expert Interview, Govt. Notifications, Press Release

EV Localization Plan in India- Journey So Far

Under Aatmnirbhar Bharat, India has devised a 3 pillar strategy to promote local manufacturing ecosystem development – FAME, Import Restrictions & Fiscal Incentives



△ – Allowed but not Priority; X- Not Allowed; ⊙- Priority



Source: Expert Interview, Govt. Notifications

EV Localization Plan in India- Future Strategy to Promote Local Manufacturing

Going ahead, Govt. has devised three pillar strategy to promote local manufacturing ecosystem development – FAME Scheme, Import Restrictions, Fiscal Incentives

Three Strategies to Promote Local Manufacturing of EVs

2019 2020 2021 2022 2023 2024 2025

1 FAME Scheme

- To avail FAME II demand incentive, **Most EV Critical components will have to be localized by 2021**
- **Localization of Child Part Assembly is expected**
- Recently, in wake of COVID, deadline for certain components has been pushed to April, 2021

- No visibility beyond 2022
- FICCI in July 2020 has recommended extension of FAME 2 till 2025 (no announcement yet by DHI)
- Might expect stricter localization criteria, New components might be added to the localization criteria

2 High Import Duty on Child parts (PMP)

0% for Child parts → **15 % for child parts**

Intention if for local assembly of AC or DC Charger, AC or DC Motor, AC or DC Motor Controller, Power Control Unit, Energy Monitor, Contactor, Brake System for recovering, Electric Compressors.

3 Fiscal Incentive for Manufacturing (PLI Scheme)

Performance Linked Incentive for manufacturing capability development*

- Automotive- INR 57,000 Cr., LiB Battery Manufacturing- INR 18,000 Cr., Electronics- INR 46,000 Cr.
- Reason for import of most xEV components from China is cost benefit (not technology)
- PLI intends to offset India's cost disadvantage by incentivizing production with a high weightage on 1) local value addition, 2) Scale, 3) Quality; and thus will spur higher investments

Note * - Not Specific to EV but includes Battery Manufacturing, Automotive, Electronics Manufacturing

FAME-II Timeline — Extension of FAME-II Budget ····· FAME-III → Other Financial Scheme

Source: Expert Interview, Govt. Notifications

1 FAME Scheme Localization

FAME-II deadline for EV components localization has been extended considering the disruption from the pandemic & limited localization achieved

Initial FAME Timeline

#	Target parts	Timeline for M1				
		'19/7	'19/10	'20/4	'20/10	'21/4
1	Traction Battery Pack					
2	HVAC					
3	Power and control wiring harness along with connectors					
4	AC Charging Inlet- Type 2					
5	DC-DC Converter					
6	Electronic Throttle					
7	Vehicle Control Unit					
8	On Board Charger					
9	Instrument Panel					
10	Body Panel					
11	Lighting: Headlamp, Tail lamp, indicator, interior lamp, flasher etc.					
12	Electric Compressor					
13	MCB, Circuit Breakers, Electric Safety device					
14	DC Charging Inlet CCS-2/CHAdeMO					
15	DC Charging Inlet BEVC DC 001					
16	Traction Motor					
17	Traction Motor Controller/ Inverter					
18	Wheel rim integrated with hub motors					

New FAME Timeline (with effect from Oct. 2020)

#	Target parts	Timeline for M1				
		'19/7	'19/10	'20/4	'20/10	'21/4
1	Traction Battery Pack					
2	HVAC					
3	Power and control wiring harness along with connectors					
4	AC Charging Inlet- Type 2					
5	DC-DC Converter					
6	Electronic Throttle					
7	Vehicle Control Unit			1 Year		
8	On Board Charger					
9	Instrument Panel					
10	Body Panel					
11	Lighting: Headlamp, Tail lamp, indicator, interior lamp, flasher etc.					
12	Electric Compressor					
13	MCB, Circuit Breakers, Electric Safety device				1/2 Year	
14	DC Charging Inlet CCS-2/CHAdeMO					
15	DC Charging Inlet BEVC DC 001					
16	Traction Motor					
17	Traction Motor Controller/ Inverter					
18	Wheel rim integrated with hub motors					

- Shifted due to global supply chain disruption-Covid-19
- FAME-certificate was fist extend for 3 months but Covid-19 issue became much bigger than expected in the beginning
- OEMs had plan for localization in India which got disrupted by disruption in Supply chain
- So the earlier committed localization timeline became difficult to meet by OEMs (extension was given by considering that OEMs will localize the parts within 6 months)
- That's why the overall timeline itself has been shifted so that OEMs get enough time for managing the supply chain disruption

Source: Govt. Notification

2 Phased Manufacturing Program (PMP) – Custom Duty

PMP targets to achieve child part localization in long term by increasing the import duties

Sr.	Item Description		BCD (Basic Custom Duty)			
			April' 17	Jan' 19	April' 20	>April' 21
1	CBU	Bus & Trucks		25%	*50%*	
2	SKD	PV & 3W		15%	*30%*	
		2W, Bus & Truck			*25%*	
3	CKD	PV, 2W, 3W, Bus & Truck		10%	*15%*	
4	Lithium Ion cells for manufacture of Lithium Ion accumulator		0%	5%		10%
5	Battery Packs (LiB)		0%	5%		15%
6	Parts (Assemblies)					
6.1	AC or DC Charger		0%	0%		15%
6.2	AC or DC Motor					
6.3	AC or DC Motor Controller					
6.4	Power Control Unit (Inverter, AC/DC		Not included			
6.5	Converter, Condenser)					
6.6	Energy Monitor					
6.7	Contactor					
6.8	Brake System for recovering					
6.9	Electric Compressor					

Source: Primary Interview

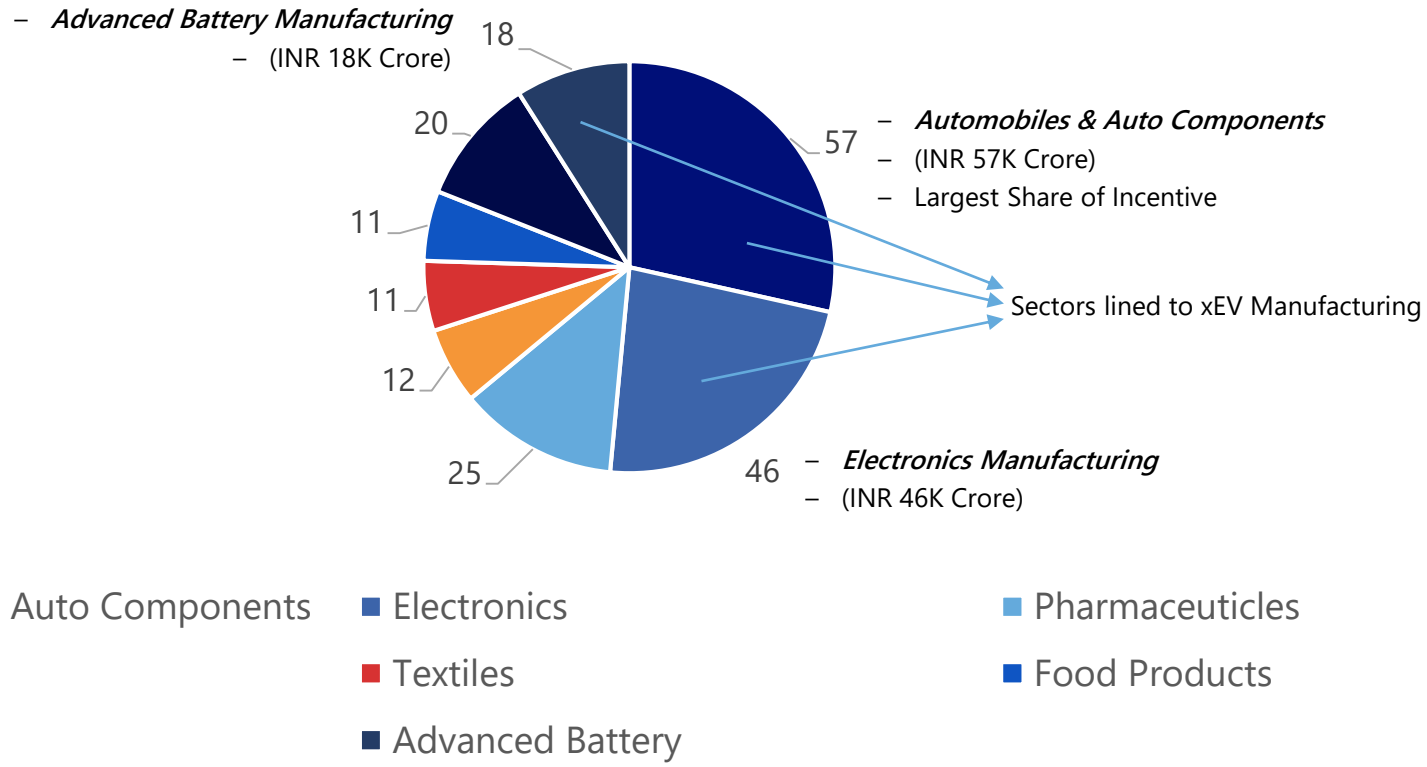
Proposed Basic custom Dusty (BCD)by Ministry of Finance

3 Production Linked Incentive Scheme

On November 11, Govt. announced a production linked incentive of ~INR 1.5 Lakh Crore to boost local manufacturing in sectors like Automotive, Battery etc.

Breakup of Total Production Linked Incentive Scheme to Boost Local Manufacturing

Total Additional PLI of INR 145,980 Crore on November 11, 2020 + Rest ~ 50,000 Crore Previously



- Auto and Auto Component Industry got the biggest slide in terms of INR 57,042 Crore.
- Advanced battery also received a large share of INR 18,100 Crore.
- A Percentage of Production Value will be Provided as an Incentive to companies
- **For Battery Makers, Cash subsidies will be provided to depending on 1) Local Value Addition %, 2) Scale of Production (GWh)**

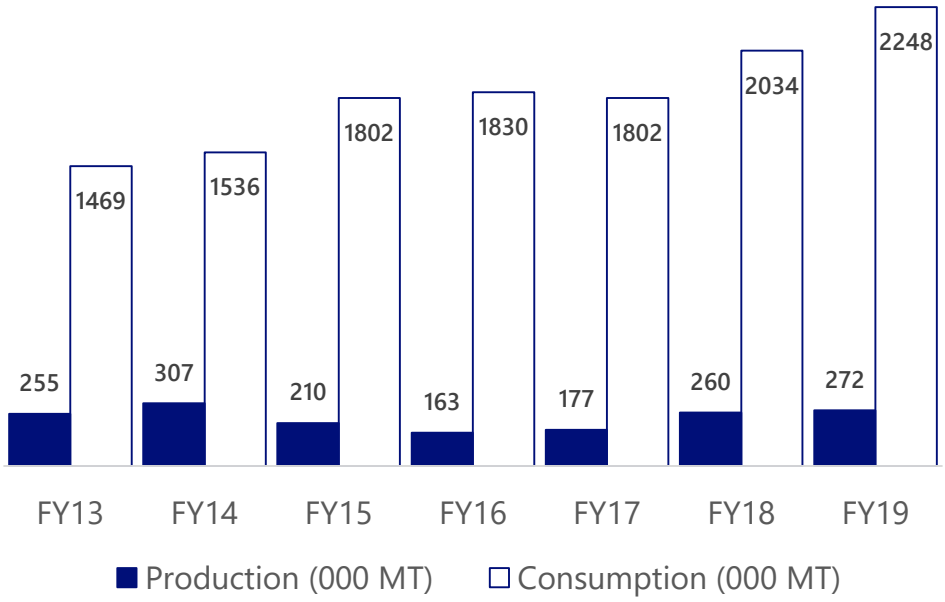
Source: Government Release

Other Potential Alternate Powertrain Options (Methanol, Hydrogen Fuel Cell)

Methanol overview

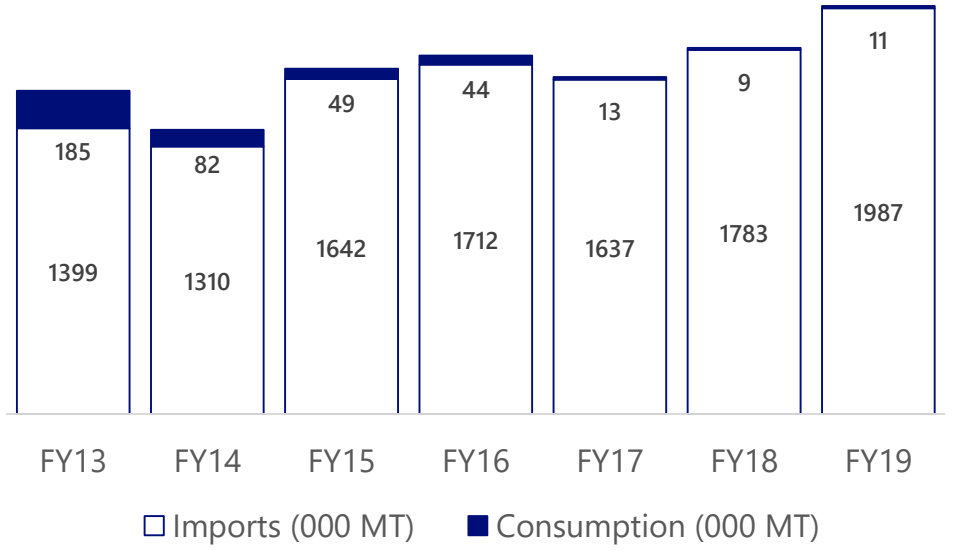
Since, India is producing methanol from imported natural gas, it must use coal for production which makes it economically viable than importing

■ Methanol Production in India (in 1000 MT)



- Since, the **installed production capacity of methanol has largely been static**, falling domestic production has **led to constant decline in the capacity utilization** factors of Methanol Industry
- The domestic **production of methanol has fallen** by 57% from 2010-11 to 2015-16, whereas **the consumption has risen** by 61% over the same period

■ Methanol Import and Export (in 1000 MT)



- India imports **99% of its methanol from Iran and Saudi Arabia**, where **methanol is produced** from natural gas which is abundantly available in latter countries **at extremely low prices**
- On the other hand, **India relies on imported natural gas for methanol production** due to which it **loses its competitiveness in comparison with imports**

Source: Department of Chemicals & Petrochemicals

NITI Aayog is working on developing roadmap for India's leapfrog to Methanol Economy in collaboration with International groups like Methanol Institute

■ The Journey

	Sep 2015	Jan 2016 – Mar 2016	Sep 2016
	Brainstorming session *By NITI Aayog*	**Call for proposals** ***(DST)***	**India's Leap into the Methanol Economy:** Opportunities and Options for Energy Security *By NITI Aayog*
Event	– First brainstorming session on possible road map for Methanol Economy for long term Energy security of India	– Call for Proposals for research on **Production and utilization of Methanol & DME** as sustainable fuel	– Forum to understand the viability of Methanol Economy in India, its potential uses in transport & energy sector
Decision	– **3 committees** constituted by DST on advice of NITI Aayog to have focused discussions on issues related to **Production, Utilization and R&D**	– **87 Project proposals** received – Project selection in R&D expert group meeting in April 2016	– **Target of 15% blending by methanol/DME in gasoline/diesel by 2022** – If achieved could result in savings of around $8 billion by 2022
Action	– Expert Groups to work with Methanol Institute (US) to **increase methanol production from coal and biomass**, and utilize methanol and DME as **transportation fuels**	– **Committee recommended 3 proposals** & suggested modifications in another 5 proposals	– **60 global participants** and **500 domestic** delegates from Government of India, Academia and leaders of Indian Industry

India's Leapfrog to Methanol Economy

Source: Niti Aayog, NRI analysis

Opportunities with Methanol

Coal to methanol being a proven technology, India must tap its large coal reserves to produce methanol as a substitute or drop-in for conventional fuels

Opportunity for India

❑ Methanol to be used as a Transportation fuel

❑ Methanol to help in achieving the objective of access to clean cooking fuels
❑ Displacing diesel in Telecom Towers
❑ Production of various chemicals
❑ Dovetailing with Swachh Bharat Mission

1 **Reduce Import of Crude Oil**

- Methanol can be blended with gasoline and diesel or can completely substitute the latter fuels respectively
- India has already set itself an ambitious target of 10% reduction in import dependence of oil & gas by 2022 in comparison with 2014- 15 that can be supported by methanol blending

2 **Emissions & Vehicle Efficiency Improvement:**

- High methanol blends offer significant vehicle efficiency improvement with potential of 25%
- The tailpipe emissions from methanol usage are quite low in comparison with gasoline and diesel, however, the well to wheel (WTW) emissions for coal to methanol production in comparison with gasoline are more

3 • Methanol or DME blending with LPG or the complete substitution of latter through former can not only **gradually displace LPG imports**, but would also help in **enhancing the access to clean cooking fuels** in India

4 • Telecom towers in India consume around 2% of diesel consumption which is a significant amount indicating a vast potential for DME to replace diesel

5 • Methanol can be used for **producing various chemicals** like formaldehyde, acetic acid and olefins which can be exported

Source: Niti Aayog

Hydrogen Fuel Cell - Summary

The journey of Hydrogen Fuel Cells adoption in India was started in 2003 and regular developments have been adopted since then

2003	National Hydrogen Board was formed
2005	India's first Hydrogen refueling station was set up at IOC, Faridabad
2006	National Hydrogen Energy Roadmap was introduced
2009	Clean Energy Research Initiative was set up by DST
2012	Hydrogen powered 3W 'Hy Alfa' was developed by M&M with the help of International Centre for Hydrogen Tech & IITD
2014	Make in India was introduced by Government of India
2015	Global Initiative called Mission Innovation was setup to accelerate clean energy innovation
2015	National Renewable Energy Act was introduced
2016	Draft report on Hydrogen storage & application was submitted under the chairmanship of Dr. K k Kasturirangan
2018	India's first Hydrogen fuel cell bus was introduced by IOC and Tata Motors
2018	DST call for oriented research & Technology Development proposal on 'H2 & Fuel Cell (HFC)
2018	DST-IIT Bombay Energy Storage Platform on Hydrogen & DST-NFTDC center for materials and Energy storage platforms was formed

Source: Department of Science & Technology – India country status report on H2 & Fuel cells

Fuel Cells – Way Forward

Hydrogen has very clear-cut advantages as against the conventional fuels and a potential for decarbonisation of several sectors

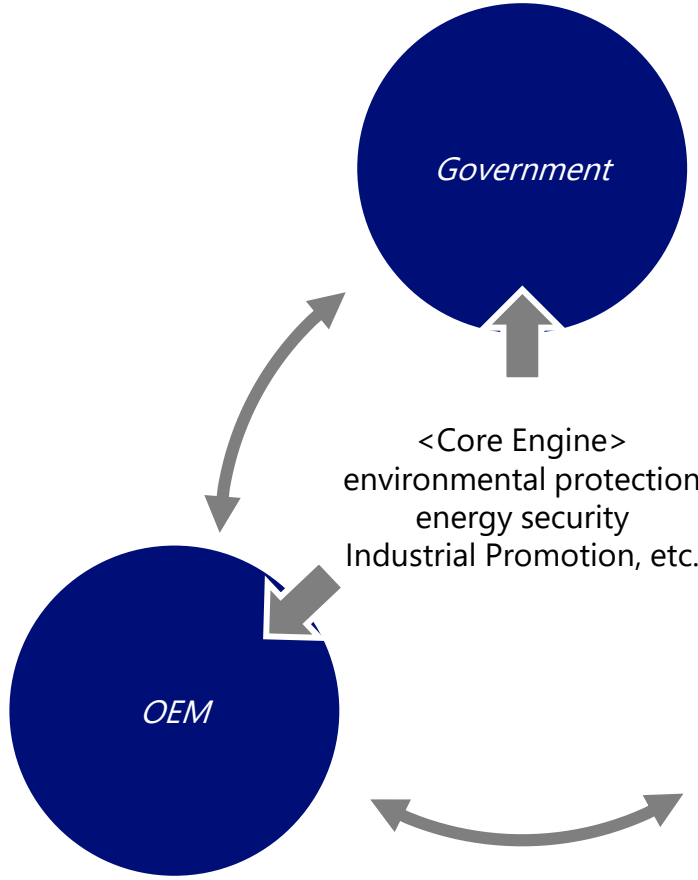
Way Forward

1 Role of Government	The need of the time is policy support, **help in demand creation, reduction in risk of the investors, standards and regulations in place, R & D support, creating public awareness** and projection of all the data to create a confidence in hydrogen and hydrogen-based technologies
2 Transportation Sector	One emerging area being transportation sector, since India heavily depends on imports and transportation sector is major consumer of oil, thus hydrogen can play a crucial role. But **the domain in transportation sector where hydrogen fuelled vehicles can be best suited is long haul, heavy transport and commercial fleets**
3 Hydrocarbon production	An interesting route and use of hydrogen is combining hydrogen with the captured CO2 from sequestration plants to **produce a variety of hydrocarbons like methane, methanol, synthetic petro-chemicals or transport fuel**
4 Shipping	Hydrogen or ammonia could be possible solution for shipping while biofuels and other synthetic fuels i.e., **power to liquid option of hydrogen could be the choice**. These areas should be thought of as the next generation of applications
5 Railways & Trucks	**Introducing FCs in railways and trucks** could also be an economically feasible solution as the implementation of hydrogen-based mobility is economically more viable as compared to electrification of railways

Source: Department of Science & Technology – India country status report on H2 & Fuel cells

Fuel Cell Vehicles: Availability

For FCVs to be widely used, it is essential to promote the core propulsion system & the three-fold promotion of the government, OEMs, and hydrogen companies



Role

- Setting Target Roadmap
- Formulation of Policies That Motivate OEMs and Hydrogen Business Operators
- Formulation, etc. of PoC Concepts

Role

- FCV development and sales
- Developing Related Parts
- Participation in Hydrogen ST Promotion Organization

Role

- Installation and Operation of Hydrogen ST
- COMPOSITION OF HYDROGEN ST PROPULSION TISSUE
- Construction, etc. of Supply Chain

Source: Secondary Research, NRI analysis

Contents

Assumptions

ICE

W2W Emission Assumptions

	2020	2025	2030
Mileage(Km/l) - Gasoline	16.42		
Mileage(Km/l) - Diesel	18.80		
Mileage(Km/l) – ICE	16.57	18.16	19.90
Fuel Improvement Factor (YoY)	1.85% (No more improvement considered after 2030(19.90 kmpl)) – Source: eia.gov		
Transportation (Scope 3) Emissions	1.3 times the Refinery (Scope 1 & 2) emissions		
Co2 Emissions – Crude Oil Extraction	10.3 gCo2/MJ Crude		
Heat Value – Crude Oil	47 MJ/kg		
Density – Crude Oil	0.88 kg/l		
Tank to Wheel	<1400 cc models considered		

Import Cost Assumptions

Manufacturing Import Cost

- **Increase in Localization (%)**:
  - 2020-22: **4%** || 2023-24: **3%** || 2025: **4%** || 2026-28: **2%** || 2029-30: **1%**

Operating Import Cost

- Lifetime emissions have been calculated for 15 years based on the base year (2020, 2025, 2030) emissions
- Import content in gasoline or diesel in India has been directly correlated with import percent of crude oil in India, which is expected to increase marginally from current 87% to 88% by 2027 and continue at 88% post that

Assumptions

Ethanol (E10)

W2W Emission Assumptions

	2020	2025	2030	*Source*
Ethanol Blending	E5	E10	E20	
Mileage difference with ICE- (i)	0	-2%	-6.5%	*ARAI*
Fuel Improvement Factor (YoY)-(ii)	1.85% (No more improvement considered after 2030(19.51 kmpl))			*eia.gov*
Mileage after i & ii (Km/l)	16.57	17.80	19.51	
Co2 Emissions difference in W2T with ICE	-5%	-10%	-20%	
Tank to Wheel Emission difference with ICE	0	0	1.143 gco2/km	*ARAI*

Others:

- **Production**:
  - Up to 20% blending can be achieved through domestic production
  - Emissions: Zero emissions considered in the production and transportation of Gasoline
- **T2W emissions**: The calculations for Ethanol are based on ICE and not gasoline (If it is done basis Gasoline data then Ethanol emissions will be higher than ICE till 2025)

Assumptions

EV

W2W Emission Assumptions

	2020	2025	2030	*Source*
NMC Efficiency	6 km/kWh			*Battery University*
Battery Size		30 kWh		*Standard battery*
Fuel Improvement Factor (YoY)	1.85% (No more improvement considered after 2030(19.90 kmpl))			*eia.gov*

- **Well to Charger Transmission & Distribution Losses:** Major losses come from T&D and T&D losses decrease, reaching 19% by 2030, 16% by 2047

Import Cost Assumptions

Manufacturing Import Cost

	2020	2025	2030 Onwards
Battery Unit Cost (US$)	240	210	160
Battery Import (%)	80%	57%	40%
Motor + Cont. Import (%)	100%	50%	50%

- **Battery:** Maximum 60% can be localized in India, Raw material localization is impossible

Operating Import Cost

- **Renewable Energy**: Renewable sources are expected to generate 25% of India's electricity demand by 2030 and share from fossil fuels will go down to 75% by 2030 (71% from coal)
- **Battery:** Maximum 60% can be localized in India, Raw material localization is impossible

Assumptions

Hybrid

W2W Emission Assumptions

	2020	2025	2030
Mileage(Km/l) – Hybrid	23.73	26	28.5
Fuel Improvement Factor (YoY)	1.85% (No more improvement considered after 2030(28.5 kmpl)) – Source: eia.gov		
Tank to Wheel	Toyota Yaris Hybrid considered for T2W emission factors		

- Manufacturing: ICE:EV contribution in hybrid in terms of per km driving has been taken as 60:40

Import Cost Assumptions

Manufacturing Import Cost

	2020	2025	2030 Onwards
Battery Unit Cost (INR)	75,000	66,000	48,000
Battery Import (%)	80%	57%	40%
Motor + Cont. Import (%)	80%	50%	50%

- Motor + controller unit for hybrid is assumed to be 60% of EV case, in terms of size, cost and localization percentage
- Degree of localization in EV components is considered similar to EV case

Assumptions

CNG

W2W Emission Assumptions

	2020	2025	2030
Mileage(Km/l) – CNG	19	20.82	22.82
Fuel Improvement Factor (YoY)	1.85% (No more improvement considered after 2030(22.82 kmpl)) – Source: eia.gov		
Density – Natural Gas	0.68 kg/SM3		

Import Cost Assumptions

Manufacturing Import Cost

- CNG powertrain also includes some CNG specific components. So, import percentage of 35% for additional CNG specific components has been added to ICE value
- Localization criteria is considered to be same as ICE localization assumptions

General Disclosures

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Final Word…

❑ So what is the best technology for India?

- **All technologies have their pros and cons** from the perspective of National Objectives
- **Real benefit of Electrification** based technologies will be realized only **with good degree of localization** and **power generation from renewable sources**

❑ Limitations

- The focus of the study was **Passenger Vehicles** and should not be used for drawing inference for other segments

❑ Intended Objective & Audience

- The analysis comprehensively addresses the linkages between the issues to assess the effectiveness of various alternate powertrains in reduction of fossil fuel consumption and carbon emissions
- We hope this report will **help shape future powertrain roadmap strategies for Government, testing agencies, OEMs and component suppliers**


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