Low-carbon Energy Supply Strategy

For

Low Carbon & Sustainable Mobility in India
(Decarbonisation of Indian Transport Sector)

FICCI

Knowledge Partners

IPPMG

WWF

SHAKTI SUSTAINABLE ENERGY FOUNDATION



INDEX

PREFACE 4
INTRODUCTION 5

SECTION 1: ENERGY FOR TRANSPORT

CHAPTER 1
HEART OF THE PROBLEM 7

CHAPTER 2
IN RESPONSE 8

CHAPTER 3
CHALLENGES ALONG THE WAY 11

CHAPTER 4
ROUTES TO CHANGE 11

SECTION 2: OIL & GAS

CHAPTER 1
HEART OF THE PROBLEM 13

CHAPTER 2
IN RESPONSE 15

CHAPTER 3
CHALLENGES ALONG THE WAY 18

CHAPTER 4
ROUTES TO CHANGE 20

SECTION 3: ENERGY FOR ELECTRIC VEHICLES

CHAPTER 1
HEART OF THE PROBLEM 27

CHAPTER 2
IN RESPONSE 29

CHAPTER 3
CHALLENGES ALONG THE WAY 30

CHAPTER 4
ROUTES TO CHANGE 32

SECTION 4: DESTINATION LOW CARBON ENERGY SUPPLY 35
Actionable Recommendations

PREFACE

To move down the path of reduced emissions from the Indian transport sector and provide direction to low carbon and sustainable mobility for India, FICCI embarked on the initiative for Developing an **India Roadmap** for Low Carbon and Sustainable Mobility with thrust on decarbonisation of the Indian transport sector. FICCI is supported in this initiative by knowledge partners, WWF-India, Paris Process on Mobility and Climate (PPMC) and Shakti Sustainable Energy Foundation (SSEF). The India Roadmap has eight distinct components outlined below.

1. Urban transformation for healthier, inclusive lifestyles and efficient, resilient, prosperous cities
2. Low-carbon energy supply strategy
3. Improve intermodal and mode-wise system efficiencies
4. Optimise supply chains to manage freight transport emissions
5. Avoid vehicle kilometres for commuting, shopping and accessing services
6. Provide low-carbon solutions for the rural (non-urban) populations
7. Accelerate action on adaptation in the transport sector
8. Large scale deployment of economic instruments and leveraging finance

Each of these components is covered in detail under individual reports, available separately as Theme Reports. The India Roadmap provides summaries of each component and actionable recommendations for short-term (2020-22), medium-term (2022-30) and long-term (2030-50). For detailed narrative of each component, the reader may refer to the individual theme reports of the respective component. For getting an overview of all components, the India Roadmap provides the complete context for low carbon and sustainable mobility for India.

This report covers the second component on "Low-carbon Energy Supply Strategy".

The work on the India Roadmap has been guided by the FICCI Core Group on Sustainable Mobility consisting of eight working groups, each of which has worked on the eight components. The components are based on the Global Macro-Roadmap developed by PPMC. This methodological approach developed by PPMC is at the heart of the India Roadmap, with components of the India Roadmap being customised to Indian context and circumstances.

INTRODUCTION

"Climate emergency" is the 2019 Oxford Word of the Year. Global warming is closely connected to the phenomenon and is grabbing a lot of limelight in conversations around the world. By definition, global warming is the long-term rise in the average temperature of the earth's climate system. It is a major aspect of current climate change, and has been seen in direct temperature measurements and by measurements of various effects of the warming. The term commonly refers to the mainly human-caused increase in global surface temperatures and its projected continuation. Indeed, there were prehistoric periods of global warming, but the quantum of changes observed since the mid-20th century has been much greater than those seen in previous records, covering decades to thousands of years.

In 2013, 97% authors of 4014 research papers were unanimous that humans are the cause of global warming. The largest human influence has been the emission of GHGs (greenhouse gases) such as carbon dioxide, methane, and nitrous oxide. The main human activity that emits CO_2, is the combustion of fossil fuels such as coal, natural gas and oil, for energy and transportation. Most of the GHG emission from transportation is CO_2 resulting from the combustion of petroleum-based products. Relatively small amounts of methane (CH_4) and nitrogen oxide (N_2O) are emitted during fuel consumption. A small amount of hydrofluorocarbon (HFC) emission is also attributed to transportation.

The breakup of CO_2 emission in India is as under:

1. Energy and Transportation 68.7%
2. Agriculture 19.6%
3. Industrial processes 6%
4. Land-use change and forestry 3.8%
5. Waste 1.9%

CO_2 is continuously being exchanged in the atmosphere, ocean and land surface as it is produced and absorbed by many microorganisms, plants and animals. Emission and removal of CO_2 by these natural processes tend to balance out absent anthropogenic impacts.

The effects of global warming include rising sea levels, regional changes in precipitation, more frequent extreme weather events such as heatwaves, and expansion of deserts. Surface temperature increases are greatest in the Arctic, which has contributed to the retreat of glaciers, permafrost, and sea ice. Overall, higher temperatures bring more rain and snowfall, but for some regions, droughts and wildfires increase instead. Climate change threatens to diminish crop yields, harming food security. Rising sea levels may flood coastal infrastructure and force the abandonment of many coastal cities. Environmental impact includes the extinction or relocation of many species as their ecosystems change, most immediately the environments of coral reefs, mountains, and the Arctic. Due to the persistence of CO_2 in the atmosphere and the inertia of the climate system, climatic changes and their effects will continue for millennia even if carbon emissions are stopped. Possible societal responses to global warming include mitigation by reduction in emissions, adaptation to its effects, and maybe climate engineering. Countries work together on climate change under the umbrella of the United Nations Framework Convention on Climate Change (UNFCCC), which has near-universal membership. The ultimate goal of the convention is to "prevent dangerous anthropogenic interference with the climate system." Parties to the UNFCCC have agreed that deep cuts in emissions are required and global warming should be limited to well below 2°C (3.6°F) as per the Paris Agreement. Yet the Earth's average surface temperature has already increased by about half this threshold, and current pledges by countries to cut emissions are inadequate to limit future warming.

The report aims to analyse the present gaps and challenges that prevent the transition to a renewable based energy supply for sustainable low carbon transport in India and propose practical recommendations, including short-term and long-term, necessitating the need of standardisation and laying standards that could aid the development of renewable sources of energy and their deployment in the Indian transport sector.

SECTION 1

ENERGY FOR TRANSPORT

The transport sector at the global level continues to grow unabated, with several experts forecasting a potential doubling of transport activity by 2050, which gives a BAU (Business as Usual) emission scenario of 12-13 GtCO2e per year by 2050 (as per GMR). Yet, there are ways to address this and resolve the scenario one step at a time.

CHAPTER 1

HEART OF THE PROBLEM

Getting to the root of the problem is the first step to solving it.

The transport sector accounts for nearly 18% of the total energy consumed in India. Nearly 98% of the energy needs of transportation are met through petroleum products and almost half of the total consumption of petroleum products in India occurs on account of transport activities.

India's total GHG emissions in 2014 were 32.02 billion metric tonnes of CO_2 ($BtCO_2$) totalling 6.55 % of Global GHG emission. In 2018, India contributed 7% of the CO_2 emissions out of 37.1 Bt CO_2 in the world.

However, India is the 3rd largest producer of CO_2 in the world and it is growing faster than any other major energy-consuming nation.

In 2018, the GHG emissions increased by 4.8 % from the preceding year.

The per capita CO_2 in India is only 40% of the global average.

As per a study by the Ministry of Environment, Forest and Climate Change (MoEFCC), Government of India, the energy sector is the largest CO_2 emitter, as most of the electricity is generated from coal in India. The range of CO_2 generated/unit of electricity is 0.82 to 1.0 kg/kWh. CO_2 emission depends upon the carbon content of the coal and the coal usage (plant efficiency). The transport sector is the second largest contributor to CO_2 of which road transport contributes 87% of total CO_2 equivalent. By 2030, road transport is expected to contribute 850-900 MT of CO_2 if BAU continues. These huge numbers add up to a large impending problem in the energy utilised for transport. And the future of this sector depends on how we respond to it today.

CHAPTER 2

IN RESPONSE

The early response often determines the ultimate solution

ALONG *THE ROAD*



In November 2017, the Paris Process on Mobility and Climate (PPMC) issued a GLOBAL MACRO ROADMAP (GMR) outlining an actionable vision towards decarbonised, resilient transport, implementing the Paris Agreement on climate change in the transport sector. This was in support of a net zero-emission, climate-resilient economy by 2050 or shortly thereafter.

According to the GMR, at present, the sector as a whole (mobility of people and transportation of goods) accounts for about 7.7 Gt of CO_2 emissions, with 23% CO_2 emissions from the burning of fossil fuels and 14% from anthropogenic GHG emissions, making it one of the largest sources of CO_2 emissions. Road and rail transport represent the bulk of transport emissions.

The GMR envisaged both short as well as mid to long-term actions, and stipulated a three-pronged low carbon energy for transport strategy including:

a) Decarbonising power generation

b) Developing a clean hydrogen industry

c) Ensuring a sustainable bio or synthetic fuel supply with improved energy efficiency as a key part of the transport sector transportation

CROSSROADS *OF CHANGE*



A total of 195 countries negotiated and adopted the Paris Agreement that includes the objectives to peak greenhouse gas emissions as soon as possible. This is with an aim to limit the global average temperature increase above the pre-industrial level to well below 2^0C and to pursue to limit the increase to 1.5^0C.
The PA, which entered into force on 4 November 2016 requires parties to put forward their best efforts through Nationally Determined Contributions (NDCs). India's first NDC inter-alia includes:
a) Reduce the emissions intensity of GDP (gross domestic product) by: 30-35% from 2005 levels by 2030.
b) Achieve about 40% of cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030, with the help of the transfer of technology and low-cost international finance, including from Green Climate Fund (GCF)
c) Better adaptation to climate change by enhancing investment in development programmes in sectors vulnerable to climate change, particularly agriculture, water resources, health and disaster management, and regions, such as the Himalayan region and coastal regions.

India has already been progressing slowly but steadily on the path of reducing the emission of CO_2 and other GHGs. There has always been a considerable amount of emphasis on RE (renewable energy). The current installed power generation and energy capacities and the way forward are:

Table 1: Cumulative installed capacity as on 31-01-2019[1]

Sector	Figures in MW	Proportion in %
Hydro*	45399	13.0
Coal+ Lignite	197452	56.5
Gas	25575	7.3
Nuclear	6780	1.9
RES	74081	21.2
Total	**349287**	

Table 2: Installed generation for 2018-19 as on 31-12-2018

Sector	Figures in MWh	Proportion in %
Thermal **(Coal+ Lignite+Gas)**	805433	76.9
Nuclear	28457	2.7
Hydro	111719	10.7
Bhutan Import	4322	0.4
RES	97923	9.3
Total	**1047854**	

Though the installed capacity of thermal sources such as Coal, Lignite and Gas, is about 64% of the total installed capacity, the generation from these sources is around 77% of the total. The share of RES (renewable energy resources) is 21% of the total installed capacity, but its share in the total energy generation mix is only 9% (excluding share of hydro). This is due to the intermittency of RES and lack of storage options, which limits the plant utilisation.

ALONG *THE ROAD*



In the Union Budget of 2015, the Government of India set the target of achieving 175 GW through RES by 2022, comprising:

- 60 GW from wind
- 100 GW from solar
- 10 GW from biomass
- 5 GW from small hydro.
- Of 100 GW solar, 40 GW is estimated to be from roof top solar while the remaining 60 GW to be from ground-mounted, grid-connected medium and large solar projects.

The estimated RE potential versus RE target is depicted:

Table 3: RE capacity: Potential Versus Target 2022

Sector	Potential (GW)	Target by 2022 (GW)	Apportionment (%)
Solar	750	100	13
Roof Top		40	
Ground-mounted		60	
Wind	750	60	8
Small/ Mini Hydro	21	5	24
Biomass Energy	25	10	40
Total	**1546**	**175**	**11**

[1] MNRE physical progress report 2019

Table 4: Progressive Installed RE Capacity Targets (GW) Sector-wise[2]

Year	Roof Top Solar	Ground-Mounted Solar	Total Solar	Wind	Small Hydro	Biomass	Total
2014-15 Cumulative capacities		3	3	24	4.1	4.4	35.5
2015-16	0.2	1.8	2	3.2	0.14	0	5.3
2016-17	4.8	7.2	12	3.6	0.14	0.9	16.6
2017-18	5	10	15	4.1	0.14	0.9	20.1
2018-19	6	10	16	4.7	0.14	0.9	21.7
2019-20	7	10	17	5.4	0.14	0.9	23.4
2020-21	8	9.5	17.5	6.1	0.14	0.9	24.6
2021-22	9	8.5	17.5	8.9	0.14	0.9	27.4
Total (GW)	**40**	**60**	**100**	**60**	**5.08**	**9.8**	**174.9**

If the target of 175 GW by 2022 is achieved, it would contribute to 11% of the total RE potential of 1546 GW. The grid-scale battery energy storage technologies have started gaining popularity globally as their cost of installation is falling over the years. Since roof-top space is limited, it is imperative that this space is occupied only by high efficiency (KW/sqm) solar panels. It is expected that battery energy storage technologies would become financially viable and complement RE as a prominent generation source in the coming years. Central Electricity Authority of India (CEA) has projected an estimated storage need of around 34 GW (136 GWh[3]) by 2030.

The estimated installed capacity and generation mix of fossil & non-fossil fuel by 2029-30 is:

Table 5: Estimated installed capacity mix of fossil & non-fossil fuel by 2029-30

Fuel Type	Capacity (MW) in 2029-30	Percentage Mix (%)
Coal + Lignite	266827	32.1%
Gas	24350	2.9%
Sub Total Fossil Fuel	291177	35.0%
Hydro*	73445	8.8%
Nuclear	16880	2.0%
Solar	300000	36.1%
Wind	140000	16.8%
Biomass	10000	1.2%
Sub Total Non-Fossil Fuel	540325	65.0%
Total (MW)	**831502**	

Table 6: Estimated Gross Generation (BU) in 2029-30[4]

Fuel type	BU	% Proportion
Hydro*	197	8
Coal+ Lignite + Gas	1297	52
Nuclear	101	4
Solar and Wind	887	35
Biomass	26	1
Total	**2508**	

Thus by 2029-30, non-fossil fuel-based installed capacity is likely to be about 65% of the total installed capacity. Non-fossil fuel would contribute around 48% (including hydro) of the gross electricity generation in the year 2029-30.

[2] Source: Report - NITI Aayog, 2015, For Grid connected RE only
[3] Perspective transmission plan 2016 – 36, CEA
[4] It was observed that the RE generation falls in the range of 0% (on minimum RE generation day) to 17 % (max. RE generation day)

CHAPTER 3

CHALLENGES ALONG THE WAY

A challenge is only as big as the imagination.

Compared to 2018-19, the installed capacity and energy will increase from 349 GW to 841 GW and 1048 BU to 2508 BU respectively by 2030. Wheeling of this energy will necessitate significant upgradation of trasmission and distribution network.

The percentage of non-fossil fuel in installed capacity will increase from 36.15 % in January 2019 to 65 % by March 2030. As per INDC target, the percentage of non-fossil fuel in installed capacity is 40%. Thus, INDC targets are likely to be exceeded by a significant margin.

Table 7: Likely Annual CO_2 emission

	Year 2022 (as per NEP[5])	Year 2029-30
CO_2 Emission in Million Tonnes	**1026**	**1154**

The International Energy Agency (IEA) predicts that decarbonised power production (20g CO_2/kWh) will be possible by 2050 in the OECD countries. Developing countries are likely to take longer (2070).

To get the impetus, countries that are currently above 400-600 g CO_2/ kWh (India- 800-1000g CO_2/kWh) will need to embrace a shift in the primary energy mix without delay and prioritise renewable sources (solar & wind) of energy.

CHAPTER 4

ROUTES TO CHANGE

The faster the change is embraced, the better

Decarbonising power production would need:

a) Supporting renewable energy through better storage (batteries, supercapacitors and H2) and by SMART grids to optimise energy needs and flows. Development of e-mobility with matching interoperable charging infrastructure.

b) Closer alignment of energy and transport sector for developing a joint pathway for the production of renewable sources of energy and their deployment in transport.

As is evident, climate change related to the transport sector requires short, medium-term and long-term solutions. Renewable energy will play a significant role in implementing this change. The energy, transport and infrastructure sectors will need to work in tandem to develop a sustainable pathway for the production of renewable sources of energy, which will give a facelift to the transport sector as we know it today.

[5] National Energy Policy

SECTION 2

OIL & GAS

To reduce dependence on oil and make meaningful efforts to decarbonise the transport sector, renewable fuels provide a plausible solution with minimal changes to vehicle stocks and distribution infrastructure. The Government of India has prepared a road map that envisages a strategic role for biofuels in the Indian energy basket to reduce the import dependency in the oil & gas sector. The Government envisions the scope for the higher production of biofuels. It believes that higher production of biofuels will increasingly substitute fossil fuels while making a significant contribution towards the national energy security, climate change mitigation, besides creating new employment opportunities in a sustainable way.

Prioritisation of Renewable Energy is Key to the Low-Carbon Supply Strategy.

CHAPTER 1

HEART OF THE PROBLEM

A problem is as challenging as its solution

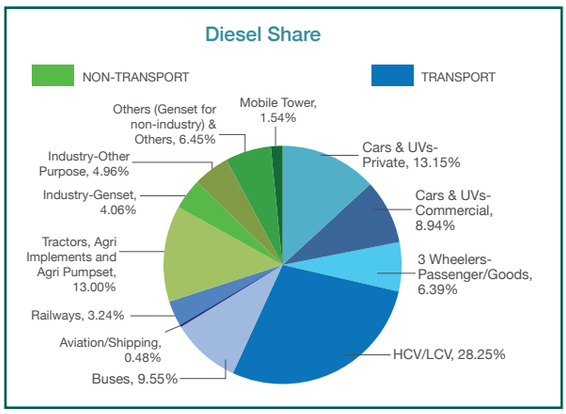
According to BP, the total energy consumption in India during 2017 using conventional sources such as Oil, Coal and Natural Gas was 692 MMtOE. This is expected to rise to 1018 MMtOE by 2020 and 1440 MMtOE by 2030 according to India Energy Outlook of IEA. As per the India Energy Outlook of IEA, this is expected to rise to 1018 MMtOE by 2020 and 1440 MMtOE by 2030.

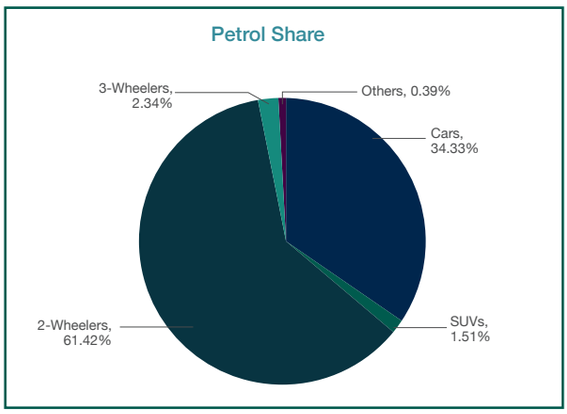
India's dependency on fossil fuels for its energy needs has two major concerns: a growing import bill (India imports 80% of crude oil for 40% of its energy requirements) and carbon emissions.

The road transport sector accounts for 6.7% of India's GDP. Currently, diesel alone meets an estimated 72% of transportation fuel demand followed by 23% petrol and balance by other fuels such as CNG (compressed natural gas), LPG (liquefied petroleum gas) and others. Consider this: crude oil required for internal consumption of petroleum products in FY 2017-18 was about 210 MMT.

India's transport sector is a major energy consumer, accounting for more than half of the country's total petroleum consumption and 18% of its total energy. It also accounts for about 13% of the carbon emissions from the energy sector.

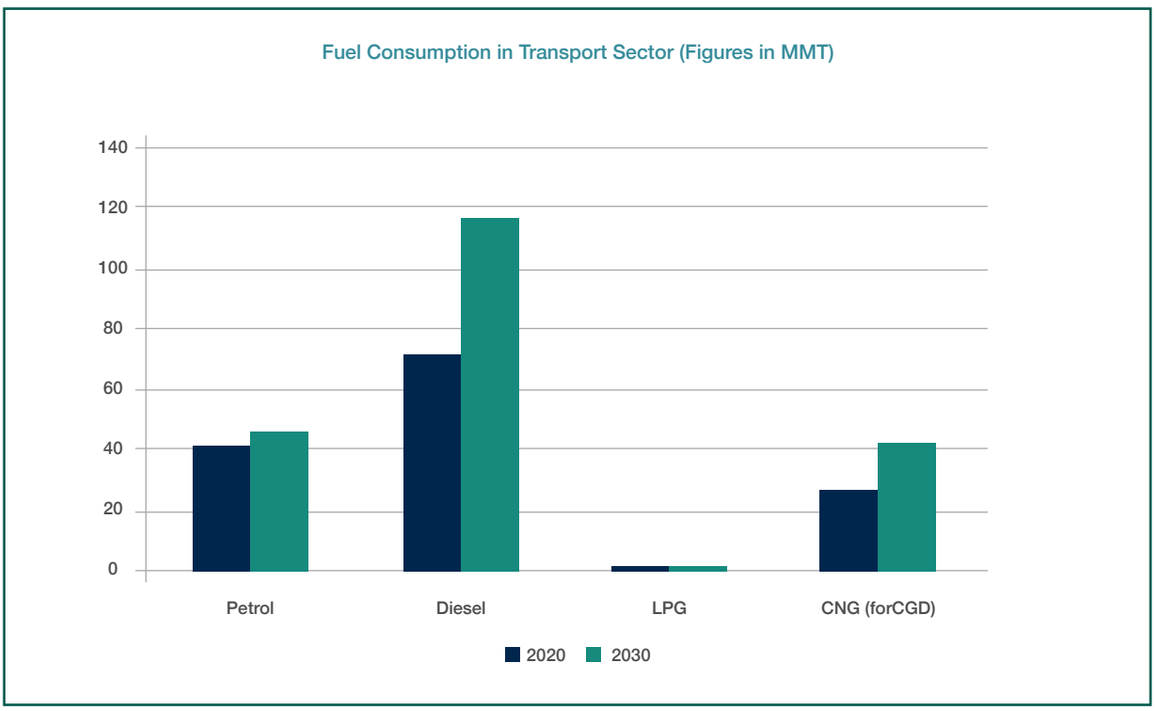
All India end-use share of diesel and petrol in retail across various sectors according to Petroleum Planning & Analysis Cell (PPAC) is provided in the charts below.





In 2018-19, the total diesel consumption was 83.5 MMT and petrol Consumption was 28.3 MMT. Out of this, 99.61% of petrol and 70% of diesel had been consumed in transport. About 262 MMT of CO_2 emissions were generated by diesel and about 87.5 MT of CO_2 emissions by petrol.

As per the BAU scenario, the energy from conventional sources (Coal, Oil, and Gas) will attribute to 78% (48% Coal, 23% Oil, 7% Gas) by 2030, with an increase of 41% from 2017 to 2030. The transport fuel demand growth, combining PPAC, Petroleum and Natural Gas Regulatory Board (PNGRB) and internal projections is estimated to grow at a CAGR (Compounded Annual Growth Rate) of 4.4% in passenger transport and 6.8% in freight transport respectively from 2015 to 2040. The contribution of natural gas in the transport sector is expected at 20%.



CHAPTER 2

IN RESPONSE

The response determines the course of action.

ALONG *THE ROAD*



Various notifications specifying mass emission standards for Compressed Natural Gas, Biodiesel (B-100), Flex fuel (E 85) or (E100) and Ethanol (ED 95), LNG and Flex fuel Methanol M15 or M100, Methanol MD 95, A20 (blend of 15% methanol and 5% ethanol) and duel fuel vehicles have been issued by the Government of India.

The Government of India has also prepared a roadmap that envisages a strategic role for biofuels in the Indian energy basket to reduce import dependence on oil & gas sector by adopting a four-pronged strategy:

(i) Increasing Domestic Production,
(ii) Adopting Biofuels & Renewables,
(iii) Implementing Energy Efficiency Norms, and
(iv) Improving Refinery Processes and Demand Substitution.

The roadmap envisages a strategic role for biofuels in the Indian energy basket. The Government has already announced policies that have set the broader framework and provided the initial thrust required for the development of the sector.

MoP&NG forecast for Petroleum Products demand, for planning Refinery capacity, by 2030 & 2040 is as under:

S.No.	Item	Requirement in MT	
		2040	2030
1	Diesel	240	163
2	Petrol	83	49
3	LPG	41	34

National Policy on Biofuels 2018

Thrust Areas: Increase in domestic production, setting up Second Generation (2G) biorefineries, development of new feedstock & technologies

New Feedstock: B-Molasses, Sugarcane Juice, Agriculture Residues, Sugar & Starch Crops, Damaged Food Grains etc. for Ethanol

Non-edible Oilseeds, Used Cooking Oil (UCO), Animal Tallow, Acid Oil, Algal Feedstock etc. for Biodiesel

Biomass, MSW, Industrial Waste, Plastic Waste etc. for Advanced Biofuels

Biomass Potential: Biomass surplus availability: 120-160 MMT

Bioethanol potential: 30,000 Million Litre

Indicative blending target by 2030: Ethanol in Petrol : 20%, Biodiesel in Diesel : 5%

Ethanol Blending Programme (EBP): The Ethanol Blending Programme (EBP) was announced by the Government of India on 4 September 2002. Initially, the blending was permitted up to 5% of Ethanol in petrol, which was later revised to up to 10% blending on 2 February 2013.

Biodiesel: Policy initiatives have been undertaken by Government of India to increase biodiesel blending. In 2003, a National Biodiesel Mission (NBM) was formulated with a goal of 20% biodiesel blends by 2011-2012. In December 2009, in order to strengthen and formalise the country's commitment to promoting a sustainable biofuels industry, India adopted the National Policy on Biofuels. The policy encouraged the use of renewable fuels and proposed a 20% biofuel (ethanol and biodiesel) mandate by the end of 2017.

Compressed Biogas under SATAT scheme: Ministry of Petroleum & Natural Gas has launched the 'SATAT' (Sustainable Alternative Towards Affordable Transportation) scheme for CBG (Bio-CNG) on 1.10.2018. It envisages targetting production of 25% of available CBG potential in the country i.e. 15 MMT by 2023, from 5000 plants. 15 MT of CBG corresponds to over 1/3rd of present natural gas consumption of 44 MMT. Thus, production of CBG from biomass/waste resources can substitute the import of LNG in the country.

Pradhan Mantri JI-VAN (Jaiv Indhan-Vatavaran Anukool Fasal Awashesh Nivaran) Yojana' provides financial support to integrated bioethanol projects using lignocellulosic biomass and other renewable feedstock. The JI-VAN Yojana will be supported with total financial outlay of INR 19.695 billion from 2018-19 to 2023-24. Out of the scheme fund of INR 19.695 billion, INR 18 billion has been allocated for supporting 12 commercial projects, INR 1.5 billion has been allocated for supporting 10 demonstration projects and remaining INR 0.95 billion will be provided to Centre for High Technology (CHT) as administrative charges.

The Government is extending soft loans of INR61.39 billion through banks to the sugar mills for setting up new distilleries and installation of incineration boilers to augment ethanol production capacity. The government will bear interest subvention of INR 13.32 billion for this. Further, government has planned to create a buffer stock of 3 million MT to be maintained by sugar mills for which the government would reimburse carrying cost in terms of interest, insurance & storage charges towards the maintenance of buffer stock.

'Galvanising Organic Bio-Agro Resources Dhan (GOBAR-DHAN)' scheme: To convert cattle dung and solid waste in farms to CBG and compost. GOBAR-DHAN scheme proposes to cover 700 projects across the country in 2018-19. The programme will be funded under Solid and Liquid Waste Management (SLWM) component of Swachh Bharat Mission-Gramin (SBM-G) following the suggested guidelines of SBM-G.

The total assistance under SBM-G for SLWM projects is on the basis of total households in each Gram Panchayat (GP), subject to a maximum of INR 0.7 million for a GP having up to 150 households, INR 1.2 million up to 300 households, INR 1.5 million up to 500 households and INR 2 million for GPs with more than 500 households. Only those Gram Panchayats that have not availed SLWM funds under SBM-G are eligible to receive the financial assistance under GOBAR-DHAN scheme.

Ministry of New and Renewable Energy has notified Central Financial Assistance (CFA) of INR 0.04 billion per 4800 kg of CBG per day generated from 12000 m3 of biogas per day, with a maximum of INR 0.1 billion per project. The CBG generation shall be based on biogas generated from urban waste/agricultural waste/industrial wastes/effluents or a mix of these wastes. In case the developer wants to set up CBG generating unit at already existing biogas generation unit, applicable CFA will be INR 0.03 billion. As per the policy, INR 0.01 billion CFA has also been provided per 12000 m3 biogas/day for biogas generation from urban waste/agricultural waste/industrial wastes/effluents or a mix of these wastes (distillery effluent is excluded).

Blending of various fuels by Indian Oil:

Year (April-March)	Percentage of ethanol blended in Petrol	Percentage of biodiesel blended in Diesel
2015-16	3.46%	0.01%
2016-17	3.54%	0.04%
2017-18	2.80%	0.05%
2018-19	5.25%	0.08%

CHAPTER 3

CHALLENGES ALONG THE WAY

Every challenge makes way for progress.

1. Renewable Fuels: There is a pressing need for renewable fuel in India, and a range of critical factors affect the Renewable Fuels Supply Chain. It is crucial to understand them before they can be addressed.

a. **Bioethanol:** 1G and 2G: As per the current production, even after using additional sugarcane juice or the B-molasses pathway, it will not be possible to achieve the targeted 20% ethanol blending envisaged under National Biofuels Policy-2018. There is a pressing need for alternate feedstock. Import of biofuels is not allowed under National Policy on Biofuels 2018. Even in countries like the US and Canada Ethanol blending is 10%. There is a pressing need for alternate feedstock. Additionally, import of biofuels is not allowed under National Policy on Biofuels 2018. Blending of 10% ethanol would require Bio-Ethanol of 6,533 million litres by (2030).

b. **Biodiesel:** According to the Biodiesel Association of India, the installed production capacity of biodiesel in the country is ~1.2 MMT. Currently, at around 0.3 MMT, Indian domestic production is insufficient to meet the palm oil demand in the country, leading to India's dependence on imports of palm oil from Indonesia and Malaysia. The biodiesel blending percentage achieved so far has been extremely insignificant (<0.03%).

To achieve the target of 10% blending of Biodiesel, 6.3 million tonnes of Biodiesel would be required by 2030.

The figures are likely to be lower with (a) Bio-CNG displacing MS (b) EV's with Batteries and Direct Alcohol Fuel Cells displacing ICE's (c) Public Transport and Shared Mobility reducing Personal Vehicles use.

c. **Used Cooking Oil:** Used Cooking Oil (UCO) which is waste or spent cooking oil collected from commercial food factories, restaurants, schools' canteens, bakeries, etc. is a potent feedstock for increasing biodiesel production due to its triglyceride and free fatty acid content. The potential of Biodiesel from UCO in India is estimated as 3 MMTPA. However, the collection and supply of UCO remains a big challenge.

2. Framing of Standards will Set the Right Precedent

a. **Compressed Biogas (CBG):** Automotive grade CBG shall meet IS 16087:2016 specifications of BIS and further revisions in the said specifications.

IS 16087 : 2016 Standard		
S No.	**Characteristic**	**Requirement**
1	Methane percentage (CH_4), minimum	90.0 %
2	Only Carbon Dioxide percentage (CO_2), maximum	4%
3	Carbon Dioxide (CO_2)+ Nitrogen (N_2)+ Oxygen (O_2) percentage maximum	10%
4	Oxygen (O_2) percentage maximum	0.5%
5	Total sulphur (including H_2S) mg/m^3, maximum	20 mg/m3
6	Moisture mg/m^3, maximum	5 mg/m^3

b. **Ethanol:** IS 15464: Anhydrous Ethanol for Use in Automotive Fuel

c. **Biodiesel:** For Biodiesel, Biodiesel (B100) - Fatty Acid Methyl Esters (Fame) Specifications are used. While pure (100%) Biodiesel is referred as B100, a 20% blend of Biodiesel with regular diesel is referred as B20, and so on. The Bureau of Indian Standards (BIS) has developed standards for standalone Biodiesel (B100), B5 and biodiesel blends from B6 to B 20.

3. Government support will be vital

a. **Compressed Biogas:** There will be a need for assured supply of segregated waste and biomass at a long term steady price to ensure plant viability and bankability. CBG will need to be included in the priority sector lending with interest subvention scheme and in the 'White Category' for Pollution Clearance.

b. **Bio-manure from CBG Plants:** To ease production and propagation of bio-manure, specifications in The Fertiliser Control Order 1985 (as amended up to January 2018), may be introduced for Bio-Manure from CBG plants in line with specifications for Bio-enriched organic manure and City Compost (where moisture content maximum 40% and NPK Nutrients - total N, P_2O_5 and K_2O nutrient should not be less than 1.2%). A mandate of 20% blending of bio-manure with chemical fertilizers will be needed

c. **Financing of CBG Plants:** The CBG Plants will require assistance from banking sector for financing. The All India Financial Institutions such as National Bank for Agriculture and Rural Development (NABARD), Small Industries Development Bank of India (SIDBI), PSEBs have to extend assistance to ensure success of the projects. CBG plants under the SATAT scheme may be included in Priority Sector Lending under Renewable Energy for ease of soft financing for such projects. State wise Nodal Officers may be nominated by lead Banks for facilitating loans on CBG Plants.

d. **Waste to Fuel:** Segregated waste will need to be delivered free of cost, land given on nominal lease, and Municipal Corporation will need to participate in the waste supply chain.

CHAPTER 4

ROUTES TO CHANGE

Change is moving ahead, one step at a time.

In Oil and Gas, a line-up of solutions is proposed to bring about impending change:

1. Renewable Fuels will be at the Centre of Change

In order to reduce dependence on oil and contribute to the growing efforts to decarbonise the transport sector, renewable fuels provide a way of shifting to low-carbon, non-petroleum fuels, often with minimal changes to vehicle stocks and distribution infrastructure.

Renewable fuels are fuels produced from renewable resources. Examples include: Biofuels (e.g. Bioethanol, Biodiesel, Biogas, Biomethanol etc.) and Biohydrogen. Renewable fuels can also include fuels that are synthesised from renewable energy sources, such as wind and solar.

Classification of Biofuels			
Generation	**Feedstock**	**Technology**	**Example**
First Generation (1G) Biofuel	Sugar, starch, vegetable oils, or animal fat	• Cold / hot pressing, extraction & Transesterification • Cold / hot pressing, extraction, and purification • Hydrolysis and fermentation	Bioethanol, vegetable oil, bio-diesel, biogas
Second Generation (2G) Biofuel	Non-food crops, rice/ wheat straw, corn, wood, solid waste, energy crop	• Hydrolysis & fermentation • Pyrolysis, gasification, methanation • Pyrolysis, gasification, water gas shift reaction (WGSR)	Cellulosic bioethanol, bio SNG, synthetic biofuels and bio-hydrogen
Third Generation (3G) Biofuel	Algae	• Transesterification • Fermentation	Vegetable oil, biodiesel

The vision for renewable or alternative fuels in the country is to utilise, develop and promote domestic feedstock, and its utilisation for producing biofuels. This will help in increasingly substituting fossil fuels while contributing to national energy security, climate change mitigation, besides creating new employment opportunities in a sustainable way.

a. Bioethanol: 1G and 2G

Bioethanol is an alcohol (CH3CH2OH) made by fermentation, mostly from carbohydrates produced in sugar or starch crops, such as corn or sugarcane (1st generation) or from cellulosic biomass, derived from non-food sources, such as crops, plants and grasses (2nd generation).

Ethanol can be combined with petrol in any concentration up to pure ethanol (E100). Anhydrous ethanol, that is, ethanol without water, can be blended with petrol in varying quantities to reduce the consumption of petroleum fuels, as well as to reduce air pollution.

2G ethanol, one of the potential alternative solutions, refers to the ethanol produced from lignocellulosic material. The feedstock includes agri-residues like rice & wheat straw, sugarcane bagasse, corn cobs and stover, cotton stalk etc. which are inedible.

As per an estimate, surplus biomass availability in the country is in the range of 180 MMT per annum, which, if converted, has the potential to yield 50 million litres of ethanol annually.

b. Bio-methanol & Bio-dimethyl Ether (Bio-DME)

Methanol (CH_3OH) is the simplest member of a group of organic chemicals called alcohols. Also known as wood alcohol, it is generally produced by steam-reforming natural gas to create syngas (a mixture of H_2 and CO).

Dimethyl ether (DME) is the simplest ether, consisting of two methyl groups bonded to a central oxygen atom (CH3OCH3); also known as wood ether. The energy efficiency and power ratings of DME and diesel engines are virtually the same. DME does not have any carbon-to-carbon bonds – thus using it 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.

c. Plasma Gasification

Plasma gasification is an emerging technology that can process Municipal Solid Waste (MSW) and other wastes including hazardous ones to convert carbon-based materials into fuels.

Plasma gasification gets its name from the use of plasma torches to enhance gasification in addition to conventional furnace, as opposed to conventional fires and furnaces.

ALONG
THE ROAD



As per the report of the Task Force on Waste to Energy, constituted by erstwhile Planning Commission, **62 million tonne of MSW is annually generated in urban India.**

This may be utilised to produce about 9 billion litres of bioethanol, based on plasma gasification technology. As per PPAC, the total consumption of petrol in 2017-18 was 33 billion litres. Thus, bioethanol from MSW route can achieve 27% ethanol blending.

d. Compressed Biogas

Producing CBG from biomass/waste resources can substitute the import of crude and LNG in the country. Waste/biomass sources, agriculture residue, cattle dung, sugarcane press mud, municipal solid waste and sewage treatment plant waste, etc. produce biogas through anaerobic decomposition. This biogas can be purified to remove hydrogen sulphide (H_2S), carbon dioxide (CO_2), water vapour. Biogas can be used as a fuel for the production of electricity, cooking and transportation fuel and to produce CBG.

e. Biodiesel

Biodiesel is a renewable alternative fuel created from new and used vegetable oils, animal fats and greases through a chemical process called transesterification.

Biodiesel can be blended with petroleum diesel in any percentage, including B100 (pure biodiesel) and, the most common blend, B20 (a blend containing 20% biodiesel and 80% petroleum diesel). The blended diesel significantly reduces emissions and gases that contribute to global warming.

f. Biofuels from Algae

Algae are single-celled organisms having a photosynthetic ability to convert sunshine into chemical energy. For some species of algae, this chemical energy exists in the form of oils very similar to common vegetable oil. These oils can be processed and used to produce biodiesel.

g. Drop-in Fuels & Bio-crude

According to IEA, drop-in biofuels are defined as “liquid bio-hydrocarbons that are functionally and chemically similar to petroleum fuels and are fully compatible with existing petroleum infrastructure”.

Drop-in biofuels are liquid hydrocarbons that are functionally equivalent and as oxygen-free as petroleum derived transportation blend stocks (fuels).

2. Feedstock for Renewable Fuels will be Crucial

Feedstock and potential of ethanol and CBG production is available from a range of sources:

Source	Availability	Ethanol Potential	CBG Potential
		Mill. lts	MMT
Agriculture Residue	180 MMT	52	18
Press Mud	15 MMT		
Spent Wash	30 billion lt.		14
Bagasse	115 MMT		
Collectible Cattle Dung	700 MMT		41
Chicken Litter	25 MMT		
Forest Residue	220 MMT		22
Municipal Solid Waste	72 MMT		3
Total		52	98

Potential sources for the future could be specific energy crops grown in barren, waste and single cropland.

3. Government Support and Financing will give the Right Impetus

Government policies would be the major drivers for the growth of the biofuel industry. The variability in petroleum prices that impact the short-term demand and investment in biofuel projects, need for rural development, energy security, reduction in import dependence, environmental concerns would be major contours of the policy framework for biofuels.

THE CASE OF HYDROGEN

Hydrogen is considered an alternative fuel due to its ability to power fuel cells in zero-emission electric vehicles, its potential for domestic production, and the fuel cell's potential for high efficiency.

It is an energy carrier that can be used as a possible substitute for liquid and fossil fuels. Unlike conventional biofuels (bio-ethanol, biodiesel, biogas, etc.) and fossil fuels, hydrogen produces only water as the by-product of its combustion; and hence, is considered as one of the cleanest renewable energy carriers for future.

• Hydrogen fuelled automobiles use hydrogen on-board to generate motive power, either directly through internal combustion engine or indirectly, i.e. first to electrical energy through fuel cell then to motive power. Hydrogen can be used in different configurations of Internal Combustion (IC) engine, such as spark ignition (SI) engine, compression ignition (CI) engine / dual-fuel engine and CNG dual-fuel engine. Hydrogen can also be blended with CNG to make HCNG **(HCNG = CNG + H_2)**, which can be used as a fuel of the Internal Combustion Engine. HCNG is a cleaner source of fuel, more powerful and offers more mileage than CNG.

Presently, most of the hydrogen is produced from fossil fuels, which accounts for about 98% of its total production. Conventional physiochemical methods for H_2 production are based on steam reforming of natural gas (40 %); coal gasification (18%) and pyrolysis or gasification of biomass, which produces a mixture of gases (H_2, CH_4, CO_2, CO, and N_2). All these methods require high temperature (>850°C) and, therefore, are energy-intensive and expensive. In addition to the above, hydrogen is produced for non-energy application, e.g. in fertiliser industries and petroleum refineries.

In India, there are abundant sources of hydrogen in industries, which produce around 6600 tonnes of hydrogen (unutilised) from the Chlor-alkali industry alone, in 2016. Biological production of hydrogen is carried out using microorganisms in an aqueous environment at a particular temperature and pH. However, the yield of hydrogen production is low as compared to other conventional methods but there is reduced emission of GHGs by 50-70% using biological methods.

Hydrogen can also be produced by electrolysis of water. The most environment-friendly way to generate hydrogen would be via electrolysis with excess renewable energy. The current best processes, which have an efficiency of 50 - 80%, require 50 – 79 kWh electricity to produce 1 kg of hydrogen with a specific energy of 143 MJ/kg (Ministry of New and Renewable Energy 2016). At the cost of electricity as $0.08/kWh, hydrogen from electrolysis would cost $4.00/kg hydrogen, which is 3 to 10 times the price of hydrogen obtained from steam reforming of natural gas.

A variety of solid-state hydrogen storage materials like hydrides (MgH2, Mg2NiH4, NaAlH4, etc) can be used for hydrogenation and dehydrogenation reaction and storage of hydrogen. Hydrogen has the potential to replace LPG and CNG for cooking because it has superior characteristics to LPG and CNG fuel in terms of ignitability, it has a low ignition.

However, the biggest challenge in the hydrogen economy is the infrastructure.

Hydrogen storage needs special attention as hydrogen is the smallest molecule, lightest by density, has the lowest ignition energy and a wide range of explosion limits with air, leading to the embrittlement of materials of construction of hydrogen storage vessels and safety hazards. Currently, hydrogen is being stored in a compressed form, at 350 bars (5,000 psi) in onboard in demonstration vehicles and 700 bars (10,000 psi) in Type IV carbon composite cylinders. The cryogenic hydrogen can be stored in specially insulated vessels at (-) 252.88°C. The high pressures and special pipes needed to store hydrogen at ambient conditions make it difficult to transport and store. The cost of production of hydrogen is at the same level as that of its cost for distribution and storage (Dou, Sun, Ren, & Dong 2017)

The distribution cost is highest because special nickel pipelines are required to keep away from hydrogen embrittlement along with high-pressure compression costs.

The supply chain is not yet well established, especially in India where most of the material is sourced from abroad. Owing to this ecosystem, there is no commercially available fuel cell car in India yet. However, such cars by Toyota, Honda and Hyundai are available in countries like Japan, Germany and Korea.

Hydrogen unlocks many benefits and exciting future prospects

Hydrogen fuel cell-powered vehicles have a longer range and shorter refilling time. The fuel cells and hydrogen storage requires less space and weight (Thomas 2009). This is linked to the weight of the batteries and lifecycle greenhouse gas emissions needed to cover this extra range. At the same time, fuel cells can be combined with battery-powered EVs to extend their range.

CROSSROADS *OF CHANGE*



Today several EU nations and the USA are working towards Hydrogen Injection in the Gas Grid (HIGG), wherein Hydrogen up to 20% volume can be injected into the natural gas or CNG grid without any major changes (based on the country regulations). Hydrogen can be further removed using separation techniques eventually fueling fuel cell vehicles (Quarton & Samsatli 2018).

This would have significant cost reductions as compared to building a separate pipeline infrastructure for distributing hydrogen. Considering the fact that fossil fuels are not going to be removed as an energy source very soon, generating hydrogen via coal or natural gas and using Carbon Capture Utilization and Storage (CCUS) is another path being explored in various countries (NREL 2013).

Lastly, generating on-site hydrogen via electrolysis at locations that have lower electricity prices and excess renewable energy could be synergised with the hydrogen mix in natural gas grids. By 2030, solar and wind energy prices will drop down to 0.027-0.035 $/kWh in India, which indicates a strong possibility of using excess renewable energy to generate hydrogen at a competitive price (Pachauri, Spencer, & G. Renjith).

Stranded power generation from renewable energy is yet another source of generating hydrogen that would otherwise be wasted.

Sourcing hydrogen from renewable energy via electrolysis is not only a sustainable method but has two-fold benefits.

- It reduces the oil and gas imports of India.
- Hydrogen purity is the highest when electrolysis is used while methods involving fossil fuels need downstream treatments to reach the required purity levels of fuel cells (Kalamaras & Efstathiou 2013).

Now, there are several lessons to be learnt on the way to building a hydrogen economy.

CROSSROADS *OF CHANGE*



Japan's Hydrogen Economy: Japan's hydrogen economy has been resting solely on a focussed approach and a wide cooperation system among the government, industry, and research sectors for developing technology and promoting the popularisation of hydrogen technologies. They are on track to having 200,000 fuel cell vehicles by 2025.

Their roadmap to a hydrogen economy is divided into three phases:

Phase 1 (2015): Focus on the rapid popularisation of the hydrogen economy, while investing heavily in research and development while introducing commercially available fuel cell products in mobility and power generation.

Phase 2 (2025): Fully introduce hydrogen power generation, establish large-scale infrastructure for hydrogen supply (Dou, Sun, Ren, & Dong 2017). With the increment of hydrogen demand, promote the utilisation of hydrogen technology to the field of unused energy so that hydrogen with electricity and heat would become three main forms of secondary energy.

Phase 3 (2040): Establish totally CO_2-free hydrogen supply systems. Combination of Carbon Capture and Storage in hydrogen production and utilisation of renewable fuel, a CO_2-free hydrogen supply system can be realised in totality. Similar strategies can be applied in the Indian context.

ALONG THE ROAD



In 2004, the Ministry of New and Renewable Energy in the National Power Energy Roadmap projected that one million hydrogen-fuelled vehicles on road and 1000 MW aggregate hydrogen-based power generating capacity be set up in the country by 2020 through PPP. Though there has been an effort to encourage a hydrogen economy, the focus has probably been lost. However, recently, Tata Motors in association with Indian Oil Corporation has flagged off the trials of the first-ever hydrogen fuel cell power bus in 2018.

The way forward towards a hydrogen economy

Overall literature review and industry interviews suggest that there is no clear progress towards building a hydrogen infrastructure in India. There are sufficient sources of hydrogen available, but the infrastructure needs to be built to proliferate the hydrogen economy. Three main recommendations basis the time of their implementation are:

1) Short Term: Mixing of Hydrogen into the CNG grid at a low volume will enable transportation of hydrogen without needing to build separate nickel-coated pipelines, hence saving costs. Investing in research to bring down electrolysis costs could be another pragmatic step.

2) Medium-term: Proper pipelines dedicated solely to hydrogen need to be built, while the costs of doing so need to be brought down by economies of scale and investment in research.

3) Long Term: Focus on generating hydrogen on-site via electrolysis powered by renewable sources of energy. Solar and wind prices are expected to drop down exponentially by 2030, which indicates a good scope for use of this pathway.

This will not only help India reduce greenhouse emissions, but also cut down the oil and gas imports by using hydrogen as the energy carrier.

In India's NDCs, India aimed to reduce emission intensity of GDP by 33-35% from 2005 to 2030.

The interim report of the expert group on reducing emission intensity consists of a three-pronged strategy.

a) Avoid: Adopt a systems approach and reduce the need for transport through appropriate choices for locating industries and other business, and through better planning to minimise commuting needs. The concept is to grow vertically and provide residential–cum-commercial complexes to fulfil all needs in one building only and to cut down the need for travel. Though the TOD (Transit Oriented Development) policy of Ministry of urban development has been issued, it has been a non-starter so far.

b) Shift: Focus on using more carbon-efficient modes of transport (priority to Rail, Metro, LRT, Buses, taxis etc)

	Mode of Transport	Emission (gCO_2eq/ km/Passenger)
1.	Passenger Car	82
2.	Taxi	73
3.	Auto Rickshaw	50
4.	Metro rail	27

Thus, the city should provide the most mobile corridor for a more energy-efficient system of transport like metro, public transport, electric buses etc. There should be holistic planning at the city level.

c) Improve: Emphasise on use of the most carbon-efficient technologies for any mode of transport. (Hydro fuel and EVs)
For improving the fuel efficiency of the vehicle fleet, it is recommended to:

a) Introduce vehicle labelling/ratings systems

b) Introduce minimum efficiency standards

c) Introduce corporate fleet efficiency standards

The Government policies would provide a prime impetus for growing the biofuel industry. Shifting petroleum prices impact the short-term demand and investment in biofuel projects, need for rural development, energy security, reduction in import dependence, environmental concerns would be major contours of the policy framework for biofuels.

The production of biofuels will substitute fossil fuels increasingly, while creating new vistas for national employment and catalysing climate change mitigation.

SECTION 3

ENERGY FOR ELECTRIC VEHICLES

Electric vehicles or EVs are thrice as energy efficient as compared to the ICE vehicles. Introducing 30% EVs by 2030 itself will reduce the Petrol and Diesel requirement and hence, reduce the carbon emissions as well as the import bill. Therefore, irrespective of the fact whether the EV power is drawn from the RES or not, the introduction of EV is desirable. However, many challenges presently exist in the path to mass-scale adoption of EVs.

CHAPTER 1

HEART OF THE PROBLEM

The only way out of a problem is to solve it.

Charging infrastructure is a critical component of the emerging EV ecosystem. Internal Combustion Engine (ICE) vehicles are equipped with fuel storage tanks that accommodate sufficient fuel for long journeys. EVs store electrical energy in the form of chemical energy through on-board batteries, which is then converted back to electrical energy for use in vehicle.

Presently, since battery accounts for almost half the vehicle cost, large capacity batteries EVs will require a huge upfront capital cost. It is therefore important to develop an appropriate charging network to enable the deployment of all types of EVs. It is vital to discuss the EV population under various timelines and penetration scenarios along with various challenges and potential solutions. This includes details of different type of Electric Vehicle Supply Equipment (EVSE), including slow charging, fast charging and battery swapping. Linear projections based on vehicle registration data from the Ministry of Road Transport and Highways (MoRTH), Government of India combined with EV penetration targets from NITI Aayog have yielded critical numbers. Considering only passenger road transport vehicles, the figures are:

EV penetration estimation by 2030 and 2050

Category used by MoRTH (VAHAN Dashboard)	Vehicle registration penetration by 2030 (NITI Aayog-RMI)	On-road EVs at 2030 (in millions)[6]	Vehicle registration penetration by 2050 (estimated)	On-road EVs at 2050 (in millions)[7]
Motor Car	30%	7	100%	66
Motor Cab	70%	1.1	100%	5.8
Bus	40%	0.17	100%	1.21
M-Cycle/Scooter	80%	110	100%	516
Three Wheeler (Passenger)	80%	2.6	100%	11.9

[6] Includes all vehicles registered between 2020 to 2030 (11 years)
[7] Includes all vehicles registered between 2036 to 2050 (15 years)

As per the Motor Vehicles Act, 1988, these categories are defined as:

- "Motor car" means any motor vehicle other than a transport vehicle, omnibus, road-roller, tractor, motorcycle or an invalid carriage
- "Motor cab" means any motor vehicle constructed or adapted to carry not more than six passengers, excluding the driver for hire or reward
- "Motorcycle" means a two-wheeled motor vehicle, inclusive of any detachable side-car having an extra wheel, attached to the motor vehicle. It does not include mopeds/other low powered 2W categories
- "Bus" does not include the omnibus category, and does not distinguish between public (held by SRTU/STUs) and private buses
- "Three Wheeler (Passenger)" class is not defined in the MVA 1988.

The corresponding energy requirements for the projected electric vehicles are:

Estimated energy requirements for the projected vehicles

Category used by NITI	2030 (vehicle numbers)	2050 (vehicle numbers)	Annual km driven	Mileage (kWhr / km)	GWhr (2030)	% Proportion	GWhr (2050)	% Proportion
Motor cars	7000000	66000000	9498	0.225	14959	21%	141038	32%
Motor Cab	1100000	5800000	75000	0.225	18563	26%	97875	22%
Buses	170000	1210000	48589	1.100	9086	13%	64672	15%
2W	110000000	516000000	7281	0.030	24028	34%	112714	26%
3W	2600000	11900000	34400	0.050	4472	6%	20468	5%
TOTAL					**71107**		**436766**	

The estimated energy requirement of EVs (71.11 BU) by 2030 would be 6% of the total energy estimated to be produced by 2030.

Barring a few exceptions at any place or time, due to intermittency associated with RE, 6% of energy requirement is not likely to pose any major problems. The local aberrations, like local distribution grid congestion, are to be dealt on a case-by-case basis basis. Even 6% demand is unlikely to be there as by then, technology may leapfrog and more energy efficient vehicles may be developed. Hydrogen and fuel cell-based vehicles may be introduced, while the travel requirement may come down, if public transport and Time of Day (ToD) tariff are introduced. EVs are thrice as energy efficient as compared to ICE vehicles. Introducing 30% EVs by 2030 itself will reduce the petrol and diesel requirement and consequently, carbon emissions as well as the import bill. Therefore, irrespective of the fact whether the EV energy is drawn from the RES or not, the introduction of EV is desirable.

It is important to assess the overall impact of transitioning to EV based transportation from an oil based system. This includes developing a systematic approach for phasing out of internal combustion based vehicles (ICV) and components exclusively related to the ICV, along with creating a new supply chain for EV components like battery, battery management systems (BMS), electric motor, and controller etc. As an intermediate step, retrofitting existing ICE vehicles into EV for some segments can be considered after evaluating the retrofitted vehicle performance and economics involved therein. All these aspects need to be carefully examined to ensure a smooth transition to cleaner transport fleets across various vehicular segments through detailed guidelines and policy framework for phasing out petrol and diesel vehicles.

CHAPTER 2

IN RESPONSE

Action is always the best response.

ALONG *THE ROAD*



The Ministry of Power has introduced recent policy and regulatory changes:

- Permitted different standards for public charging infrastructure
- Electricity tariff shall not be more than the average cost of supply plus 15%
- Electricity tariff applicable for domestic consumption shall be applicable for domestic charging

Recently, necessary regulatory provisions for the third-party sale of electricity have been notified by the Central Government.

CHAPTER 3

CHALLENGES ALONG THE WAY

Each challenge is a pathway for growth.

To forge a clear path forward, it is important to examine each challenge in-depth, and one at a time.

Charging infrastructure-related challenges:

Firstly, EV charging is estimated to be 6% of total energy consumption of India by 2030, whereas installed capacity and energy generation is likely to increase by 140%. To wheel this additional 140% power, huge investments are needed for strengthening the transmission and distribution network. This would cover the energy requirement of EVs.

However, some local aberrations due to pulsating loads during the peak loads and other such factors can be dealt with dynamic tariff for EV (private and public). This will help manage the overall grid load better.

The difference between peak and off-peak cost of power should also be kept sufficiently high so as to influence consumer behaviour. To find the proper balance, detailed studies and pilots must be conducted on a place-to-place basis. There would be a provision to change the rates from time to time as EV charging load and pattern evolves over time.

Charging Standards: MoP guidelines specify 5 types of chargers that can be installed at a public charging station. This may change in the future, as the market evolves. **Official standards are yet to be released by Bureau of Indian Standards (BIS), and therefore currently OEMs are following standards listed:**

Current AC charging standards in India

	Standards	kW range	Application	Communication	Remarks
1	Bharat AC0001	3.5 kW max.	2W, 3W, small 4W	No communication between EV and EVSE	IEC 60309 connector (blue)
2	Type 2 (1 ph and 3 ph)	Up to 43 kW	(2W, 3W) 4W	PLC based	Provides increased safety due to communication

Current DC charging standards in India

	Standard	kW range	Application	Communication	Remarks
1	Bharat DC001 (with GB/T DC connector)	Up to 15 kW	2W, 3W, small 4W	CAN	Based on Chinese GB/T DC connector. DC only.
2	CHAdeMO	Usually 50 kW (up to 150 kW)	(2W, 3W) 4W, trucks	CAN	Many DC chargers come with CHAdeMo and CCS outlets. DC only.
3	CCS (Combo 2)	Up to 350 kW	(2W, 3W) 4W, trucks	PLC	Vehicle inlet supports DC and AC (type2)

However, there are several factors creating uncertainties in the minds of prospective buyers: high upfront costs of EVs, range anxiety, lack of EV models, and the absence of adequate charging infrastructure. There are many hurdles in the way of charging station proliferation, such as varying standards in connectors and land acquisition for charging stations. A major challenge for deploying slow chargers in India is a lack of dedicated parking spaces for vehicle owners. Making smart chargers for the purpose of tracking, billing and availing the ToU tariff and demand response system is a major impediment.

Technical Challenges

There are many technical challenges to be addressed such as:

- **Technology that allows one charger for charging several EVs simultaneously** is crucial in terms of increasing the charging infrastructure usage. It is still in a nascent stage of development.

- **High voltage charging:** Pantograph charging is at high voltage and power eg. 600 kW- at 400V to 1200 V. Hence, limited use is needed in enclosed premises like depot, etc.

- **Battery swapping needs standardisation of battery modules and additional land area.** Since the weight of swappable batteries is a limitation, it is mostly suitable for 2 or 3 wheelers only. Further, unclear standards and legality are creating an atmosphere of uncertainty. So the market is developing on its own to meet the demand, resulting in non-standard products (like e-rickshaws). These rampant products may become a bottleneck in the future during standardisation.

- **Common protocol and regulation/procedure need to be in place at the central level** towards communication between all public EVSEs and respective DISCOM for real-time transmission and display of ToU tariff for consumers. Consumers should be able to look at prices on EVSE on-screen display and then decide time and amount of charging. Sending emergency control signals (shutdown or reduce the rate of kWh charge) from the DISCOM side should be able to manage excessive loading and prevent grid outages.

Manufacturing challenges: EV manufacturing is also ridden with challenges:
To understand the challenges, it is important to know that EVs have 3 crucial components: Battery, Permanent magnet-based motor and Controller. LIBs or Lithium-Ion Batteries are considered to be the most suitable storage option as they are fast charging, possess higher power density, are smaller in size 6-12 kg/kWh and have a longer life. Presently, EVs are expensive due to high cost of LIB that accounts for 40-46% of vehicle cost. Depending upon the LIB variant, capital expenditure can be lined up for battery replacement after 3-5 years. Moreover, at present, there is no ecosystem for a secondary market of LIB. Almost all the components and raw material for LIBs (and also motors and controllers) are currently imported and hence, require supply chain security. At the end of life, LIB has a significant amount of waste, composed of precious materials that can be recovered. But India currently lacks the LIB recycling ecosystem. While the introduction of EVs is imperative to implement climate change at the earliest, there are plenty of challenges to be addressed to make mass adoption of EVs a reality in about a decade.

CHAPTER 4

ROUTES TO CHANGE

Change is the only way forward.

The growth of the EV ecosystem is possible by implanting a range of solutions with regards to charging and storage. Some class-wise recommendations are as follows:

- **By 2030, 40% of energy dispensed to electric vehicles is estimated to be consumed by 2 or 3 wheelers only:** This sector can predominantly be supplied with battery swapping, to control the logistics and reduce the cost of the vehicle for the lower income groups.
- **Buses are estimated to consume 13%of total energy required for charging:** These can be charged at depots at night and boost charging may be given en-route once a day. Considering the large power requirement at a few places (EV-heavy routes), the substations, tariffs and other factors will be planned accordingly.
- **26% energy is estimated to be consumed by motor cabs:** Cabs can well be charged at night at stands, parking, and so on. However, some cabs may also require daytime top-up charging due to long daily trip lengths.
- **21% energy is estimated to be consumed by motor cars:** These can be charged at home at night and the slow charging can be done at the parking of workplaces. For this segment, charging at commercial parking, metro stations, and railway stations may be earmarked. Once again, this is a concentrated requirement at a few places and substation, etc. can be planned accordingly.

There can be other storage options too in future beyond LIB:

Beside lithium batteries, other cell chemistries and storage technologies will have to be taken into consideration for future energy storage solutions for the transport sector. Several driving forces or optimisation strategies account for this trade-off:

- Fuel price trends for coming years
- Costs for alternate energy storage technology and raw materials
- Refuelling, recharging time of the energy storage
- Energy density of the storage
- Energy efficiency of the conversion, especially in automotive drivetrain solutions
- Technology know-how and experience in alternate storage technology deployment
- Environmental aspects, carbon footprint, well-to-wheel efficiency and sustainability.

Few other emerging technologies are being
pursued globally at prototype or lab and pilot stage, such as supercapacitors, Lithium-Air batteries and Graphene batteries. Several aspects of future energy storage solutions are currently under research on a global scale for the mass adoption of electric vehicles that can be a gamechanger in the pursuits of low carbon energy utilisation.

SECTION 4

DESTINATION: LOW CARBON ENERGY SUPPLY

Destinations come closer with every big and small step.

ACTIONABLE RECOMMENDATIONS

Meaningful climate change mitigation efforts can be implemented through constant efforts in the short, medium and long term. Here is a quick look at recommendations and plausible solutions:

1. Environment and Pollution:

Short-term (2022)
Public participation begins with informed citizens and raised awareness levels. Similarly, public awareness is a key aspect of participative vigilance over emitting sources. Thus, the concern about environment protection, global warming and its effect, and CO_2 emissions due to different activities needs to be made public. Awareness should be enhanced through a display of Air Quality Indices and spatial air quality maps using print and electronic media. The clean air mission should include sensitisation and capacity building initiatives with academic institutions and local communities. The main objectives would be to empower and educate young minds on aspects of air pollution, sources, emission factors, indoor air quality, reduction and controlling measures. Effective pedagogy and incorporating an array of teaching strategies will need to be adopted for triggering behavioural change. This will pave the way for vigorous implementation and adoption of mitigation strategies. - Raise awareness for low carbon energy mobility - Build public awareness campaigns and participation, with awareness about low carbon transportation - Adopt effective pedagogy for triggering behavioural change towards sustainable, low carbon mobility options

2. Renewable Energy

Short-term (2022)	Medium-term (2030)	Long-term (2050)
- Encourage optimum efficiency power/square meter solar technology for rooftop solar charging stations - Bundle EVSE as mandatory in new buildings through Building Codes - Ensure closer alignment of Energy and Transport Sector to develop joint pathway	• Develop framework for recycling and disposal of solar panel to EVs	100% EV stations powered from renewable energy would become imperative: either through decentralised renewable energy applications or by having PPAs on open access basis with renewable energy developers

3. Petroleum and Biofuels:

3.1

Short-term (2022)	Medium-term (2030)
a) Create enabling ecosystem, off-take agreement and financing instruments for achieving the goals of National Policy on Biofuels 2018, Pradhan Mantri Ji-VAN Yojna, GOBAR-DHAN and SATAT schemes b) Advanced Biofuels would need the following measures: - Assured supply of segregated waste - Inclusion in priority sector lending with interest subvention scheme - Inclusion in 'White Category' for Pollution Clearance c) Improve fuel efficiency of vehicle fleet by introducing labelling/ratings systems, minimum efficiency standard and corporate fleet efficiency standards	Monitor Implementation of goals of National Policy on Biofuels, 2018

3.2 As per the present Policy, only 30% of the newly registered vehicles will be EVs and the remaining 70% will remain petroleum vehicles. Existing vehicles will also continue - consequently, the petroleum fuels will continue and the following steps will need to be taken urgently:

Short-term (2022)	Medium-term (2030)
Shift: Develop and focus on the use of more carbon-efficient modes of transport (Priority to Rail, Metro, LRT, Buses taxis etc)	**Avoid:** There would be a need to adopt a systems approach and reduce the need of transport through appropriate choices for locating industries and other businesses, and through better planning to minimise commuting needs. The concept would need to be built around growing vertically and provide residential-cum-commercial complexes so that all the needs are fulfilled in one building only, cutting the need to travel. TOD Policy of the Ministry of Urban Development will need to be issued. **Improve:** There will need to be increasing emphasis on the use of the most carbon-efficient technologies for any mode of transport. (Hydro fuel and EVs). For improving fuel efficiency of the vehicle fleet, it is recommended to introduce vehicle labelling/ ratings systems, minimum efficiency standard and corporate fleet efficiency standards. A combined land and transport authority is a preferred solution to help achieve the above.

4. Hydrogen Fuels: There are sufficient sources of hydrogen available, but the infrastructure needs to be built to proliferate the hydrogen economy:

Medium-term (2030)	Long-term (2050)
- Develop time-bound National Hydrogen Energy Roadmap to make hydrogen commercially available as a transportation fuel - Enhance injection of Hydrogen into the CNG grid to enable transportation of hydrogen without the need of building separate nickel-coated pipelines, to help save costs - Invest in research to bring down electrolysis costs - Cost-effective plan to develop multiple Fuel Cell technologies on a large scale - Utilisation of excess and stranded RE to generate hydrogen via electrolysis process at location - Invest in establishing Infrastructure of hydrogen storage, delivery and transport system - Development of proper pipelines dedicated solely for hydrogen needs to be built. At the same time, costs of doing so need to be brought down by economies of scale and investment in research.	There needs to be a focus on developing on-site generation of hydrogen via electrolysis powered by renewable sources of energy.

This could not only help India reduce greenhouse emissions but also bring down oil and gas imports by using hydrogen as the energy carrier.

Challenges and Conclusion on Hydrogen Fuels

The production of hydrogen and dispensing it through a compatible storage and transport network is a capital-intensive affair. Although research and development on hydrogen in India is underway, importance should also be given to making hydrogen economically viable. This will enable it to compete with the conventional fuels and electric vehicles, which have attained more market-maturity than hydrogen. Hydrogen is largely produced from fossil fuels, and hence it is essential that producing hydrogen from renewable resources is prioritised by the government. At present, the use of hydrogen in vehicles in India has been limited to research, demonstrations, and test runs. The fuel cell technology is still expensive in India and the government, therefore, must come up with a cost-effective plan to develop the same on a large scale. It will also need to invest heavily towards establishing the required infrastructure consisting of hydrogen delivery network, storage and transport systems, and refueling stations. An active and time-bound policy is thus required in order to make hydrogen commercially available as a transportation fuel in India.

Deployment of EVs

Short-term (2022)	Medium-term (2030)	Long-term (2050)
a) Develop ecosystem to convert existing ICE vehicles to EVs and encourage large volume manufacturing of EVs to control prices b) Develop charging standards c) Due to the inadequacy of natural sources of lithium, cobalt, nickel and other key elements required for manufacturing lithium cells in India, it is imperative that the country secures the import of these metals by establishing trade agreements with international partners. This will ensure a regular supply of raw materials and provide the foundation for indigenous manufacturing of lithium-ion cells, controllers and chargers in the country d) Integration of efforts across different regulatory and governance entities relevant to the EV space is also called for. This includes developing a detailed guideline and policy framework for phasing out ICE vehicles e) Minimum renewable energy purchase obligations by EV charger installations f) Tax incentives for EV charging from renewable energy sources	a) Optimise lifecycle of lithium-ion batteries for usage in energy storage applications post use in mobility. b) Establish a clear national framework for both secondary use as well as recycling of lithium batteries should be lined up to ensure optimal utilisation of scarce resources. c) Standard practices and guidelines for the secondary usage of EV batteries for energy storage applications must also be prepared to ensure a smooth transition between the two sectors. This will provide quality assurance and reliability to potential consumers. d) Mandate for infrastructure development by City governments/ municipalities and Highway Authorities to allot space for EVSE networks on lease at concessional rates under OPEX model	To ensure as little dependence on the import of metals, such as nickel and cobalt as possible, cell chemistries, such as Lithium Iron Phosphate (LFP) that do not require these metals should be promoted for use in EVs. It is important to consider alternatives to lithium-ion batteries, such as sodium ion batteries, hydrogen fuel cells, supercapacitors, thermal batteries, and so on. Concerted efforts and Government investment in research and development will ensure that the country is not locked into one technological solution for the long-term and possesses the capability to migrate to a better solution in the future, if required.

Despite promising growth, the government's targets for 2030 seem ambitious and may be a challenge to achieve as the industry and consumers are not ready to adapt and adopt rapidly, given the relative economics. Recycling and alternate use of batteries is a relatively new process as well. The Government has already taken a lot of initiatives to control CO_2 emissions such as ambitious RE and EV deployment targets, National Policy on Biofuels-2018 etc. Some agencies and ministries involved already in the process of implementing the same are:

a) Ministry of Environment, Forest & Climate Change

b) Ministry of Power

c) Ministry of Road Transport and Highways

d) Ministry of New and Renewable Energy

e) Ministry of Heavy Industries and Public Enterprises

f) Ministry of Petroleum and Natural Gas

g) NITI Aayog

h) State Governments and Utilities for implementation

However, since many issues and government departments are involved, the approach needs to be holistic and focused. A roadmap with definite policy and guidelines is an imperative.

A mission mode, integrated, time-bound approach needs to be adopted under one agency.

ACKNOWLEDGEMENTS

We would like to express our gratitude and appreciation to all those who have contributed to this initiative. We thank the Chair of the Core Group for India Roadmap on Low Carbon and Sustainable Mobility, Mr. Bharat Salhotra, MD of Ronmas India, whose continued guidance, inputs, support and proactive engagement have helped us in the final culmination of the India Roadmap and the eight theme reports, and for his patience and perseverance in seeing this through. Sincere thanks are expressed to the Leads of the eight working groups who dedicated their time and energy to this effort from the beginning, and to all the members of each working group who have contributed their insights, inputs, and direction for the respective theme reports and for specific components in the final India Roadmap.

We thank WWF India for providing support to this project as well as its role as Knowledge Partner in steering the work of the two Working Groups (Working Group 1 on Urban Transformation for Healthier, Inclusive Lifestyles and Efficient, Resilient, Prosperous Cities and Working Group 6 on Provide Low-Carbon Solutions for the Rural (Non-Urban) Populations). WWF-India also helped in organising a stakeholder consultation in Bengaluru, conducting Working Group 1 and 6 meetings and finalising theme reports of these components.

We express our gratitude and appreciation to Shakti Sustainable Energy Foundation for providing support and inputs for the theme reports and the Roadmap.

The FICCI Environment and Climate Change Secretariat steered the entire initiative of the India Roadmap, convening meetings of the Core Group, working groups, stakeholder consultations, and experts' consultation, providing information and background research of government programmes and schemes, gathering feedback of stakeholders and collation and compilation of the reports and roadmap. FICCI also reached out to various government departments during the course of the project, and organised a kick-off event with Shri Nitin Jairam Gadkari, Minister for Road Transport and Highways, Government of India, meetings with Shri C K Mishra, Secretary, Ministry of Environment, Forest and Climate Change, Government of India, and Mr Anil Srivastava, Mission Director, National Mission for Transformative Mobility, Niti Aayog. We thank them for their blessings and feedback. FICCI helped in the finalisation of the theme reports under the guidance of the working group Leads and Members, with complete coordination for six of the eight working groups (Working Groups 2, 3, 4, 5, 7 and 8). The individual meetings of the working groups as well as joint meetings and workshops of all working groups was also coordinated and organised by FICCI.

The formation of working groups was preceded by a brainstorming session of experts in May 2018, thereafter the working groups after being formed met numerous times in the 20 months that followed. A joint workshop of the working groups took place in May 2019 to assess the development of the theme reports and Roadmap halfway through the project. Thereafter, extensive deliberations of the working groups were held alongside stakeholder consultations until the culmination of the final eight theme reports and the India Roadmap. The 8 Leads of the working groups met numerous times through the project period. The joint meetings of the working groups and frequent meetings of the Leads ensured there was no silo in the deliberations or formulation of the eight components of the Roadmap. We are thankful to all of them for devoting their time and energy in this manner.

We thank Mr Patrick Oliva of PPMC, Mr Nicolas Beaumont of PPMC/Michelin, and Mr. Pierre Cannet of WWF-France for providing their feedback on the working group reports. FICCI and the Knowledge Partners would like to thank Michelin Foundation for its support on the successful completion of this project and for its commitment for sustainable mobility in India. The support and inputs provided by WWF France are gratefully acknowledged.

We are grateful for the candid feedback and inputs of participants of the three stakeholder consultations – in Navi Mumbai organised by FICCI and BOCI at Prawaas 2019 on July 26, 2019, in Bengaluru organised by WWF-India on September 26, 2019, in Delhi organised by FICCI on October 22, 2019 – and the experts' consultation organised by FICCI and Shakti Sustainable Energy Foundation on March 6, 2020.

We acknowledge the inputs, feedback and experience sharing by international stakeholders who participated in the events organised by FICCI on the development of the India Roadmap at the Movin'On – World Summit on Sustainable Mobility in Montreal, Canada in 2018 and 2019 and the side events organised by FICCI in UNFCCC COP-24 in Katowice, Poland in December 2018 and UNFCCC COP-25 in Madrid, Spain in December 2019.

We thank Mr Mahesh Babu, CEO, Mahindra Electric for his guidance as Co-Chair during the first year of the project. We also acknowledge the hard work by ex-FICCI colleagues Krishna Chandran and Mallika Bose who were part of this initiative from the start.

WORKING GROUP

Working Group on " Low-carbon Energy Supply Strategy"



Working Group Lead: Mr Sharat Sharma, Former Director – Operations, DMRC

Members:

1. Tata Power Delhi Distribution Limited (TPDDL)
   Praveen Verma
   Sarang Pani Goswami
   Suyash Verma

2. Indian Oil Corporation Limited
   Subodh Kumar
   Shantanu Gupta

3. Center for Study of Science, Technology and Policy (CSTEP)
   Mridula Dixit Bhardwaj
   Arunesh Karkun

4. Bharat Heavy Electricals Limited (BHEL)
   Arun V Rao

5. Panitek Power AG
   Pankaj Agarwal
   Anjan K Merkap

6. CVC India Infrastructure Pvt. Ltd.
   Kolluru Krishan

7. SUN Mobility
   Yuvraj Sarda

8. Hinduja Renewables
   Sudhanshu Kamboj
   Kapil Maheshwari

9. Tata Cleantech Capital Limited
   Mudit Jain

SECRETARIAT

FICCI Secretariat



Ms Rita Roy Choudhury
Assistant Secretary General



Mr Asim Sharma
Deputy Director

WWF-India Secretariat



Dr T S Panwar
Director – Climate Change & Energy



Mr Aviral Yadav
Programme Officer – Climate Change & Energy

Shakti Sustainable Energy Foundation Secretariat



Mr Vivek M Chandran
Associate Director - Transport Program



Ms Avni Mehta
Program Manager - Transport

ACRONYMS

BAU: Business as Usual
EBP: Ethanol Blending Programme
EVSE: electric vehicle supply equipment
FICCI: Federation of Indian Chamber of Commerce & Industry
GCF: Green Climate Fund
GDP: gross domestic product
GMR: Global Macro Roadmap
GOBAR-DHAN: Galvanising Organic Bio-Agro Resources Dhan
HFC: hydrofluorocarbon
ICE: internal combustion engine
IEA: International Energy Agency
LFP: Lithium Iron Phosphate
MoEFCC: Ministry of Environment, Forest and Climate Change
MoRTH: Ministry of Road Transport and Highways
PM JI-VAN Pradhan Mantri Jaiv Indhan-Vatavaran Anukool Fasal Awashesh Nivaran
PPMC: Paris Process on Mobility and Climate
SLWM: Solid and Liquid Waste Management
SNM-G: Swachh Bharat Mission-Gramin
TOD: Transit Oriented Policy
UNFCC: United Nations Framework Convention on Climate Change

SOURCES/ REFERENCES

- Draft Report on Optimal Generation Capacity Mix for 2029-30, February 2019
- National Electricity Plan
- National Transport Development Policy Committee Report, 2013
- Measures to control air pollution in urban centres of India: Policy and Institutional Framework, TERI Policy Brief, February 2018
- National Policy on Biofuels, 2018
- Pradhan Mantri JI-VAN (Jaiv Indhan-Vatavaran Anukool Fasal Awashesh Nivaran) Yojana
- 'Galvanising Organic Bio-Agro Resources Dhan (GOBAR-DHAN)' scheme
- Sustainable Alternative Towards Affordable Transportation (SATAT) scheme for CBG -1-10-2018
- National Transit Oriented Policy - 2017
- MNRE Physical Progress Report 2019
- Report - NITI Aayog, 2015, For Grid Connected RE Only
- Perspective Transmission Plan 2016 – 36, CEA
- Ministry of New and Renewable Energy, 2016
- Dou, Sun, Ren, & Dong, 2017
- Thomas 2009
- Kalamaras & Efstathiou, 2013
- Quarton & Samsatli, 2018
- NREL, 2013
- Pachauri, Spencer & G. Renjith

ABOUT PARTNERS

FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialisation, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian Private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

PPMC

The PPMC is an open and inclusive platform that actively invites all organisations and initiatives that support effective action on transport and climate change to join in the process. The PPMC is created to strengthen the voice of the sustainable transport community in the UNFCCC process, especially with a view to the upcoming Conference of Parties (COP21) in December 2015 in Paris. COP21 is expected to result in a new global agreement on climate change, which will shape climate policy in the years to come at a global, regional and national level. By bringing together different actors and stakeholders in the sustainable transport community it will be possible for the transport sector to have its voice heard and speak with one voice on the important contribution that sustainable mobility can make to the mitigation of, and adaptation to climate change.

The PPMC contributes to realising a Global Agreement on Climate Change that empowers transport sector to take action on climate change. The realisation of this objective requires an active engagement of the PPMC before, during and after COP21. It will be equally important to advocate for an agreement that incentivises the transport sector as well as work with the transport and climate community on the implementation of a new global agreement on climate change at the global, regional, national and local levels.

WWF-India

WWF-India is one of the leading conservation organizations in the country. It is a science-based organization that addresses issues such as the conservation of species and its habitats, climate change, water, and environmental education, among many others. Over the years, its perspective has broadened to reflect a more holistic understanding of the various conservation issues facing the country and seeks to proactively encourage environmental conservation by working with different stakeholders- Governments, NGOs, schools and colleges, corporates, students and other individuals.

Shakti Sustainable Energy Foundation

Shakti Sustainable Energy Foundation (Shakti) seeks to facilitate India's transition to a sustainable energy future by aiding the design and implementation of policies in the following areas: clean power, energy efficiency, sustainable urban transport, climate change mitigation and clean energy finance.

DISCLAIMER

This document has been published for information and illustrative purposes only and does not constitute professional advice. FICCI and its knowledge partners do not accept or assume any responsibility or liability to any reader of this publication in respect of the information contained within it or for any decision readers may take. The content of the report cannot be ascribed to any particular organisation or views of any individual/set of organisations. Any use of this report other than as a whole and in conjunction with this disclaimer is prohibited. This report may not be copied in whole or in part. The information contained in this report is not intended to address the circumstances of any particular individual or entity. No one should act on such information without appropriate professional advice.

The views/analysis expressed in this report/document do not necessarily reflect the views of Shakti Sustainable Energy Foundation. The Foundation also does not guarantee the accuracy of any data included in this publication nor does it accept any responsibility for the consequences of its use.

CONTACT US

Ms Rita Roy Choudhury
Assistant Secretary General
FICCI
Email: rita.roychoudhury@ficci.com
environment@ficci.com

Mr Asim Sharma
Deputy Director
FICCI
Email: asim.sharma@ficci.com

