Technology @75
Innovation in Action

Technology Reports under the aegis of CII National Committee on Technology, R&D and Innovation

March 2022

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Confederation of Indian Industry

CII National Committee on Technology, R&D & Innovation 2021-22

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Executive Summary

CII started its technology initiatives way back in 1990s under the chairmanship of late Dr APJ Abdul Kalam, focusing on guiding Indian industry in innovation and R&D. During last three decades, CII has been heavily investing in carrying forward this mission through plethora of initiatives on its own and in partnership with the Government.

In line with this, Confederation of Indian Industry (CII) has defined its **Theme for 2021-22** as '***Building India for a New World: Competitiveness, Growth, Sustainability, Technology***.' The fourth pillar of the theme, Technology, even more than trade, is now at the core of geopolitical dynamics. The future promises to be dominated by greater knowledge intensity and more applications of technologies. Countries will compete on proprietary knowledge and technologies and Government and industry members need to work together to ensure that as a nation and as industry we accelerate into the future.

With the mission of **Promoting Technology, R&D and Innovation as a Movement to build India for a New World**, the CII National Committee on Technology, R&D & Innovation 2020-21, initiated **technology roadmaps** on three priority areas- **Mobility, Advanced Materials & Manufacturing**, **Energy** featuring: Potential technologies; Horizontal and vertical technology gaps; Short (2yrs), Medium (5yrs) & Long term (10yrs) interventions.

Key Recommendations

Advanced Materials	Mobility	Energy
1. Identification **of key materials to focus at national level and develop roadmaps from mining to commercial use** – *e.g., Titanium, Carbon Fiber, Lithium, Extraction of Nickle and Cobalt from mines overburden and urban mining, Rare Earth Materials like Neodymium, Medical materials like etc.* 2. Create a **budget pool** for development projects in the identified areas 3. Ensure **TRL-based funding mechanism** to enable funding in Basic stage to Universities & Research Labs; in Pilot stage to Govt Research Labs & Industry Labs and in Commercial stage to Industry. Govt and Industry need to co-fund to de-risk technology scale up	1. Create **an inter-ministerial group** to formulate a National Mobility Transformation Strategy (2021-30). Specific recommendations Some recommendations on Alternate fuel: Hydrogen strategy blueprint, incentivization, cleaner fuels, single window clearance mechanisms etc. 2. Industry to work with Government for **creation of Urban Integrated Mobility models**, as blueprint for cities of the future. 3. Review **Faster Adoption and Manufacturing of Hybrid and Electric vehicle (FAME) policies** for synchronized incentivisation, boost research, and PPP model for EV, Battery technologies & relevant eco-systems.	**1.** **Green Energy**: Focus on Low-cost electrolysers for Hydrogen generation and technologies for hydrogen storage. Renewable Integrated Grid management for enabling increased renewable portions using Data driven AI –based forecasting—energy systems modelling **2.** **Decarbonisation-** Carbon Dioxide capture and utilization **3.** **Energy efficiency-** Develop energy efficient electrical equipments like electric motors and air compressors

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Advanced Materials

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Vertical Issues (specific materials categories: Ti, Mg, Composites, medical, RE, EV batteries… **)**

Structural Gaps

- Inadequate academic strength in advanced materials.
- Inadequate translational capability to make components in advanced materials.
- Defense Procurement Policy offset requirements of raw materials purchase from India
- Non availability of input materials or constituents to manufacture Aerospace quality raw materials – *imported at high prices*

Financial Gaps

- Initial support like easy capital, guaranteed low tariff power supply, higher import duties and low GST on Raw materials required
- Volumes too small to attain economies of scale for critical materials – *ventures become uncompetitive*

Manufacturing/Technological Gaps

- Need to drive TRL development from raw materials -> use of metals -> commercialization
- Unavailability of facilities for a required capacity, due to poor demand to justify it (*E.g. 20000 MT forge press for aero-engine discs*)
- Technologies for high strength Al alloys, coating for high end gas turbine engine components, etc. are unavailable
- Converting raw materials to desired shapes and forms like extrusion, castings, thick plates, thin sheets, tubes is a capability deficit
- Internet of Things/Industrial engineering or automation key enablers for efficient manufacturing
- Metals: Mg, Li, Co, Rare Earth Metals need to be commercially produced/recovered; Non-metals: High quality T-800 carbon fibre, PVDF (sensor material), SiC single crystal

Vertical Issues…..

Organizational Gaps

- Dedicated Project Management structure covering planning, risk management and monitoring aspects
- More MTech/PhDs in Material research domain
- Better connectivity and staying lean in COVID-19 times

Design Gaps

- National facilities for testing & characterization to promote indigenization
- Good concepts, academia and simulation capabilities, but lack design codes & specifications - *unable make a product for global business*
- Encourage use of Make in India products - *even if slightly inferior, in order to implement, improve & learn*

Recycling

- Transform recycling from unorganised to an organised sector; Proposal on eco-park to recycle e-waste by MEiTY
- While IMMT and NML working on Tungsten recycling; India needs to work on Recycling of Carbon Fibre Composites

Collaborative Gaps

- Provide private sector with access to national labs and facilities
- Volume of industry-academia collaborations are low and research needs to be supported
- Good inter-governmental collaboration but gap b/w industry and R&D *(e.g. DRDO-FICCI)*

IMMT: Institute of Minerals and Materials Technology NML: National Metallurgical Laboratory

MEiTY: Ministry of Electronics and Information Technology

DRDO: Defence Research and Development Organisation

Horizontal Issues…..

Stimulating Private Sector Investment in R&D

- India **lacks focus of investment pull in innovation** – *needs focused change*
- Huge **gap between TRL 4 to TRL 9** – *needs concerted effort to cover the technology development to deployment journey*
- **De-risk through co-funding** by **Industry and Government** (*e.g.* ***UK's Catapult Centre*** *type model to drive collective effort across industry, academia and research institutions*)
- Government funding essential at all stages, with **Industry co-funding** scale up of technologies.

Models for STI Financing in STI Policy

- **Financing framework** to foster collaboration across ecosystem entities, reward cooperation, drive regular evaluation & robust governance
- **Contextual funding model** based on innovation stage, entity and TRL:
  - (i) **Basic stage** – small amount of funding to universities and research labs for multiple technologies to proves technology hypothesis
  - (ii) **Pilot stage** - larger amount of funding to Govt research lab or Industrial research lab for fewer technologies
  - (iii) **Commercial stage** – large amount of funding to industry for select few technologies
- **Government funding** through **financial incentives** (*e.g. grants, subsidies, low-interest loans, etc.*) **and fiscal incentives** (*e.g. tax allowances, tax credits, total or partial exemptions of capital gains, etc.*)
- **Key Steps:** Select strategic technology focus area given nation's context → Allocation of public funding on the subject → Call for application → Selection of applications with preference to technology developments projects with collaborative participation → Co-funding by Industry

International Experiences in Translational Research

- **Synergistic efforts** across fundamental and applied research required to **solve societal challenges**
- **HISarna**, a shining case in the **Steel industry** on this approach

Horizontal Issues…..

Strengthening the Govt-Academia-Industry Troika

- Collaborative approach for **pan-TRL view of technology development and eco-system** for funding, capability building and market access
- In India, 'Professors of Practice', a new scheme launched by IIT + MHRD to drive exposure of students and faculty in industry
- Global best practices:
  - **(i)** **Fraunhofer Institutes, Germany**, with 1/3rd each of funding from institute, Government and industry, helps bridge the 'Valley of Death' between Pilot and Commercialization stages
  - (ii) Dedicated **Government funds** at **USA, UK**, etc. support basic research through projects, infrastructure and capabilities
  - **(iii)** **EU's Innovation Voucher Programme**, a cost-effective solution to encourage MSMEs and Start-ups

Higher Participation of Women in STEM

- **Interventions** at **individual** level, **family** and **peer-level** to address misconceptions, expand understanding and take actions
- **School-level** and **Societal level interventions** to facilitate early-age counselling and gender-neutral role models
- Promote **inclusive workplaces** that honours technology irrespective of the technologist
- The **National Education Policy 2020** is a step in the right direction

Making India Technologically Self-Reliant

- **Focus on themes** in sciences, engineering and social sciences to support strategic **vision of Atmanirbhar Bharat**
- Build ecosystem that helps **simultaneously develop capabilities in academia, research labs, MSMEs and industries**
- **MSME sector** - backbone of developing economy, needs **infusion of funds** for an upward spiral of R&D activity
- **Robust pipeline of ideas** addressing national issues - *CCUS, recycling of electronic & electrical waste, generation of cheap & green Hydrogen, extraction and use of rare earth metals, etc.*
- **Holistic ecosystem approach** - funding and financial policies that encourage research & innovation and incentivize diffusion

MHRD: Ministry of Human Resource Development CCUS: Carbon Capture, Utilization & Storage MSME: Micro Small & Medium Enterprises TRL: Technology Readiness Level

Way forward…..

What India should do in the Next 2 years

- Identify **key materials** to focus on at national level and develop roadmaps from mining to commercial *use*
- *Examples of key materials- Titanium, Carbon Fiber, Lithium, Extraction of Nickle and Cobalt from mines overburden and urban mining, Rare Earth Material like Neodymium, Medical materials like etc.*
- Create a budget pool for development projects in the identified areas – *e.g.*
  (i) Set up of a demo plant for extraction of Nickel and Cobalt from mine overburden under "Value From Waste" theme require Rs 350 Cr budget (ii) Set up of pilot plant for making T-700 or similar grade of Carbon Fiber from coal tar pitch of Indian steel industry requires budget of Rs 150 Cr.
- Invite project proposals in the focused areas from collaborative teams that must contain industry, academia, government (labs) & MSME
- Create a project management team for monitoring progress

What India should do in the Next 5 years

- Develop vision document for Materials and Manufacturing
- Encourage industry to set up ventures to produce REMs and magnets, Li and Co
- Deploy policy for procurement of materials from India for indigenous defense products
- Create policies that are conducive for export of products that use critical materials and have small markets in India.

Other action items

- Government policy on critical materials dissuading imports through quota systems, tariffs and subsidies and propelling "Make in India" philosophy
- Ensure TRL-based funding mechanism to enable funding in Basic stage to Universities & Research Labs; in Pilot stage to Govt Research Labs & Industry Labs and in Commercial stage to Industry. Govt and Industry need to co-fund to de-risk technology scale up
- Develop mindset of design and manufacture in India for a global market through strengthening technological capabilities, advocating indigenous development, conducive regulations and financial incentives

RME: Rare Earth Metals

Key technologies & interventions…..

Energy		
Technology	**Note**	**Intervention**
CO_2 Capture & Use	With Steel industry's aspiration to grow three fold in the coming years, the direct impact would be multifold increase in CO_2 emissions. It is imperative to focus on scale up of sustainable technologies for decarbonization. CO_2 utilization has to be tackled through varied avenues. Green Hydrogen in large volume and low cost is one the key levers for decarbonization. No single technology will solve this challenge. These areas merit a multi pronged approach across diverse technology routes to address the ask	• Government support through: Financial incentives (e.g. grants, subsidies, low-interest loans, etc.) • Fiscal incentives (e.g. tax allowances, tax credits, total or partial exemptions of capital gains, etc.) • Driving market pull - ensure preference for sustainable technology solutions for addressing market need over L1 choice
Hydrogen Generation		
Advanced Manufacturing & Materials		
Technology	**Note**	**Intervention**
Recycling of EV Battery waste	With growing impetus on electrification, conducive policies for EV ecosystem in India and high dependency on import materials (Li, Ni, Co, etc.), it is crucial to build an ecosystem for recycling of EV battery waste. India imports Li-ion batteries from China, Japan and South Korea and is among the largest importers in the world. It has quadrupled its imports in volumes and more than tripled its import bill from ₹2,600 crores (2016) to ₹6,500 crores (2019)	• Strict regulations regarding the disposal of batteries need to be enacted in order to give impetus to the battery recycling industry • Impetus on indigenous technology for metal and material recovery • Policies dissuading imports through quota systems, tariffs and subsidies and propelling "Make in India" philosophy
Medical Materials	Increasing urbanization, higher disposable income, growing aging population and higher affordable healthcare schemes is accelerating the medical and healthcare sector growth in India. With more than 75% of the sector needs currently being met through imports, there is a strong case to tap the opportunity through indigenous capability development in advanced manufacturing and medical materials like Collagen, etc.	Holistic ecosystem approach through funding and financial policies: • Promoting indigenous capabilities across MSMEs, startups and industry on materials for medical and healthcare sector while maintain internal standards • Initial support like easy capital, higher import duties and low GST on inhouse materials, etc.

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Energy

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7. Mr Ajay Joshi, Technology Innovation, and IP Management, Cummins Technologies India Pvt. Limited

Preamble

- A new approach to R&D and its translation/adaptation is required to cater to the transitions happening in the energy sector and meeting the triple objectives - **CLIMATE CHANGE MITIGATION, ENERGY SECURITY** and **RELIABILITY**

- The approach would involve a clear identification of needs and application, well coordinated between researchers, industry and government along with targeted baselines and benchmarks. Performance specific matrices for technologies that will compete or be used for diverse applications will be decided by the stakeholders together.

- Stimulating private sector investment in R&D, STI financing policy, development of MSME's and their capabilities are the key elements for industry investment to help develop the ecosystem.

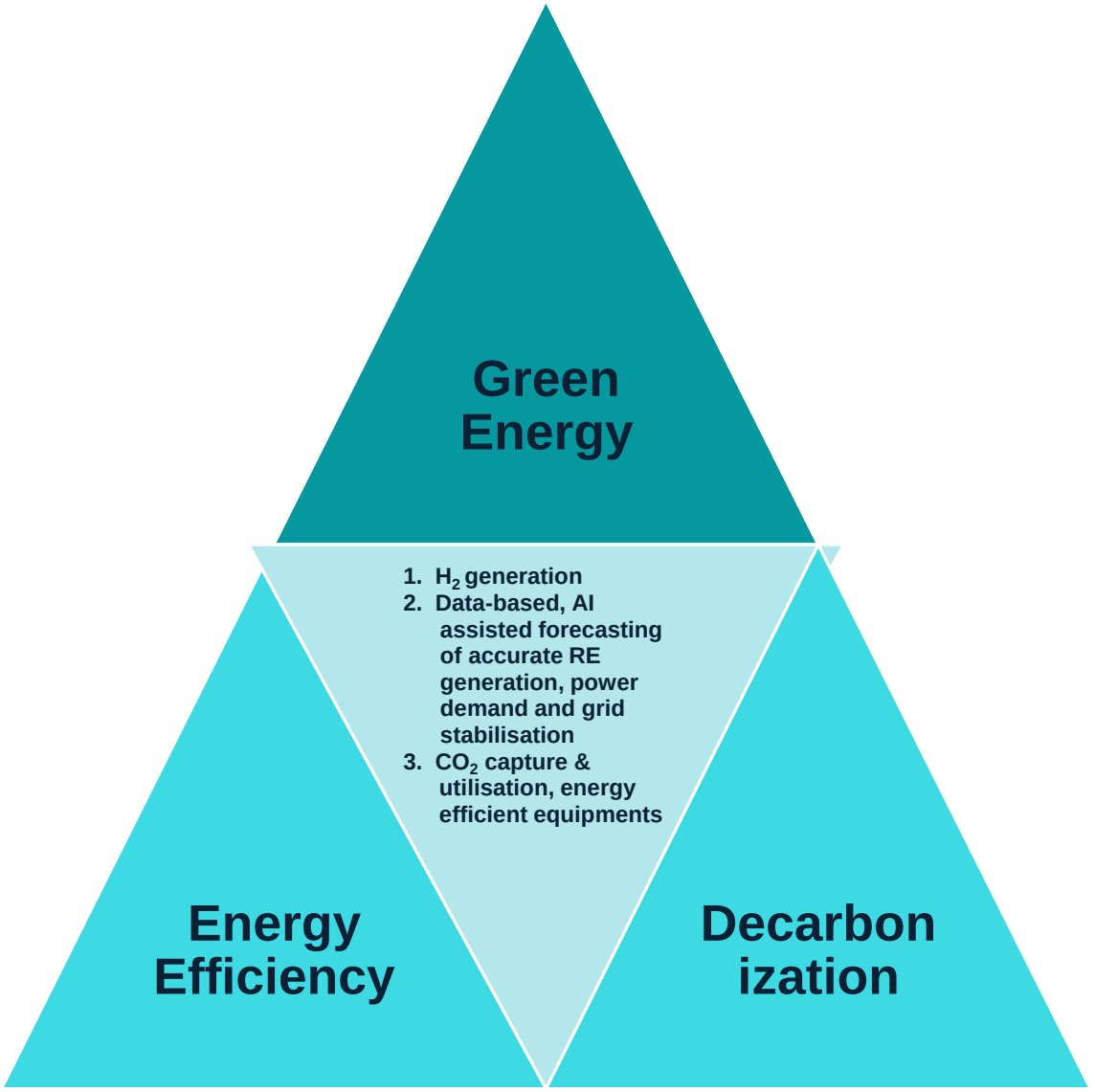
- The aforesaid elements are required to help take the technologies from TRL 3-4 to higher TR levels of 7-8, enabling the industry to take it up for commercialization. This will allow the new emerging/developed technologies (TRL 3-4) to compete and provide "informed choices" for industry to adopt for commercialization and government to develop appropriate regulations and policies for governance.

- E.g. various advanced batteries to compete on performance and evolve winner for specific applications.

Panchamrit: India @2030

- India will meet 50 percent of its energy requirements from renewable energy by 2030.
- India will reduce the total projected carbon emissions by one billion tonnes from now onwards till 2030.
- By 2030, India will reduce the carbon intensity of its economy by less than 45 percent.
- India has achieved 25% of emission intensity reduction of GDP b/w 2005-2016, and is on the path to achieve more than 40% by 2030.
- By the year 2070, India will achieve the target of Net Zero.
- India will reach its non-fossil energy capacity to 500 GW by 2030.

Path to achieve the commitments



Key Enabler Technologies for Translational Research

Green Energy:

- Avoid Duck curve : Low-cost electrolysers for Hydrogen generation and technologies for hydrogen storage
- Renewable Integrated Grid management for enabling increased renewable portions using Data driven AI – based forecasting- energy systems modelling
    - Energy Storage Solutions (Advanced Batteries with better performance and using indigenous materials and technology (Incubation)
    - Production of Green energy--R&D focus to be particularly in Floating Solar Panels (particularly the material for the panels), manufacture and demonstration

Decarbonization:

- Carbon Dioxide capture and utilization
- Hydrogen from renewables like biomass and bio-CNG

Energy efficiency:

- Develop energy efficient electrical equipments like electric motors and air compressors
- Waste heat recovery

Project 1
Low-cost electrolysers for Hydrogen generation and technologies for hydrogen storage

- Hydrogen, being an important path towards decarbonization, is also a very good energy storage solution to use the renewable energy at time of peak generation but low demand. This helps avoid the duck curve and grid collapse upon grid integration.

- However, the cost of electrolysers (mainly imported large scale ones are available) and the energy consumption are prohibitive. There are many institutions who have developed technologies up to TRL 2-3 in India. At the same time, DST sponsored Hydrogen Storage Platforms in various institutes is ongoing. Transparency and information dissemination to industry will be helpful.

- Key recommendations
  - ✓ Technology demonstration projects by universities (TRL 3-4) for individual technologies (electrolyser and storage)
  - ✓ To be followed by target setting and technology integration and demonstration projects led by industry with appropriate de-risking of investment by Government, based on the technology readiness assessment

Project 2
Carbon Dioxide Capture and Utilization

- Carbon-dioxide capture is essential in our country, especially owing to the fact that we will need a longer time to transition from coal or hydrocarbon-based fuels for industry and power generation
- Also, India is not very geologically very conducive to carbon sequestration after capture. Therefore, utilization of CO_2 after capture is as important as capture. Both technologies need to develop simultaneously
- A very important deterrent to the technology acceptance is the highly capital-intensive nature of the capture technology and which in turn makes the demonstration of utilization technologies for development to higher TR levels
- E.g.- for a pilot plant of 500 tons/day of CO_2 capture, Rs 120 crores are required (as per cement industry). Owing to the fact that CO_2 capture is an important technology for mitigation of climate change, heavy de-risking policies by the government with incentives will be helpful, which will in turn promote the CO2 utilisation technology also
- Industry-consortium led, government supported (to the order of de-risking investments) technology demonstration and integration is recommended

Project 3

Develop energy efficient electrical equipment like electric motors

- Electric motors are the driving force behind EVs. In addition to the batteries and power electronics, the electric motor is a critical component within the drivetrain. There are several key performance metrics for electric motors, efficiency being one of the critical ones. Higher efficiency leads to improved range from the same battery capacity.

- Two advanced and energy efficient motors used in the Electric powertrain
  - BLDCM (Brush Less Direct Current Motor)
  - PMSM (Permanent Magnet Synchronous Motor)

- Need to develop technologically differentiated motors at affordable price to not just reduce imports but also export.

- Creating Centre of excellence and Innovation clusters - Enabling MSMEs to innovate and develop light weight, energy efficient next generation advanced motors

Project 4: *Renewable Integrated Grid management for enabling increased renewable portions using Data driven AI –based forecasting—Centre for Energy Systems modelling and Forecasting*

- An important and urgent requirement for the country.
- Integration of renewables at large-scale introduces various challenges in grid management.
- Presently, several countries have set the maximum RE generation that their grid can handle at a given instant, thereby, resulting in potential curtailment of energy from renewables. Therefore, for accommodating higher levels of renewables, it is important to investigate critical issues in grid management and explore potential countermeasures to address such challenges.
- At a broader level, the main challenges in large scale integration include
  a) flexibility requirement to handle high RE penetration
  b) find the appropriate storage solutions and more importantly right mix of storage technology (battery, hydrogen, pumped hydro etc) for RE integration that suits best for Indian power sector
  c) adequate and sustainable plan for phasing down/out conventional generation in India
  d) reliability of large-scale solar PV power generation
  e) higher accuracy forecasting of renewable energy
- There is a pressing need to address the above stated issues for handling high penetration of renewable energy in the grid.
- A true consortium-based Institute, with industry and academic experts working together for right data (from industry/utility etc) collection, interpretation, AI based forecasting, systems modelling is required (The industry experts maybe on deputation)

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Moving India

Leading the Sustainable Future of Mobility

CII Mobility Sub-Group

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- Mr N Saravanan, President & CTO, Ashok Leyland
- Mr Vijay Sethi, Chief Information Officer, HeroMoto Corp
- Dr. Prabhjot Kaur, Co-Founder & CEO, Estimo Solutions Pvt Ltd.
- Mr SJ Dhinagar, VP, TVS Motor
- Mr Ramesha BS, Academic and Start-up Initiative, Altair
- Mr Anuj Bhandari, Innovation & Growth, JCB India Ltd.

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Foreword

- At >$20Tn of annual revenue, the transportation sector has major influences on the economies of the world, as well as its potential impact on sustainability of our planet.
- We are in the midst of “the Decade of Transformation” while the humanity fights the battle to save the planet, this is also the decade where India is set to make its mark while riding on the wave of many disruptions.
- Rising Population & Increased Urbanization – India has 21 out of 30 most polluted cities in the world. 1% Increase in urbanization leads to 0.24% increase in Co2 emissions. Need for technology alternatives that mitigate the pollution levels.
- Few big factors that are set to transform mobility in next 10 years, are
  - Carbon Reduction Goals (for Companies & Countries)
  - Urbanization
  - Renewable / Green Energy Growth
  - Digital Tech. (enabled by 5G/6G, iOT, AI & ML)
- Across the globe, Mobility is going to ride on 4 pillars – Shared; Connected; Green; Autonomous.

Foreword

- Carbon Dependent Power Generation - 76% Dependence on Coal for Total Power Generation. Government has put in significant efforts to achieve 40% by Renewable. While Electrification is a possible choice, some of the alternate fuels could provide an alternative option in the short to middle term.

- High Crude Consumption & Import Bill - 2W, 3W, Cars and Trucks consume one third of oil Imports. Import dependence has risen from 77% in 2013-14 to 84% in 2018-19.

- Geo-Political Risks – India's dependency on Imports for Fuel needs makes it vulnerable to Geo-Political Risks

- Fuels of the future – Electric Batteries, Hydrogen, Bio-fuels, Natural gas are set to take a sizeable share moving away from moving away from fossil fuels.

- India has committed to reducing the emissions intensity of its GDP by 33-35 per cent from 2005 levels.

Foreword

- While we see Autonomous penetration slower in India, the global opportunity scale in all the above would present an enormous global business opportunity for employment creation.
- The winners league table of 2030 would consist of countries that are able to ride this wave of disruptions, not only meeting the climate goals and grow sustainably, but also become the net exporters and hubs for the global trades.
- Urbanization would proceed at a rapid pace, set to grow 2X from current world 3.5Bn urban population, resulting growth in megacities (current 47 across the globe). All the megacities would have to plan integrated urban mobility models for sustainable future.
- As urbanization proceeds at a rapid pace, the growth models have to be sustainable, giving rise to integrated urban mobility models, and have to plan synchronisation of public investments, public-private partnership, factoring shared mobility and public transport, last mile connectivity with shared micro-mobility.
- Shared micro-mobility opportunity is significant for India. Est. market in China, EU & US could reach $300-$500 by 2030.

2. Global View

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Global View

Norway's parliament set a non-binding goal to ensure that all cars sold should be zero emissions by 2025.

Finland: 1st Plan & Pay App in World which includes Train, Taxi, Bike & Car share

USA: 1990 – 2019 Govt. funding of US$ 31Mn to advance the H2 Infrastructure. California Fuel Cell Partnership targets to set up 1000 hydrogen re-fuelling stations by 2030

China:
1. **99%** Consumption of E-buses in the world
2. US$1.4 trillion revenue collected annually by extended auto industry

EU: Transition to ultra low carbon hydrogen production by 2030. 3700 re-fuelling stations are targeted by end of 2030

Germany: 50% Growth of Car-sharing membership since 2010

South Korean H2 Group: SK, Hyundai Motor, POSCO, Hanwha & Hyosung to spend **$38B by end of 2030** on H2 production & distribution

India Natural Gas and LNG market is expected to grow from US$ 19.7 billion in 2015 to US$ 30.7 billion by 2025 at a CAGR of 5.06% between 2016 and 2025

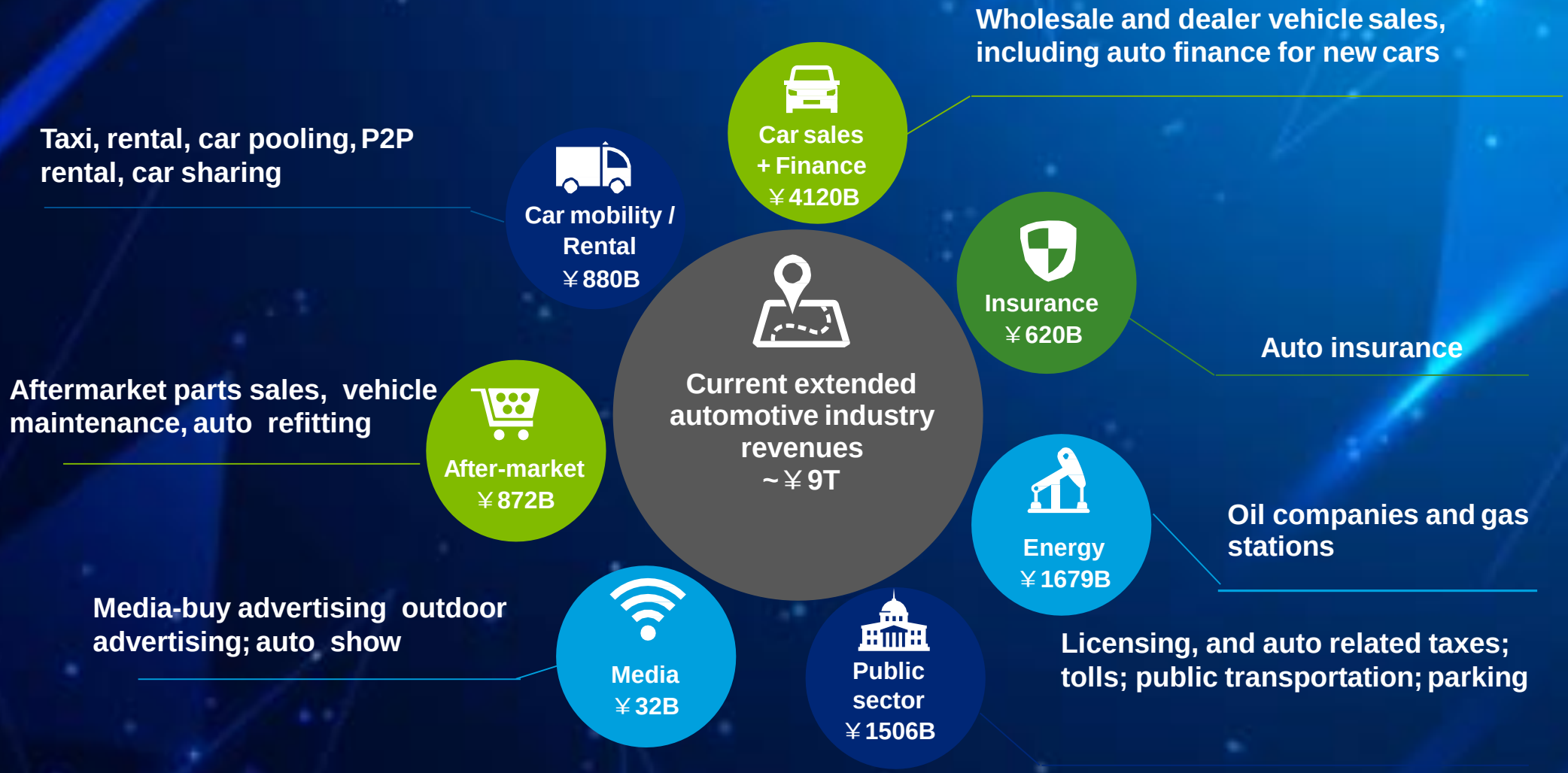
Saudi Arabia $5B Plant to make green fuel for export

World Population
1 billion (1804) → 7.8 billion (2020)
Estimated→ 9.8 billion **(**2050)

India Population
470 Million Urban Population
(28 years average age)

Mobility Eco-System Scale Opportunity

Example – China



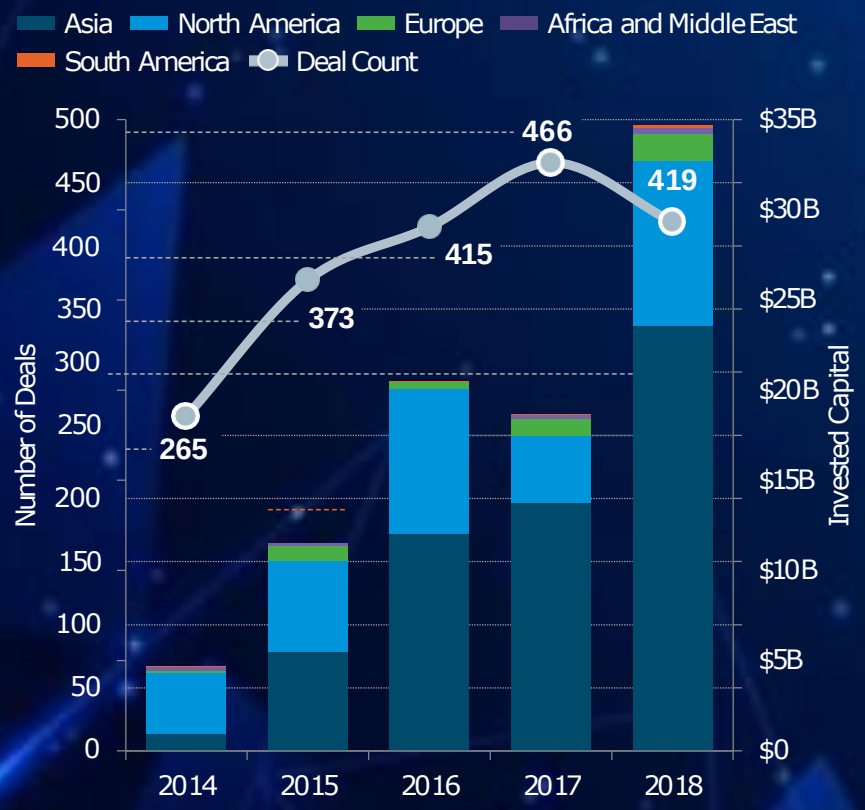
US$1.4 trillion in revenue collected annually by the current extended auto industry in China 35

Source: courtesy Deloitte Report

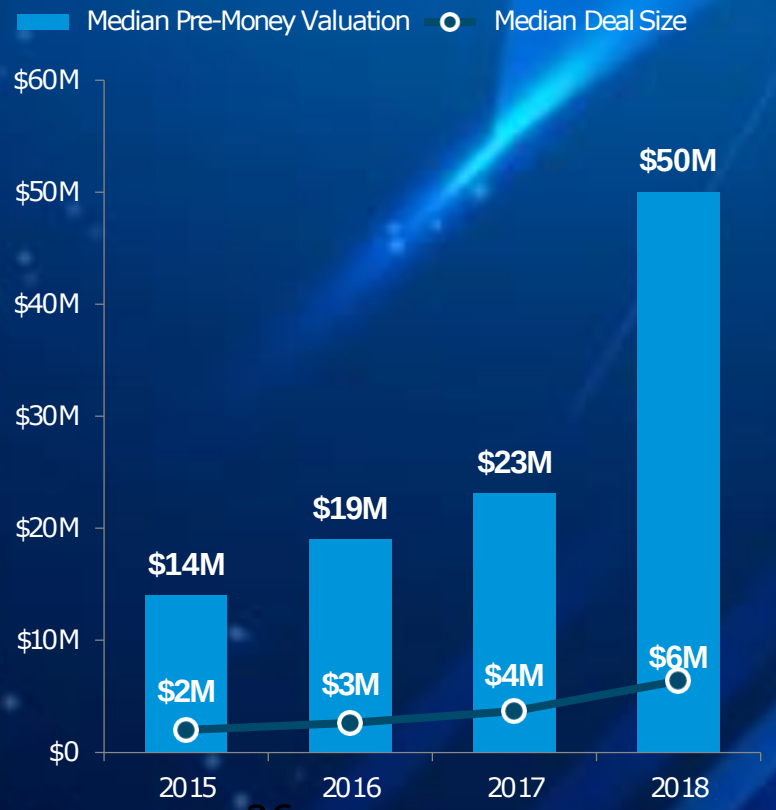
Mobility – VC Investments

By end of Q4, 2018 venture capital (VC) investment in transportation start-ups neared $35Bn and is on track to double the amount of fundraising a year ago. The bulk of this capital was directed towards ride-sharing platforms such as Uber, Didi, Grab and Lyft, which have all raised $1Bn mega-rounds in2018. At the same time, median pre-money valuations for transportation-related start-ups have almost doubled to $50Mn in 2018, up from $23 from prior year.

Venture Financing in Transportation Technology: 2014-2018



Transportation Technology: Median Pre-Money Valuation and Median Deal Size 2015–2018



Source: S&P Capital IQ, PitchBook and SVB analysis

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3. India @2030

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India @2030

Source : MGI – 'India's Urban Awakening' Report

India 2030 Policy & Strategy

Proposed Threads

Inter-Ministerial group along with Industry & Specialists core groups to formulate above 5 National Policy & Strategy papers for India@2030 Leadership

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4. India 2030: Mobility Transformation

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Integrated Urban Mobility:
Opportunities & benefits

Integrated Urban Mobility

Direct & In-direct Benefits

- Reduced congestion
- Increased ride sharing
- Increased safety
- Reduced traveltime
- Optimized use of resources
- Eco-friendly solutions

National Green Objectives

- ✓ Maintain global warming as per Paris Agreement
- ✓ Global leaders in export for EV, Alternate fuels & Hydrogen technology

Urban Mobility – Key Drivers

Integrated Approach For Sustainable Cities

Connectivity Revolution

Better & Affordable Public Transport Systems

New business & mobility models
Customer Preferences

Optimised Urban Freight Delivery And Logistics

Urban Access Restriction Schemes

Mobility – 5 Dimensions

- Green Mobility (Propulsion Technology Transformations)
  - Gradual transition from fossil fuels (Alternative Energy, non-fossil fuels);
  - EV Adoption inter-city operation & shared mobility
  - Natural Gas Alternatives (CNG, LNG, Bio-CNG)
  - Hydrogen
- Connected Mobility
  - Key enabling Technologies: Internet of Things, Connected Systems will be the entire driving force for telematics. Technologies like ADAS, LiDAR will play a major role in safety and convenience of driving.
- Shared Mobility Connected and Autonomous Vehicles (CAVs) and Mobility-as-a-Service (MaaS)
- Mobility Eco-System
  - Key to the policy driven growth, synchronising public & private investments; driving employment & growth; and generating a co-existent eco-system for multiple alternative transports.
  - EV – charging infra, policy incentives, EV fleet policies, Alternative powertrains,
- Manage & Lead the Change (Opportunities & Risks).
  - How to ride the disruption.

Manage & Lead the Change

- Advance the TCO curves, get consumers to experiment, build the initial adoption momentum
- Fast track product & solution roadmaps, go for the best in class
- Invest before the curve, push for scale
- Solve for the entire mobility ecosystem, not just rolling stock
- Build partnerships, drive disruption together and create win-win for all stake holders
- Offer a stable policy support
- Lead the change in India, and build the muscle to take it to the global markets

5. Electric Mobility

Electric Mobility - Overview

- The global electric vehicle market is projected to grow from 3 million units in 2019 to reach 27 million units by 2030, at a CAGR of 21.1%.
- EV acceleration varies by country. e.g., China EV market 3 times the size of Europe or US.
- More than 300 new EV models are expected to be market by 2025
- While global EV sales remain low, key factors that drive this change are : push for CO2 emission reduction, policy and regulatory measures by respective countries, strategic public and private investments in creating eco-systems including charging infra, incentivisation, and also rising customer demand.
- Primary factors on customers side remain however, are the Value Proposition, Expected Range for single charge (determined by Usage pattern), and availability of Charge Infra.
- Primary factors on governments side remain Energy Security, Reduction of high imports bill of Fossil Fuels, CO2 emissions, City pollution etc. Incentives for initial phase till Technology maturity (though Govt. also losses tax revenues from substitution of fossil fuels).
- Countries that take lead can be successful with clear policy & strategic intent (including supportive eco-system as well as regulatory framework on carbon emissions).

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State of Global Play

US

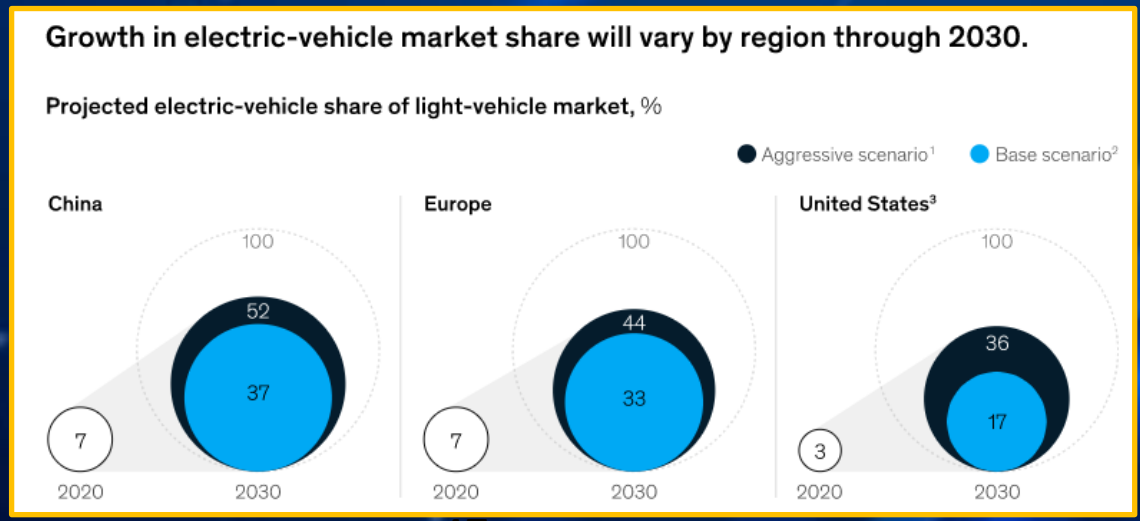
- The US electric vehicles market is expected to reach 6.9 million unit sales by 2025, up from 1.4 million unit sales forecast for 2020, due to government incentives driving EV ownership, Frost & Sullivan, Nov. 19
- Mild hybrid EVs (MHEVs) and fully hybrid EVs (FHEVs) would account for the maximum market share of 89.6% combined in the EV market by 2025

Norway

- Norway's parliament set a non-binding goal to ensure that all cars sold should be zero emissions by 2025.
- Norway is the world leader in terms of EV adoption and sales penetration.
- 2019 was another big year, with nearly 13% YoY growth and 71% new PC sales penetration
- EV sales in Norway crossed the 100K mark for the first time, getting closer to 100% penetration
- The success of EVs is being driven by strong incentivization, which makes EVs more economical than ICE vehicles and a vast charging network

China

- Canalys forecasts 1.9 million EVs will be sold in China in 2021, growth of 51% and a 9% share of all cars sold in China
- Platts assessed battery-grade lithium carbonate up Yuan 4,500/mt on Dec.'20 at Yuan 48,000/mt while lithium hydroxide was assessed Yuan 2,000/mt higher at Yuan 50,000/mt. Both assessments are on a DDP China basis. Lithium carbonate prices are now at their highest level since Jan. 10, having gained Yuan 8,000/mt since the intermittent stop-start uptick that began Sept. 9



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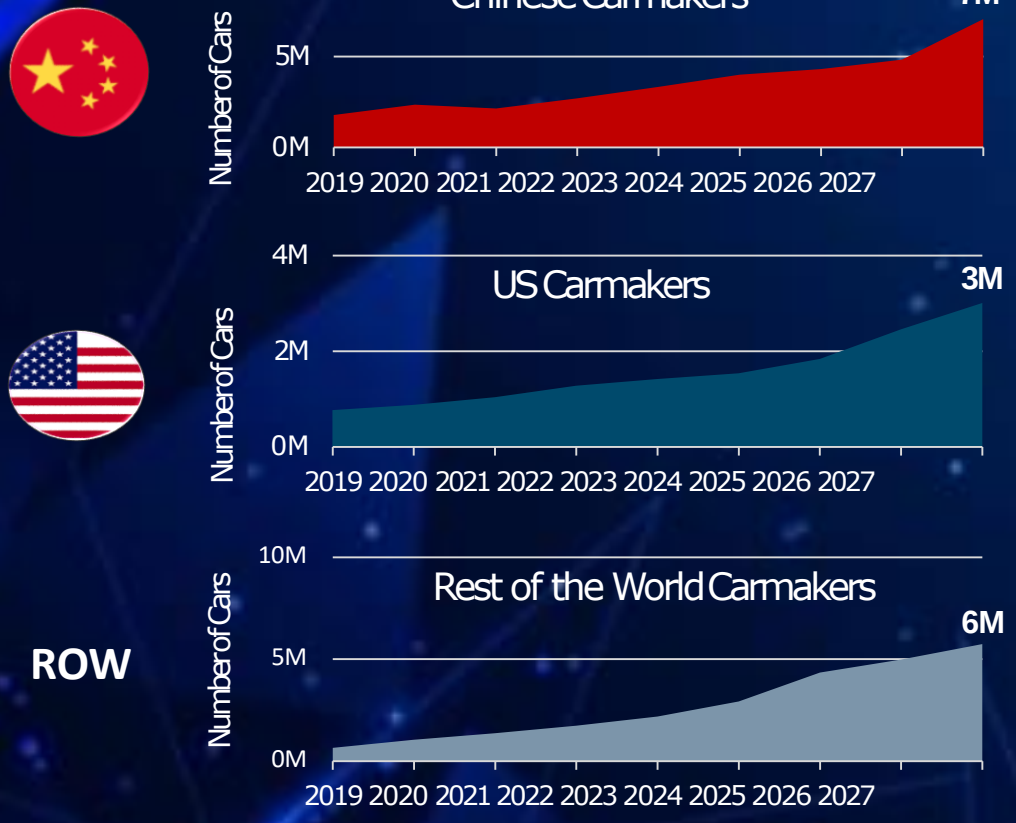
China's Push for Global Leadership

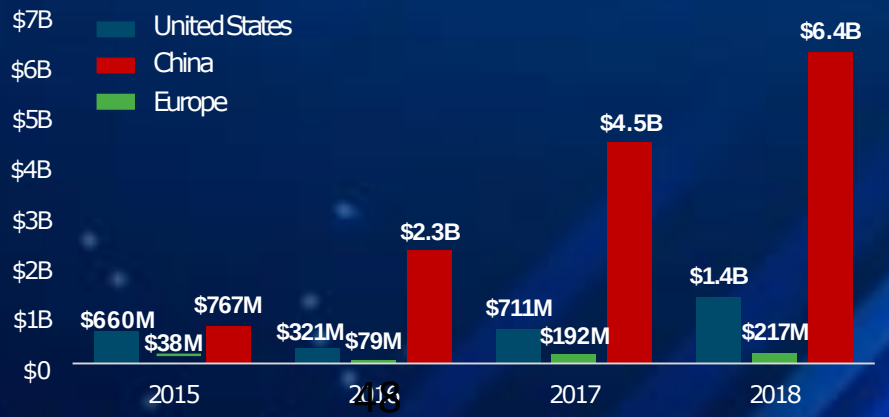
With about two-thirds of the 3 million EVs worldwide made and used in China and is emerging as a global leader in EV development and adoption

EV Sales Forecast by Global Region



Population of Five Largest Cities: China vs. US

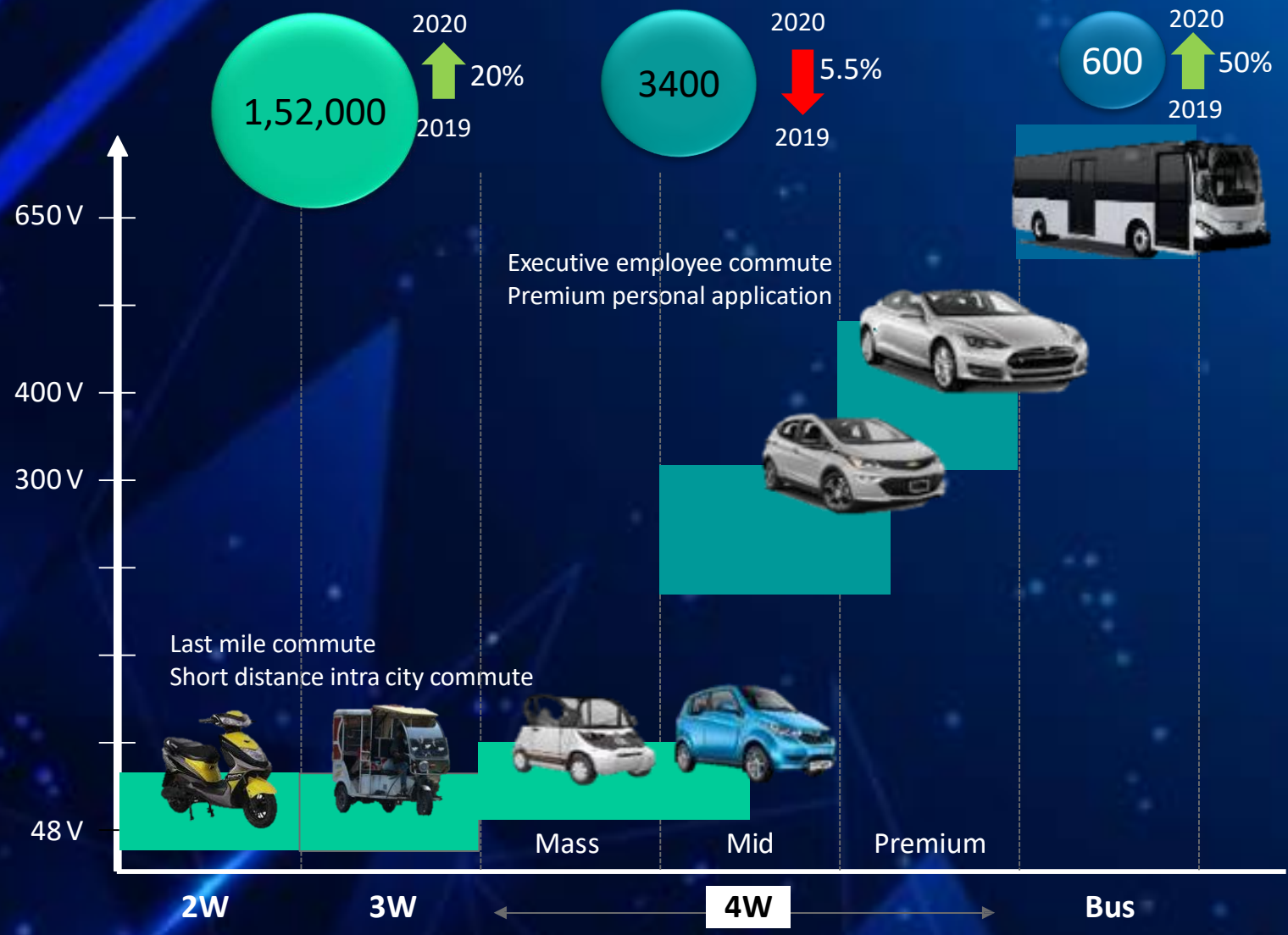
Global Venture Investment in EVs: 2014-2018



Source: The World Bank, Bloomberg, PitchBook and SVBanalysis

India EV– Application Spectrum & Adoption Curve

Despite slowdown in FY20 EV industry posts 20% growth in domestic sales
Out of 156,000 electric vehicles sold in FY20, 152,000 were two-wheelers, 3400 cars and 600 were buses



India's 2030 vision of e-mobility:

Sales to be electric by 2030 translates into 102 million EVs:

- 70% of all commercial cars
- 30% of private cars
- 40% of buses
- 80% of two-wheeler (2W) and three-wheeler (3W)

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6 Key Factors for EV Adoption

Energy Security

- India oil imports bill $110bn in 2018-19, est. to grow **to $180bn by 2030.**
- Phased Shift to EV can also provide India's financially strapped power **utilities $11 billion a year (700 billion rupees) in revenue**, enough to cut the sector's financial deficit by at least half

Source: Berkeley Lab report

Total Cost of Ownership

- **High-speed e-2W**: TCO breakeven is achieved e-2W at about 40 Km/day usage
- **E- Autos:** for an average daily use case of 100 Km, TCO is about 15% lower than an ICE Auto
- **E-4W:** For an average daily use case of 120 Km, TCO for an e-4W is 12% lower than ICE 4W
- **E-Bus:** TCO of a city e-bus is 40% higher than a diesel city bus. The FAME-II subsidy covers for this differential in TCO and hence enables a breakeven with its ICE counterpart.

Incentives

- Incentives to improve value proposition for customers – Registration Tax, GST rate to bring down initial price.
- Free parking lots, discounted road tolls
- Free battery-charging points
- Battery prices in India currently follow global price trends; could reduce global costs by as much as 50 percent

Charging Infra

- Public Investments in charging infra.
- Rules for new buildings and public places, including parking lots.
- Smart Grids
- High Speed Charging stations esp. on long haul.
- Public-Private partnerships and incentivised investments by private players.

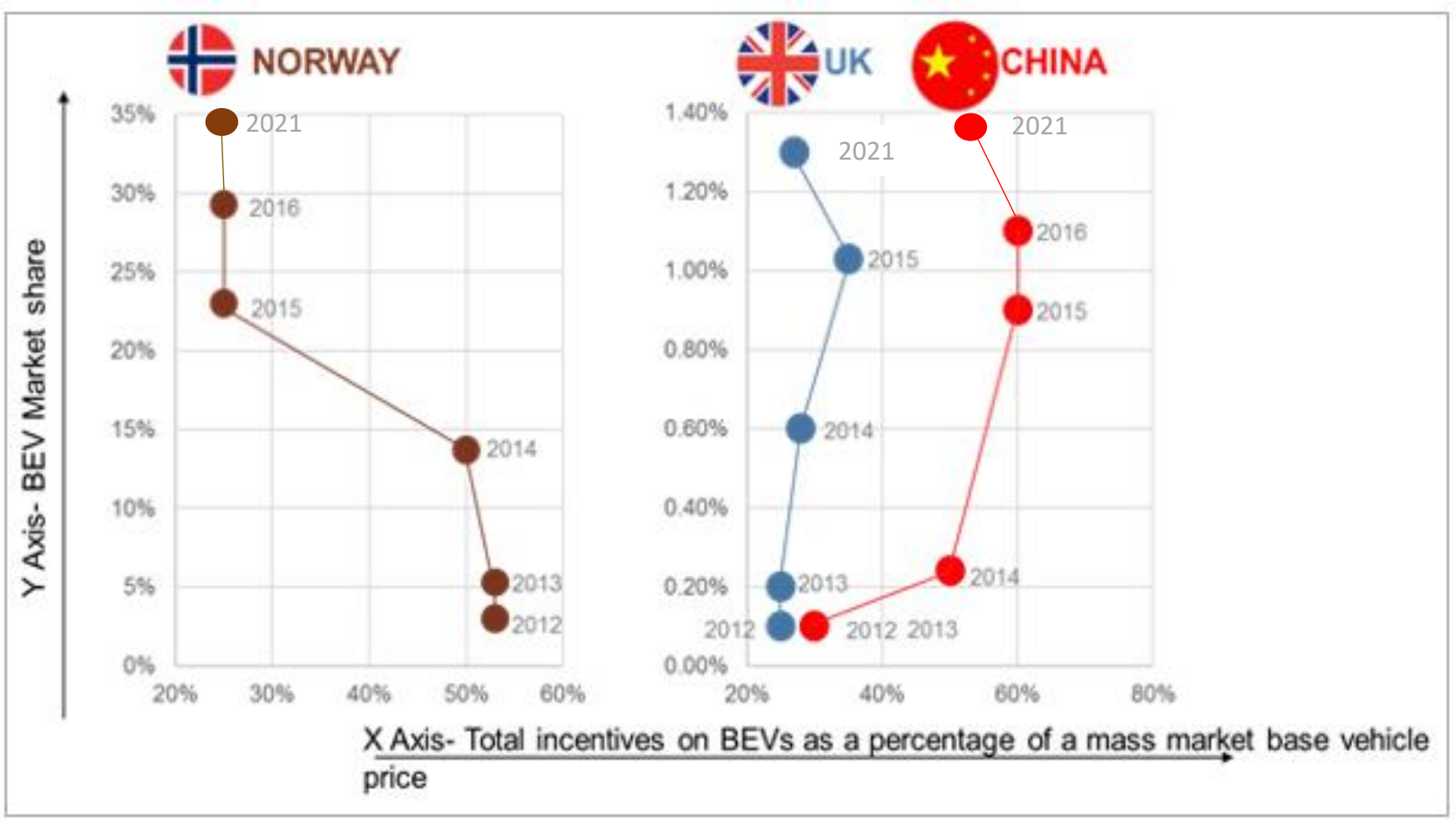
Policy

- Policy framework to encourage manufacturing and selling of EVs
- Framework to procure battery raw material from countries with special pricing
- Gove to have JV/purchase mines outside India for supply of battery raw material
- Investments in R&D to scale-up with subsidies to OEM's to manufacture low cost EVs

Battery Tech

- Range worry
- Raw material localization
- Development of alternate material for battery
- Local manufacturing of EV components and new technologies to reduce cost from import
- Skilling manpower for future tech dev.
- Advancements in cathode material and anode technology could improve energy density, prolonging battery life. Improved battery efficiency ,reducing costs

Global Policy Outlook – Incentives



Norway - The current Government has decided to keep the **incentives** for zero-emission cars until the end of **2021**. After **2021** the **incentives** will be revised and adjusted parallel with the market development

UK - The Government has cut the electric car grant from £3,000 to £2,500 and excluded models that cost more than £35,000

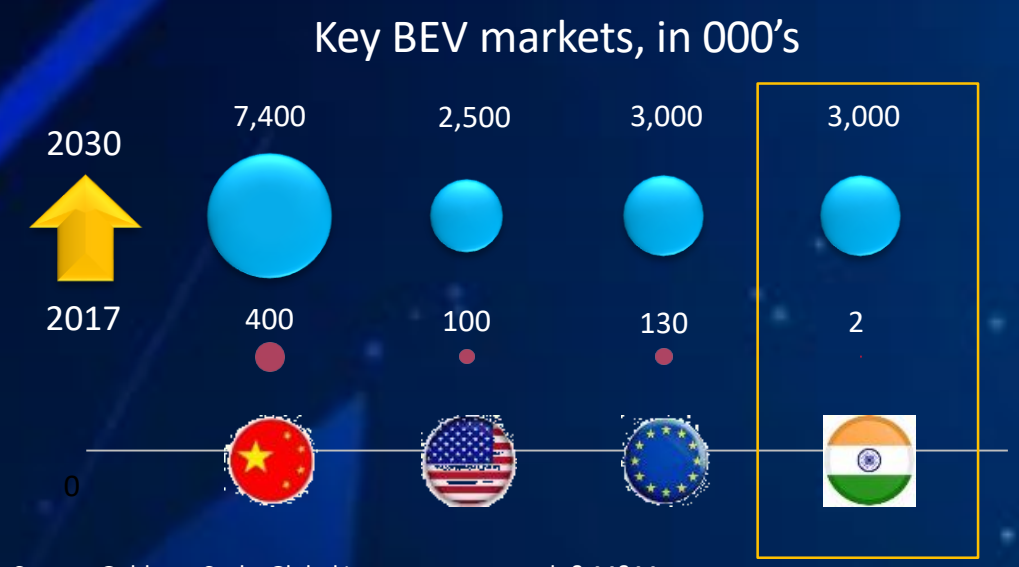
China's EV subsidies - the standard pay-out last year was roughly RMB18,000 ($2,800). That discount in 2021 will be reduced to around RMB14,400

India: Proposed Incentives for EV

- Lower tax: reduced circulation or road tax and are exempt from VAT & registration fees
- Municipality-owned parking lots to offer free parking & discounted road tolls
- Special transport lanes: access to dedicated, fast-moving lanes
- Free battery-charging points: An increasing number of publicly-funded charging stations for users to charge for free
- Growing demand, exploring high volume sourcing of critical components, resulting in significant reduction of costs

Key markets have provided a high level of incentives to help grow market share of EV's and then have tapered off the incentives helping the EV market to grow organically

EVs : The ‘Make in India’ Opportunity



Source: Goldman Sachs Global Investment research & M&M

The global electric vehicle market is projected to grow from 3 million units in 2019 to reach 27 million units by 2030, at a CAGR of 21.1%

Can India become world’s top 3 EV markets

?

- Investments in R & D
- Localization of Battery
- Investments in Infrastructure
- Leverage Export

Opportunities for India

According to ResearchAndMarkets.com the global electric vehicle component market is projeted to reach $157.4 billion by 2025 from $22.2 billion in 2018 at a compound annual growth rate (CAGR) of 29.4 per cent during the the forecast period of 2019 to 2024.

EV powertrain sub systems

Opportunity to create/grow electronics hardware industry in India

Battery module / pack

Creating manufacturing jobs for batteries and the energy storage industry

Power Electronics

Light weighting is a key necessity for EVs and can provide growth to the Al and chemical industries

Light weighting technologies

Software

Each EV model requires millions of lines of software code to operate, creating jobs in software

Potential to be Global Exporters for EV's

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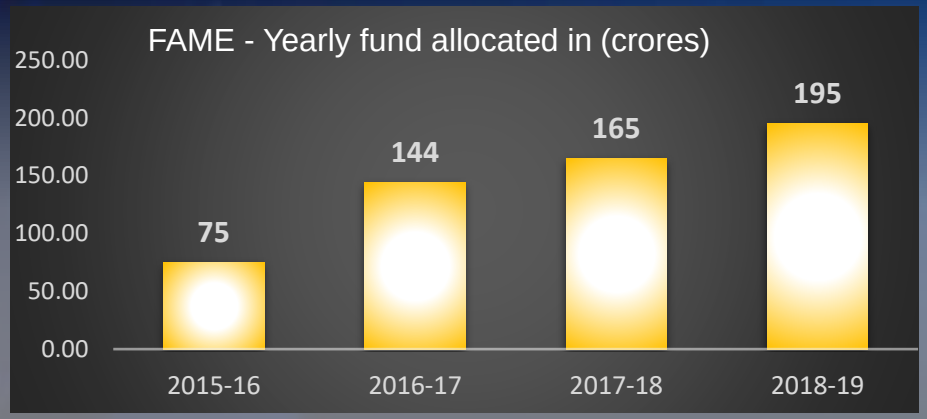
Govt. of India Initiatives

- The Government of India started Faster Adoption and Manufacturing of Hybrid and Electric vehicles (FAME) w.e.f 1st April 2015 – I & II scheme which provides financial incentives for attractive EV production and creation of electric transportation infrastructure.



Category (amount in crore)	2019-20	2020-21	2021-22	Total
Demand incentives	822	4587	3187	8596
Charging infrastructure.	300	400	300	1000
Administration activities	12	13	13	38
FAME 2 Total	**1134**	**5000**	**3500**	**9634**
FAME 1 Total	**366**	**0**	**0**	**366**

- The National Mission for Electric Mobility (NCEM) has launched the National Electric Mobility Mission Plan (NEMMP)- 2020 with an aim to invest INR 140 billion in the next 8 years for the development of electric infrastructure.
- Recently the Government released a two-pronged strategy aimed at both buyers and manufacturers, in which it offers $1.4 billion in subsidies to buyers while imposing a hike on import tariffs to increase manufacturing of these vehicles by domestic companies.

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Multifaceted Strategy & Action Plan

	Micro-Mobility (0–10 Km)	Medium Mobility (10–50 Km)	Long Distance (50+ Km)	Action Plan Phase-1	Action Plan Phase-2
	✓	--	✗	• Dedicated cycle lanes • Charging infra set-up	• Rental cycle access • TCO reduce by domestic manufacturing
	✓	✓	✗	• Charging infra set-up • Low cost products	• Govt. incentive schemes to boost adoption
	✓	✓	✗	• Low cost products • Fast charging solutions	• TCO low • Govt. incentives
	✓	✓	--	• TCO low for high adoption • Fast charging stations	• Solution for Range worry • Govt. incentive schemes
	✓	✓	✗	• Charging Infra • Govt. fleet as early adopters	• Range worry, not for long distance
	--	✓	✗	• Heavy & fast charging infra in urban, rural & highways is a challenge	• EV does not seem a solution in long-haul

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India EV – 10 year Opportunity Horizon

	Short-term (2-year)	Medium term (5-year)	Long term (10-year)
Mobility	• EV growth in both passenger & commercial segments: 2W, 3W, 4W • E-Bus segment to be deployed across smart cities	• Electric Inter-city & Long Haul CV • Investments in robust Power Grid – Smart & Flexible to deal with Renewable Energy	• Electric Dozers / Dumpers / Excavators

Technology	• EV battery tech – power density, cost $/kW, scaled-up manufacturing
	• EV system aggregates:
	  • Motors
	  • Invertors
	  • Controls & software
	  • ECUs, DCUs
	  • Semi-conductors
		• Recycling & disposal of EV and Batteries
		• EV battery tech - New battery materials, power density, cost $/kW, scaled-up manufacturing
		• Cells and Cell Component Manufacturing
		• ECUs, MCUs (HW)
		• Fast and wireless Charging technology
		• High performance computing, GPU's
		• Investments in robust Power Grid Fast charging
			• Fuel Cells, Solid State Batteries
			• Next Generation Cell Chemistries
			• ADAS – Sensors & Technology
			• Recycling of EV batteries

Interventions

Government

- Long Term Road Map – for emissions, fuels, vehicle regulatory framework
- Incentives for buying Electric Vehicles
- Debottleneck mobility – toll booths, ports
- Legal and statutory framework
- Mechanism for startups and industry to access mobility related data

Industry

- Set up a mechanism for industry to share focus areas
- Engagement opportunities with Start-ups for co-innovation and development
- Virtual product engineering solution
- Investments for future readiness of EV parts manufacturing and battery tech
- Collaboration with Global players

Academia

- Framework to work on technologies and products across TRLs
- Studies on future tech on EV's with focus on Battery tech
- Facilitate Academic institutions to collaborate with MSME technology centres

India - Key Actions / Opportunities

- Energy Transition
  - Oil imports reduction – with 25% shift from fossil fuels by 2030, we could save est. $40Bn of oil imports, as well as bring added revenue to cash strapped power utilities sector up to $11Bn billion a year (700 billion rupees).
  - Shift to clean energy for the charging infra has a significant impact on city emissions, and can help India meet its 2030 carbon reduction goals.

- Policy & regulatory framework (FAME I/ FAME II)
  - Review of current FAME policies to bring a synchronised incentivisation as well as boost public-private investments to encourage EV manufacturing & sales

- Battery Tech & EV Components Scale-up:
  - Invest in Battery Tech as well as clear roadmap for localized cell manufacturing as well battery modules
  - A large component of the cost structure, battery prices have rapidly fallen and could continue to drop Battery prices in India currently follow global price trends
  - Invest in key EV components, such as motors.

India - Key Actions / Opportunities

- Charging Infra:
  - Shaping the charging eco-system
  - Key investments and development of infra at multi locations to ease to range worry
- Re-skilling and development of complete eco-system
  - Academia-Industry eco-system for skilling and development in new EV tech
- Global Trade - Exports Opportunity
  - Investments in EV component manufacturing with a potential to becomes exports hub.
  - Free battery-charging points

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6. Alternate Fuels - Natural Gas

(CNG / LNG / Bio-CNG)

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Natural Gas Outlook

- India and the US plan to revamp the India-US strategic energy partnership “to reflect the new priorities", with a focus on low-carbon pathways and accelerating green energy cooperation and on 31st March’21 agreed to prioritise greater collaboration in cleaner energy sector- biofuels, CCUS, hydrogen production and carbon sequestration through technology exchange, joint R&D through Partnership to Advance Clean Energy Research (PACE-R)
- India Natural Gas and LNG market is expected to grow from US$ 19.7 billion in 2015 to US$ 30.7 billion by 2025 at a CAGR of 5.06% between 2016 and 2025
- India is planning a massive USD 66 billion investment in the building of gas infrastructure as the government pushes for greater use of the cleaner fuel with a view to cutting down carbon emissions.
- Share of natural gas in India’s energy basket is set to rise to 15% by 2030, from the current 6.3% (includes pipelines, city gas distribution, and LNG regasification terminals).
- Govt. is targeting 1,000 LNG stations in next 3 years, and is likely to add 20-25 mmscmd of NG demand by 2035.
- National Biofuel Policy is targeting blending of 20 per cent ethanol in petrol and 5 per cent of bio-diesel by 2030

https://www.livemint.com/industry/energy/india-and-us-to-revamp-strategic-energy-partnership-11617082630984.html
https://economictimes.indiatimes.com/industry/energy/oil-gas/india-to-see-66-billion-investment-in-gas-infrastructure/articleshow/79530384.cms?from=mdr

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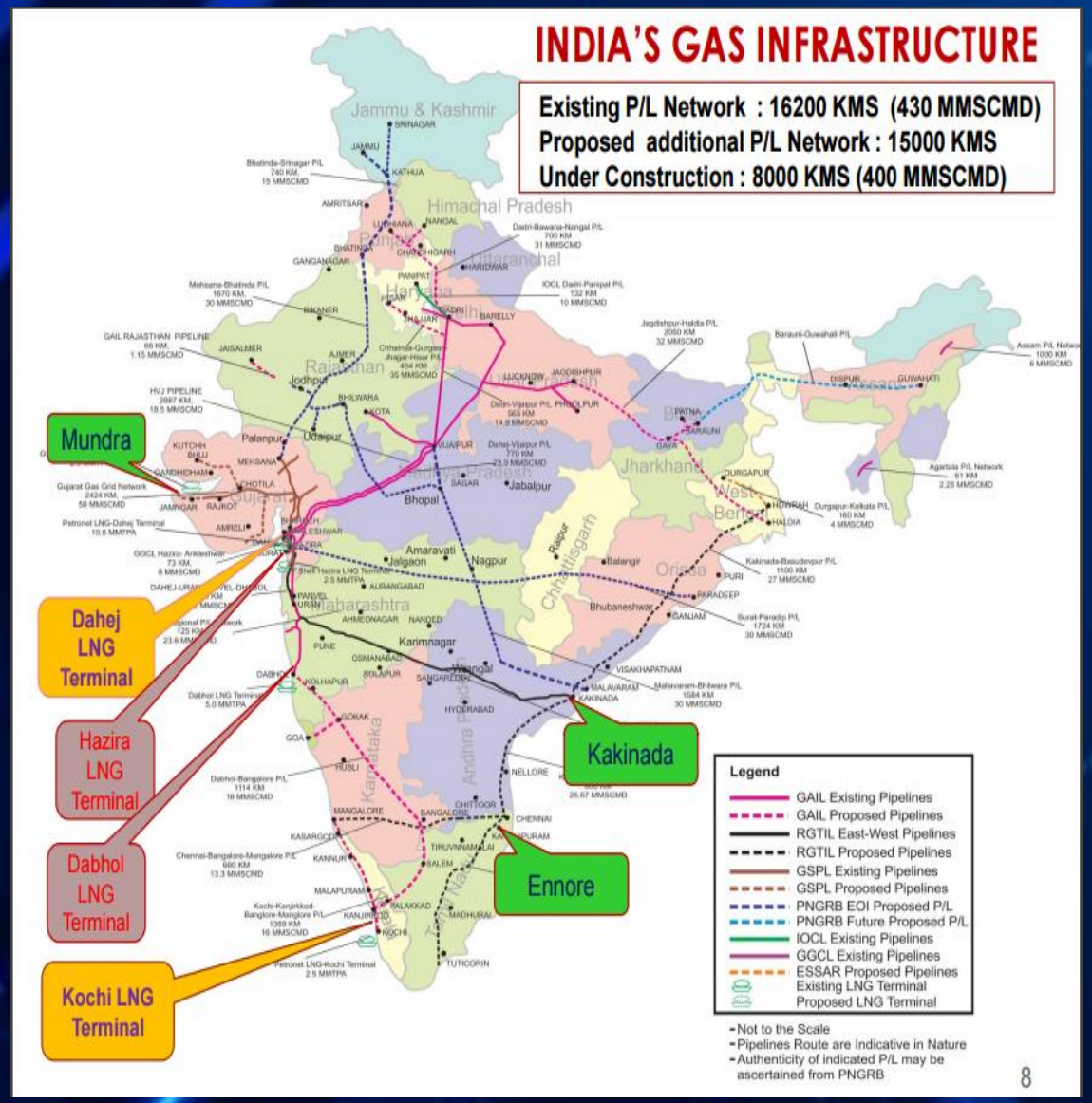
India - NG Infrastructure



- India is 4th largest LNG importer
- Additional Gas pipeline network of 14500 km in next 5 years
- By 2030 – 10,000 stations across 400+ cities

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CNG

Developing CNG Corridors

Developing Green CNG corridors on major inter-city highways with setup of CNG stations every 50 km.

Green Corridors:

- 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

Mobile CNG refuelling unit

Petrol/ Diesel supply apps in Pune, Delhi & Mumbai

Mobile CNG refuelling unit

- Gas Carrying capacity – 1500kg (> 150 cars)
- Concept being highly promoted by CGD for higher penetration of gas usage in transport sector.
- IGL plans to deploy at all National highway connecting Delhi

Mobile Cascade inaugurated by GoI

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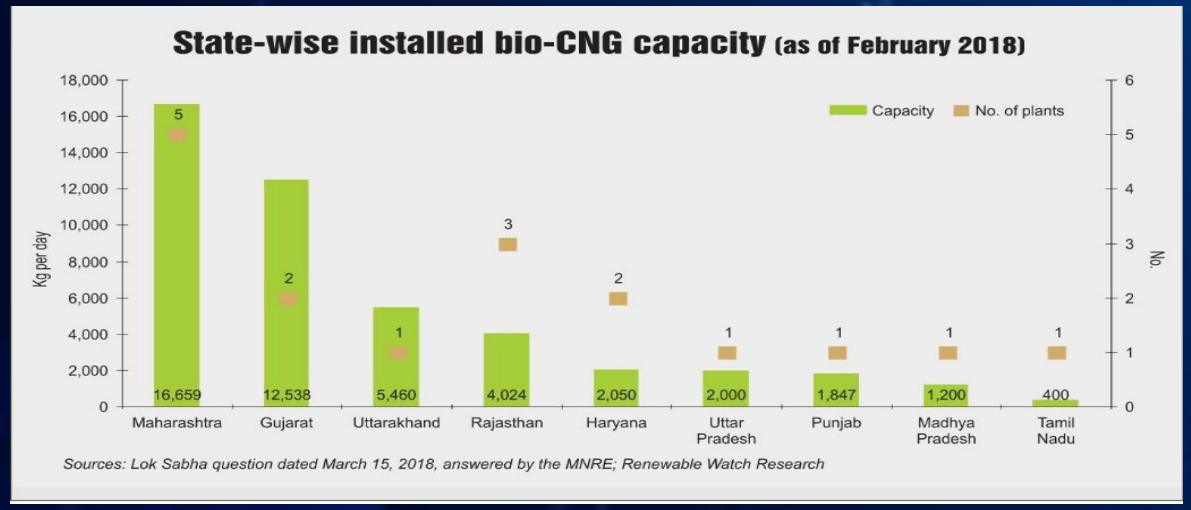
Bio-CNG

Bio-CNG – India Aspirations

- Estimated to replace two-thirds of India's Natural gas imports, which is currently at 429 billion cubic feet.
- 17 operational Bio-CNG plants operational in India, with a combined capacity of 46,178 kg per day.



Government Schemes to promote Feedstock for Bio-Gas

- SATAT (Sustainable Alternative Towards Affordable Transportation)
- Gobar-dhan Scheme
- Waste to Energy Program

Case Studies:

1. Mahindra World City, Chennai

- Converts 100% of 8 tons of food and kitchen waste into 1000 m^3 of raw biogas.
- Can be enriched to yield 400 kg/day of purified CNG grade and generated 4 tons of organic fertiliser is produced every

2. Carbon Masters, Bengaluru

- Production capacity of 1.6 tonnes of Bio-CNG per 40 tonnes of wet waste.
- Fertiliser production : 1 tonne against the capacity of 8 tonnes.

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Bio-CNG – Sustainable Energy Solution

5000 CBG plant by 2023-24
15 MMT Production
1.75 Lakh Cr Investment

India's 1st plant to convert paddy straw into biogas near Delhi
40,000 T Paddy/yr
10000 kg CBG/Day

First of its kind project
8000 kg/day Bio-CNG

Bio CNG Plant at MWC, Chennai
400kg/day CNG equivalent to 200kW Power Plant

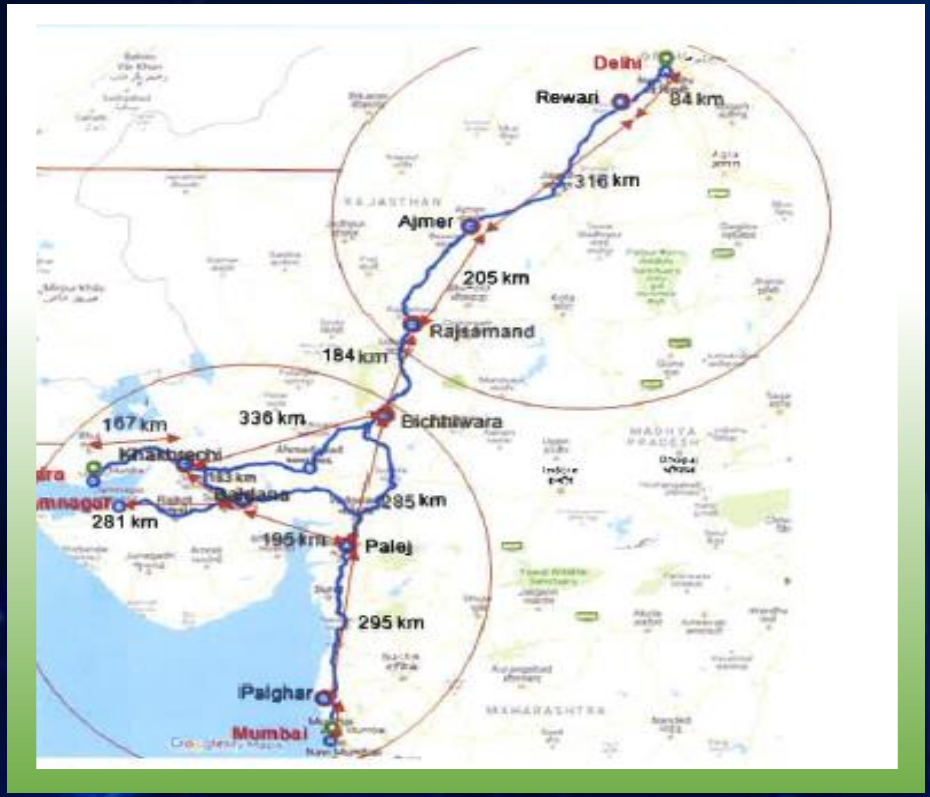
LNG

GoI - Vision

LNG Station every 250 Km, Covering major highways – Blue Corridors

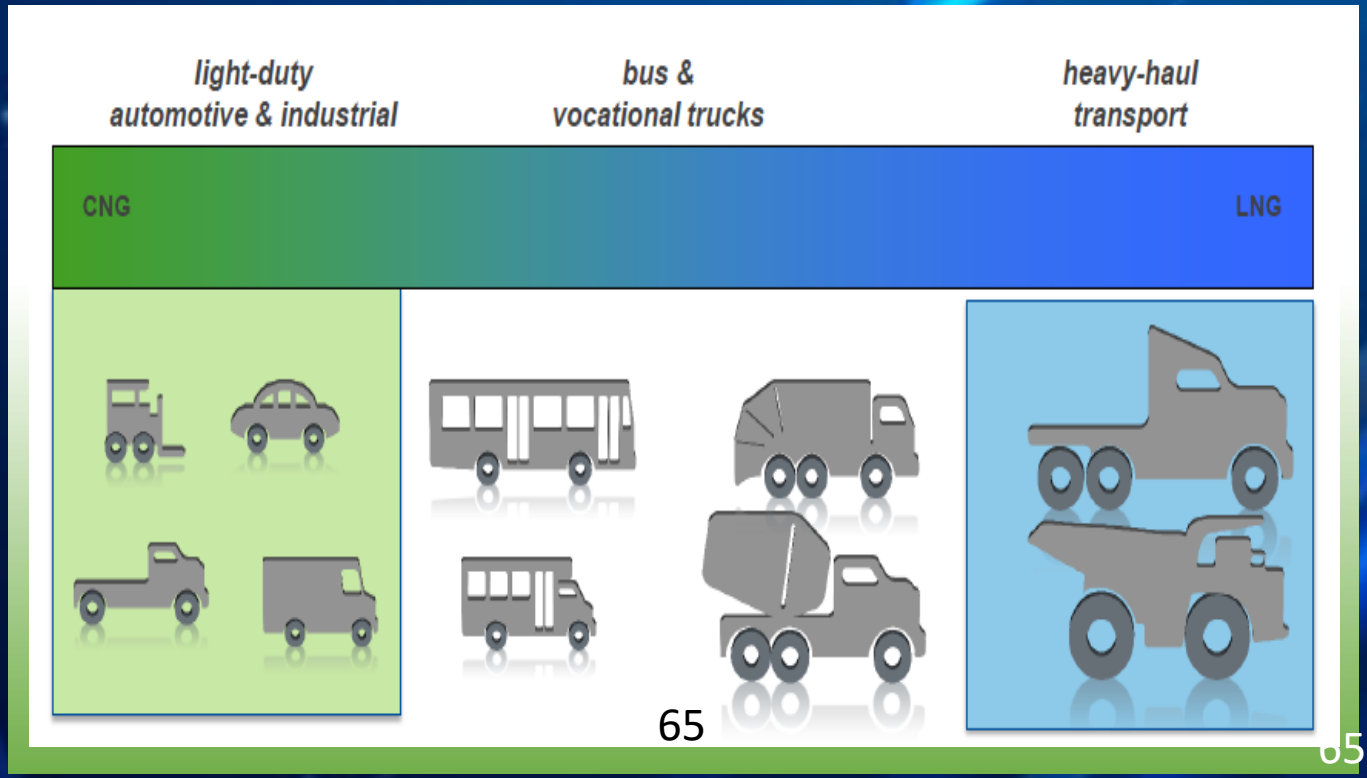
Phase 1 (2021-22)

- Covers 4000 km of National highway on Delhi-Mumbai & Southern corridors
- Cater to anticipated 6500 LNG Trucks.
- 50 dispensing stations, Demand of 0.17 MTPA



Phase 2 (2023-24)

- Covers Golden Quadrilateral & major highways
- Cumulative 20,000 Trucks
- 1000 Dispensing stations
- Demand of 1 MTPA



India Portfolio of Achievements

JCB DUALFUEL

- **68 % Substitution in Excavation**
- **19 Hours Single Fill Operations**
- **£ 1,100 Per Year Savings**

CNG

Automotive Industry :

- Maruti Suzuki has sold 1.57 lakh CNG cars in FY21 (48% growth over FY20). Offers offers - 8/14 models in CNG
- Hyundai, Tata also aggressively developing CNG variants
- Tata motors plans to sell 25,000 CNG trucks (Growth of 200% over last year)
- Mahindra, Eicher and SML – 3 digit growth

Alternate Fuels Maturity - Requirements

Fuel	Details	Technology	Infrastructure
CNG	Can be used in modified ICE in place of Petrol & Diesel.	Vehicle & Storage Technology in Place	Need for City Gas Infrastructure Buildout
LPG	Limited to smaller vehicles	Technology Available	City Distribution Infrastructure required
LNG	Best suited for Long Haul Vehicles – Particularly Trucks and Buses – from a TCO perspective	Vehicle Storage Technology need to be localized	Distribution remains a key challenge
Bio Diesel	Form of Diesel made from a variety of sources	Technology generally available but fuel quality challenges remain	Distribution and Quality control
Ethanol	Used primary as a blend with gasoline or “neat”	To develop flex-fuel Engines	Distribution and Quality Control
Synthetic Fuel	Wide variety of Fuels that directly substitute diesel and gasoline	Significant challenges for large scale production	Significant challenges for large scale production

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10-Year Technology Spectrum

	Short-term (2-year)	Medium term (5-year)	Long term (10-year)
Mobility	• Leverage existing fuels to increase penetration • CNG, LPG, Bio-diesel etc.	• Increased use of LNG, Ethanol etc. • Pilot batches on use of H2 – ICE and Fuel Cell	• 20% Penetration of Alternate Fuels • Increased use of alternate fuels in Mobility
Technology	• Production for LNG cylinders • Localization of key components used in Alternate Fuel Vehicles	• Technology for Alternate Fuel Storage – LNG, H2 etc. • Fuel Cell development for Vehicle use • Technology for Green Hydrogen production • Battery for use in H2 Fuel Cell vehicles	• Low cost on-site H2 Production • Local Production of Fuel Cell & H2 Storage Tanks

Interventions	Government	Industry	Academia
	• Incentives for setting up CNG, LNG, stations & investment in renewable power • Fuel Cost of Alternate Fuels managed to enable TCO competitiveness • 5 Year Roadmap for Alternative Fuels • Regulatory Framework for Alternate Fuel Distribution and Vehicles • Phased Manufacturing Program for Alternate Fuel components • Incentivize the production and use of Green Hydrogen • Enable ecosystem for H2 and other fuels by encouraging various stake-holders • Continued Push for Co2 neutral fuels such as Green Hydrogen, Synthetic Fuels	• Product Portfolio focused on Alternative Fuels • Increased R&D focus on Alternate Fuel Vehicles – partnerships and alliances • Focus on Fuels that are Carbon Neutral – Tank to Wheel • Commitment to reduce Co2 • 20% of Portfolio on Alternate Fuels • Investments to explore opportunities with alternate fuels, its validation, storage and component manufacturing for future readiness	• **Framework to work on technologies and products across TRLs** • **Focus of research of Alternate fuels technology and management** • **Facilitate Academic institutions to collaborate with MSME technology centres**

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Key Actions- Mobility

- 5 – 10 Year Alternate Fuel Map to enable all the stakeholders to align and optimize resources
- Regulatory framework for distribution, dispensing and use of alternate fuel
- Maintain favorable economics for Alternate Fuels vs Existing Fuels – Limiting other fuels in high congestion areas, Tax rebates etc.
- Marketing Alternate Fuels across segments and incentivize OEMs to manufacture variety of Alternate vehicles & support Penetration by incentivizing STUs.
- Incentivize existing City Gas Distribution players to expand pipeline infrastructure and retail stations- especially in Key Metro areas.
- Single Window Clearance Mechanism to setup retail stations, on-time regulatory approval from PESO & local municipalities, etc.
- Phased Manufacturing Program for the local manufacturing of critical components in the production, storage and vehicle.
- Support R&D of Technologies required for the Eco-system – as some of them will not succeed and individual stake-holder would be risk averse

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7. Alternate Fuels - HYDROGEN

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Hydrogen - Global Overview

- Significant Committed investments in Green Hydrogen world-wide – prod, storage, transportation and dispensing.
- Major countries have a stated Hydrogen Policy -
- USA : 1990 – 1st Hydrogen R&D Act by US Govt. 2019 – Govt. funding of US$ 31 Mn to advance the H2 Infrastructure. California Fuel Cell Partnership targets to set up 1000 hydrogen re-fuelling stations by 2030
- **Europe :** 2003 – 25 EU nations launched European H-Infrastructure & Technology R&D program. 2019 Hydrogen Road Map. Transition to ultra low carbon hydrogen production by 2030. 3700 re-fuelling stations are targeted by end of 2030.
- EU Hydrogen Strategy – To decarbonize Industry, Transport, Power Generation & Buildings – to transform this potential into reality – investments, regulation, market creation, and research and innovation
- **Japan :** H-established as National Energy. 2016-18: US$ 88 Mn budget on R&D and $ 500+ Mn budget on construction subsidies for H2 Stations. 2020 - Building up a commercial based domestic system for efficiently distributing hydrogen.
- **China** : Hydrogen is listed as Top 15 Tech & Infra programs of Govt. Targets 5,000 fuel-cell vehicles by 2020 and 1 million by 2030. Tax exemptions for hydrogen vehicles. Wuhan as a hydrogen city with up to 100 fuelling stations for around 5,000 fuel-cell vehicles by 2025.

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India Hydrogen Policy & Scale at National Level

- National Hydrogen Energy Road Map (NHERM) published by Ministry of New & Renewable Energy (MNRE) has set up clear milestones for India Hydrogen Economy

- Two major initiative programs of NHERM Board
  - Green Initiative for Future Transport (GIFT) – To develop & demonstrate H-powered IC engines and Fuel cell based vehicles
  - Green Initiative for Power Generation (GIP)

Post Covid (Current State) 2021 Perspective

- H-Cost at delivery point @ INR 240 /Kg
- H-Storage capacity ~2% weight
- Budgeted spend by GOI on H-infra: INR 25,000 Cr
- Three H-Dispensing stations, One Pure H2 & Two H-CNG blend
- Three vehicles by manufacturers – Tata Motors and M&M
- Safety & regulation legislations to be in place

Original Target of GOI – Pre-Covid

- H-Cost@ INR 60-70/Kg by 2020
- H-Storage capacity target 9% weight
- Adequate supporting infrastructure & Dispensing stations
- Pre-Covid Target: 1,000,000 H-vehicles
- 7,50,000 two/three wheelers, 150,000 cars/taxis and 100,000 buses, vans.

Infrastructure Implications of GOI Hydrogen Vision

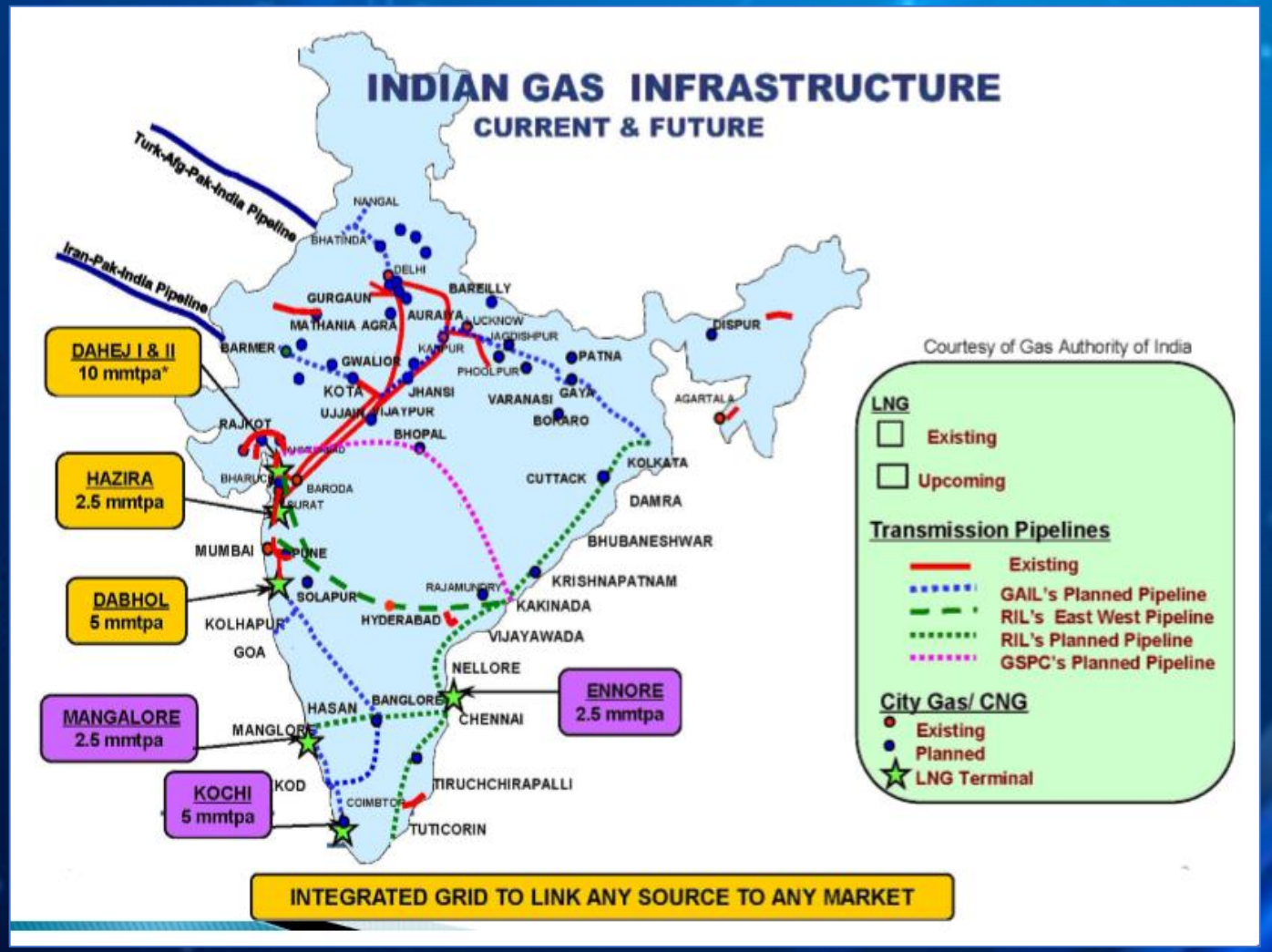
- GOI is revising its approach on H-Infra and generation capacity plan
- GIFT Vision to Demonstrate 1 million Hydrogen Vehicles would need 7,000 Tonnes of H_2 per day
- Green Initiative for Power Generation(GIP) - Setup 1,000MW Hydrogen Based Power Generation capacity
  - 50MW small IC engine stand alone generators
  - 50MW stand alone fuel cell power packs
  - 400MW Gas Turbine Based Power Plants
  - 500MW Central Fuel Cell Power Plants
- 900 MW aggregate capacity centralized plant
- Hydrogen bulk storage and pipeline systems to be in place
- Infrastructure spend by GOI – INR 25,000 Cr

Assumptions:

- Cars will run on Fuel Cells only
- 3-wheelers will run on both ICE & FCs
- Buses & Heavy machines will run only on Hydrogen ICE

Hydrogen Fuelling Infrastructure in India

- Key Infrastructure players -
  - Indian Oil Corporation (IOCL)
  - Gujrat State Petroleum Corporation
  - Hindustan Petroleum
  - Bharat Petroleum
  - Reliance Group
- Pipelines tend to run in major cities and for industrial applications/buses
- Key challenge is Bulk delivery
- Liquid/Gaseous Hydrogen providers in India
  - Inox AP
  - Air Liquide
  - Praxair
  - Linde Presence
  - Eden (Hythane/L&T)



Picture courtesy Gas Authority of India Ltd.

Hydrogen Vehicles in India

Tata Motors developed H-Fuel Cell bus (2017)

Hydrogen IC Engine based by Mahindra & Mahindra (2016)

Hy Alfa – Hydrogen Powered 3 Wheeler (2012)

Passenger Vehicles planned by 2023 by world manufacturers in India

- Toyota Mirai (range 500km)
- Honda Clarity (range 590km)
- Hyundai Tucson Fuel Cell (425 km)

JCB Announces Hydrogen Fuel Combustion Engine Technology

By FuelCellsWorks | May 17, 2021 | *3 min read* (409 words)

Heavy equipment manufacturer JCB Announced a hydrogen-fueled piston engine that emits no CO2 and believes it will help the transportation industry reach the UK government's zero-emissions target faster than existing solutions.

According to the survey, JCB has a new engine JCB Diesel Max 4484 Cylinder Engine However, significant changes to the top end not only do not produce CO2, but both have significant advantages over the fairly expensive battery-powered electric and hydrogen fuel cell solutions.

Key Recommendations

- Need to develop a Hydrogen Strategy blueprint / National Hydrogen Energy Road Map .
- India must explore ICE technology fuelled by Hydrogen – least impact on current supply chain. IIT-D research project 2006
- Distribution - Experience from H-CNG project to benefit in development.
- Switchover to Fuel cell route to be made once Fuel cells become cost competitive.
- CII should form a dedicated “Hydrogen Mobility Sub-group” to create Hydrogen India strategy

8. IoT & Connected Mobility

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IoT - Global Scale

- IoT connected devices estimated 24.1 billion by 2030, from 7.6 billion active in 2019
- 2030 revenue US$1.5 trillion, from 2019 US$465 billion.
- India has world's largest smart phone users, IoT growth projections can beat above estimates.
- By 2023, c. 25% of all passenger cars in use worldwide will be connected.
- Shared mobility set to transform (daily rides on shared platforms will increase from 1 million in 2017 to 11 million in 2025).
- By 2025 17% of rides will be using shared mobility, compared to 10% in 2017.
- Global 5G enabled IIoT market will reach $314.6 billion by 2030, growing by 26.9% annually over 2020-2030 despite the impact of COVID-19

IoT - Global Scale

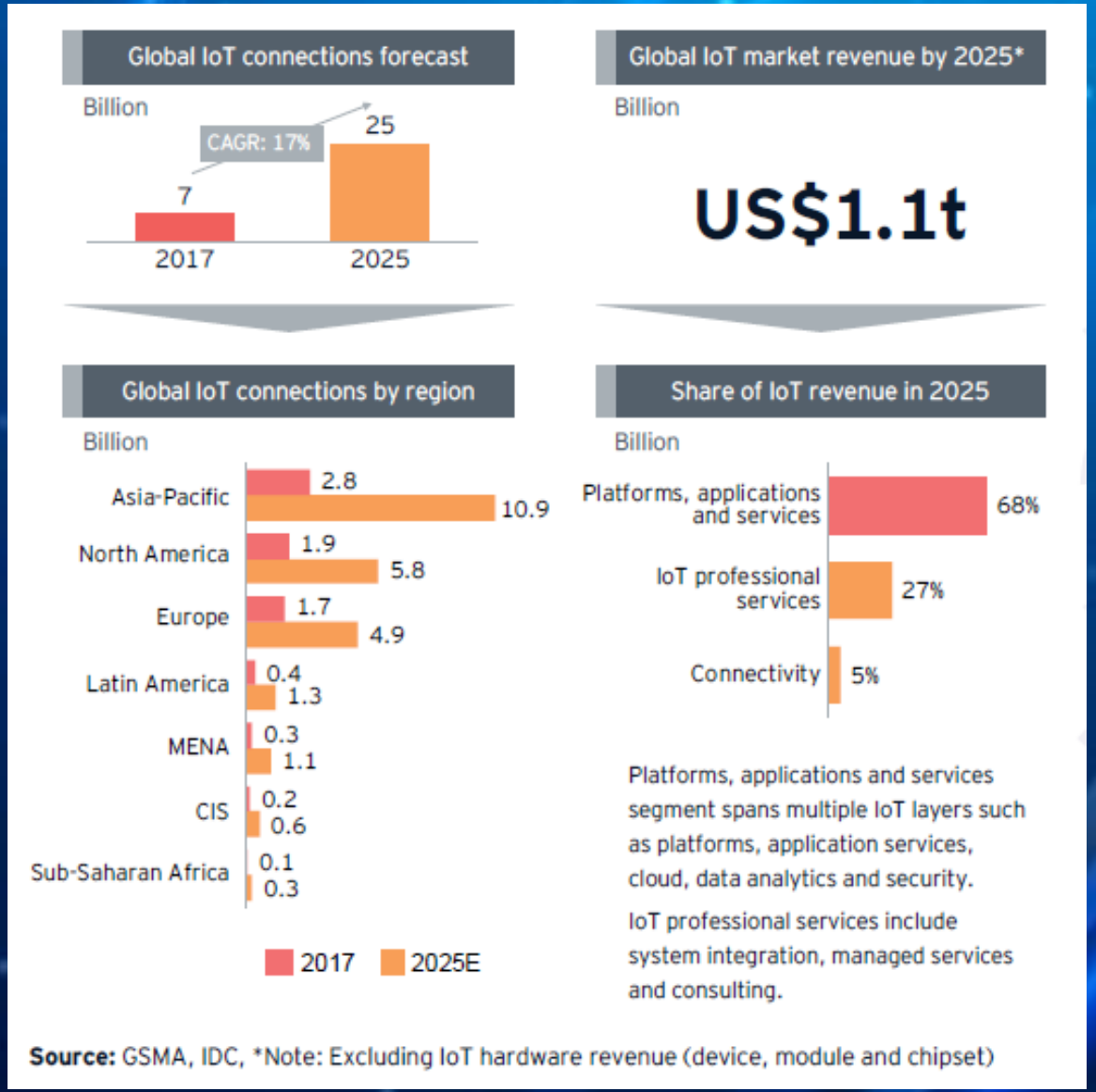
Global IoT market revenue split :

- 68% from Platforms, applications & services
- 27% from IoT professional services
- 5% from connectivity

Global IoT devices regional split (of 24 billion est. devices by 2025) :

- Greater China region (comprising China and Taiwan) is the largest with 6.9 billion
- Europe at 5.5 billion
- NA 5.2 billion
- India >5 billion
- ROW <1.6 billion

Can India leverage global opportunity?



Shared Mobility

Micro-Mobility

0–5 Miles

Electric bikes, scooters, skateboards

Medium Distance

5–15 Miles

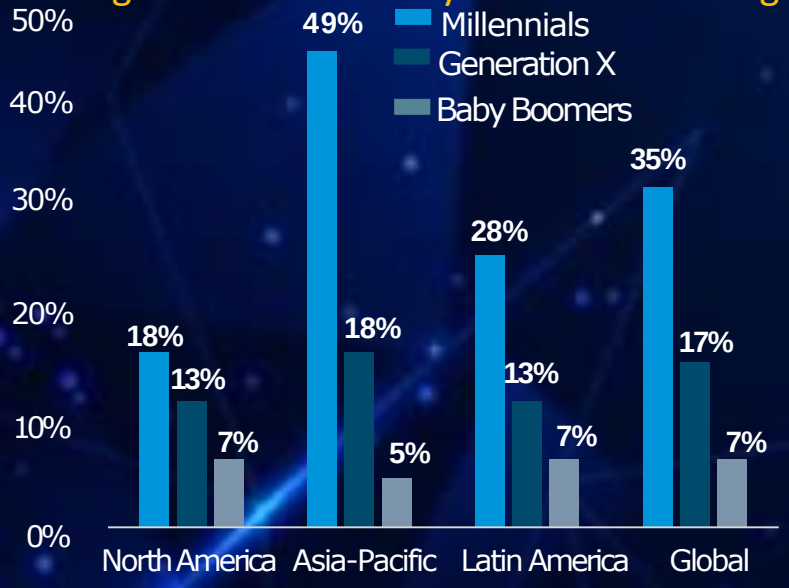
Ride-hailing

Long Distance

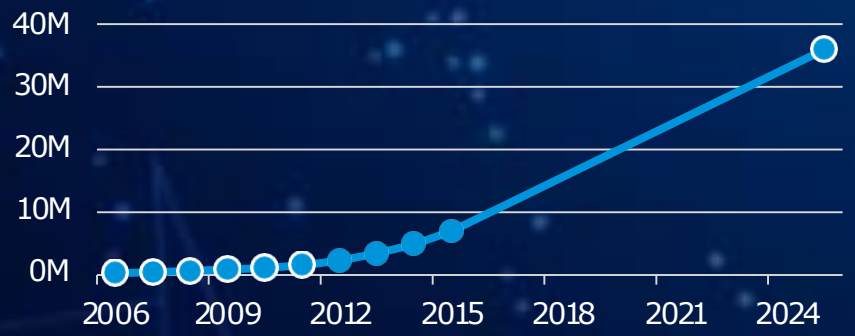
15+ Miles

Car-sharing, public transport, aerial transport

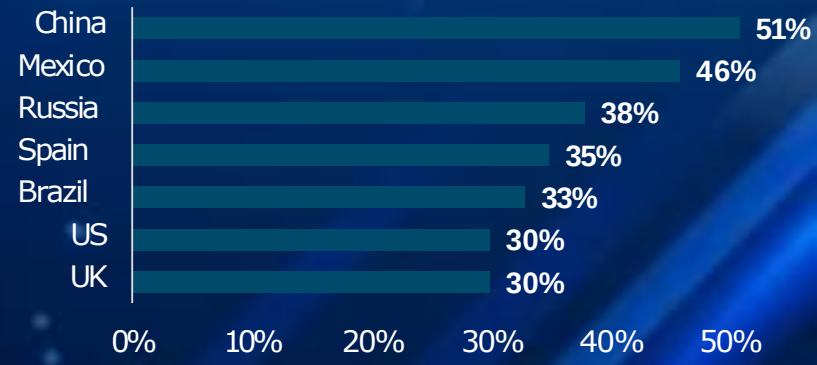
Willingness to Car-Share by Generation and Region



Number of People Worldwide Who Share Vehicles



Percentage of People Who Use Ride-Sharing Services by Country



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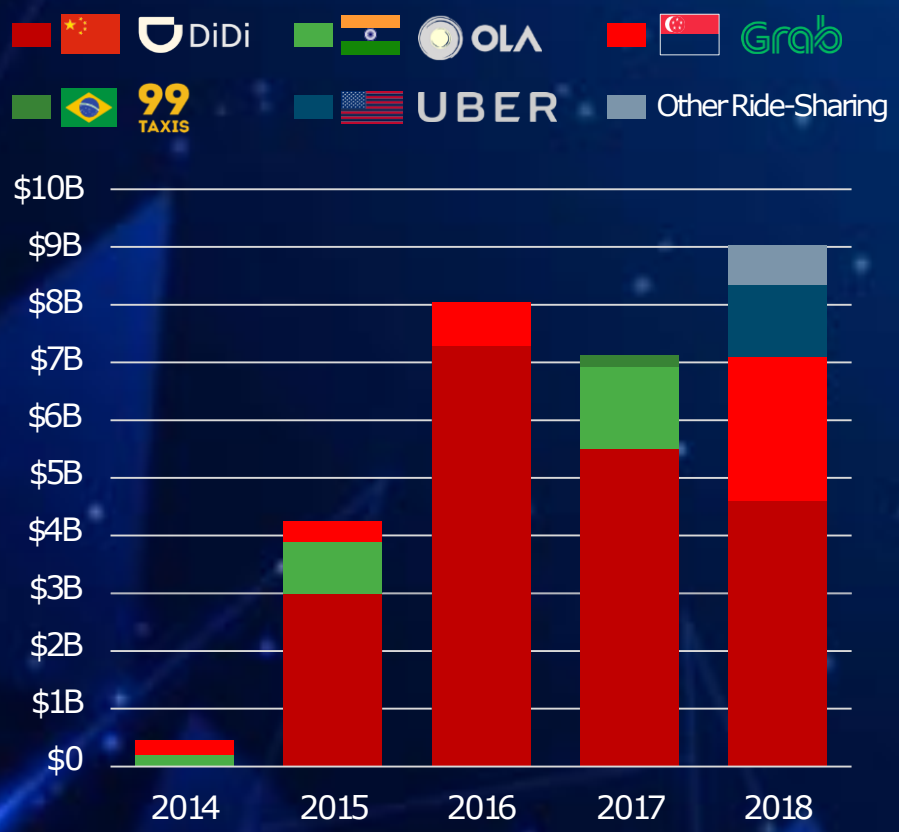
Source: Goldman Sachs, Dalia Research and Statista courtesy SVB Analysis

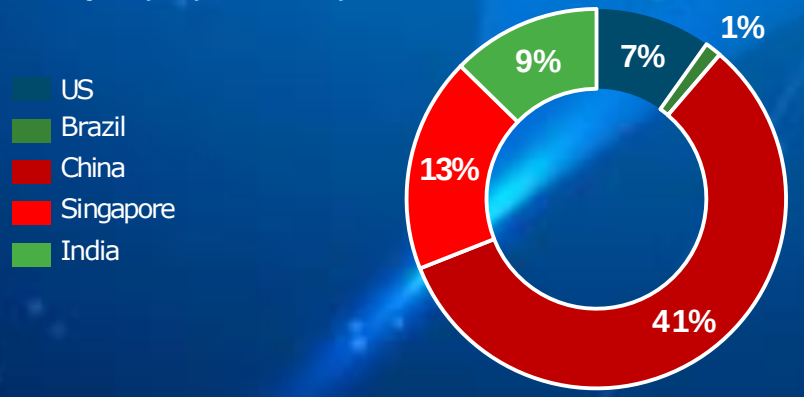
Shared Mobility – Private Capital

The Japanese conglomerate Soft Bank has made waves by writing big checks. It has made multibillion $ investments in ride-sharing companies around the globe, including china, India and Brazil, while the number of companies is concentrated in the United States

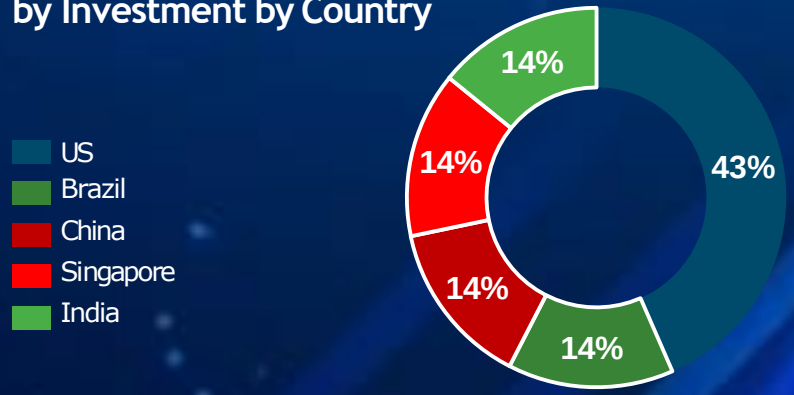
SoftBank Investments in SharedTransportation Companies: 2014-2018



SoftBank: Breakdown of Shared Transportation by Company by Country



SoftBank: Breakdown of Shared Transportation by Investment by Country



Source: PitchBook and courtesy SVB analysis

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India Opportunity

- India expected to have 5 billion connected devices by 2022, with >9bn$ revenue. Indian IoT Market Is Set to Soar to USD ~15 Billion by 2021, (Zinnov, 19 Jun, 2020).
- The IoT-enabled sensors market in India is anticipated to expand at a CAGR of ~62.96% to reach a value of INR 81.07 billion by 2024, from INR 4.83 billion in 2018
- India Smart Cities Mission to roll-out 100 smart cities within the country, to boost IoT-enabled sensors to enhance and optimize city operations propelling the growth of the IoT-enabled sensors market in India.
- In line with the GoI's vision of a Digital India, the Department of Electronics and Information Technology (DEITY) launched India's first draft IoT Policy Document in 2016. It will play an essential role in realizing the GoI's vision of building US$15b Indian IoT market and enabling India to hold nearly 5%-6% of global IoT industry.
- National Digital Communications Policy (2018), has set futuristic goals and policy initiatives for communications and access of digital services in India. This policy aims to create a roadmap for the emerging technologies in areas like IoT and may result in improving the efficiency and economic benefits.

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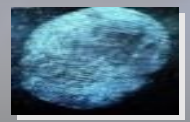
Technology Spectrum

Connected Mobility

Technology Spectrum

- Big Data & Analytics

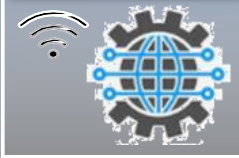


- Augmented Reality

- Smart Manufacturing

- The Cloud

- IoT



- Cyber-security

- 5G Network

- Artificial Intelligence

Benefits Spectrum

Surveillance & Safety

- Reduction of Crime
- Accident Alerts
- Crime Detection and Resolution
- Theft and Tow Alerts

Transportation System

- Navigation assistance
- Vehicle tracking
- Traffic assistance
- Video and audio entertainment
- Remote diagnosis
- Over the air upgrades
- Remote immobilization
- V2x Communication
- Fleet management

Environment

- Enhanced environmental monitoring
- Reduction in emissions

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10-Year Technology Spectrum

	Short-term (2-year)	Medium term (5-year)	Long term (10-year)
Mobility	• Connected Multi-modal transport solutions (Metro-Rail-Airport-Taxi-Bus) • Mobility solutions for last mile connectivity (Shared mobility – Bicycle – Walk)	• Connected Inter-modal solutions for rural areas	• Maturity build up for connected cities • Urban & rural connected infrastructure and transport system
Technology	• AV sensors & voice recognition • Adaptive sensors in smart traffic lights • IoT • AI/ML penetration • Bid Data & Analytics, cloud-infra • Cyber-security • V2V, V2I , V2X	• ADAS – Sensors & Technology • V2V (Vehicle to Vehicle) • V2I (Vehicle to Infrastructure) • V2X (Vehicle to everything) • 5G • Active Safety Systems	• V2V (Vehicle to Vehicle) • V2I (Vehicle to Infrastructure) • V2X (Vehicle to everything)

Interventions

Government

- Long Term Road Map – for policy & regulatory framework
- Draft Policy 2016 & National Digital Communications Policy 2018 to be implemented aggressively
- Set-up of IoT testing labs and collaboration with International labs
- Mechanism for regularly updating policy & specs
- Build eco-system of Govt-Industry-Academia-Start-up for co-innovation & technology leadership

Industry

- Set up a mechanism for industry to share focus areas for future development
- Invest & set-up of technology centres & collaboration with international players
- Invest in manufacturing for future readiness of sensors & devices

Academia

- Framework to work on technologies and products across TRLs
- Encourage 5G IoT studies
- Facilitate Academic institutions to collaborate with MSME technology centres

Key Actions

- IoT Technology Blueprint, with aim for global leadership with integrated manufacturing strategy. 2025 blueprint manufacturing end-game strategy with globally integrated supply-chain.
- Ubiquitous connectivity, Inter-Operability, Security, Device Authentication, with policy and standards / guidelines for data, privacy, cyber-security including cryptography and encryption as a foundation for Connected Vehicles.
- Under Digital India umbrella, invest on skill and capability building, digital literacy and enhancement of the entire Mobility eco-system.
- Focus on building or boosting enabling infrastructure be it in terms of electronics, connectivity or devices etc.

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9. Integrated Urban Mobility Model

Cities of the Future

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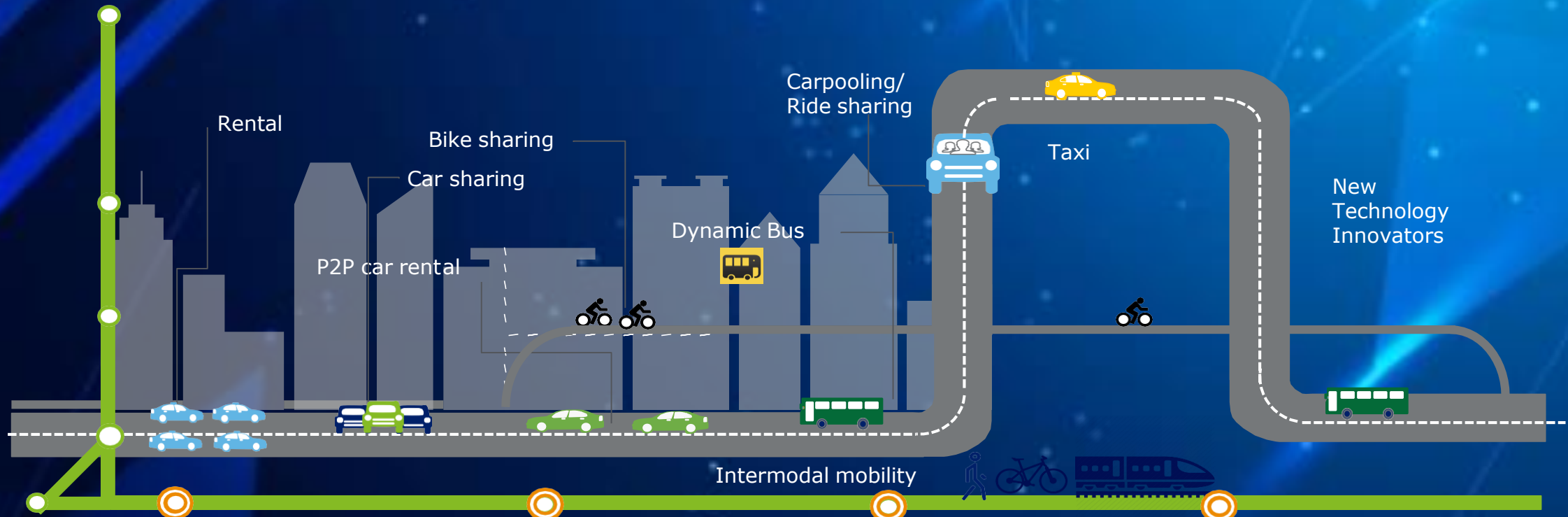
Integrated Urban Mobility – Illustration



Driving Forces

China's new urbanization

- By 2030 China will have 23 mega cities that hold more than 131mn people
- Integrating small cities and towns into new megaregion
- High speed trains connecting outskirts to hub cities within one-hour commute

Regulation and policies

- City planners revise land use plans and rethink urban sprawl
- Turn the existing vehicle-centric transport ecosystem to a more transit and pedestrian friendly one

Consumer behaviors

- VKT by private cars dropped continuously
- Cost, convenience and timeliness become top priority when choosing transport modals
- On-demand and real-time mobility becoming commonplace

Emerging mobility providers

- Complement public-transit system
- Increase service availability, drive cost down and meet riders' diverse demands
- Continue to grow in significance

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Source: courtesy Deloitte report

Smart Cities : *A Global Mega Trend*

Smart Mobility: Intelligent Mobility

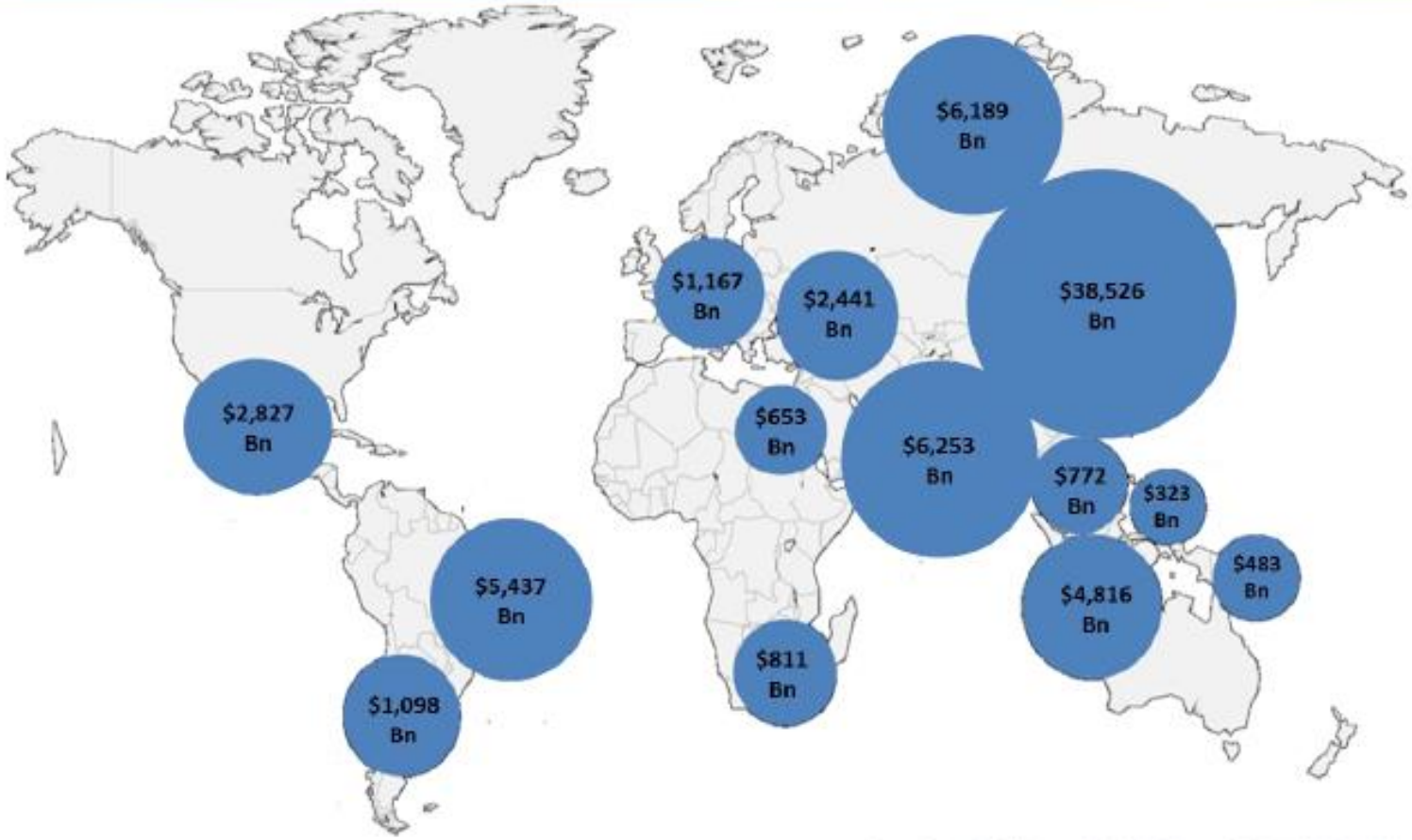
- Advanced traffic management system (ATMS)
- Parking management
- ITS-enabled transportation pricing system

Smart Security: Next Generation 911

- Surveillance
- Biometrics
- Simulation modeling and crime protection
- C2 and response

Smart Energy: Digital Management of Energy

- Smart grids
- Smart meters
- Intelligent energy storage



Smart Infrastructure: Digital Management of Infrastructure

- Sensor networks
- Digital water and waste management

Smart Governance and Smart Education: Government-on-the-Go

- eGovernment
- eEducation
- Disaster management solutions

Smart Healthcare: Intelligent Healthcare Technology

- Use of eHealth and mHealth systems
- Intelligent and connected medical devices

Smart Buildings: Automated Intelligent Buildings

- Building Automation
- Intelligent Buildings: Advanced HVAC, Lighting Equipment

Smart Technology*: Seamless Connectivity

- 4G connectivity
- Super broadband
- Free Wi-Fi
- 1Gbps download speeds

Smart Citizen*: Civic Digital Natives

- Use of green mobility options
- Smart lifestyle choices

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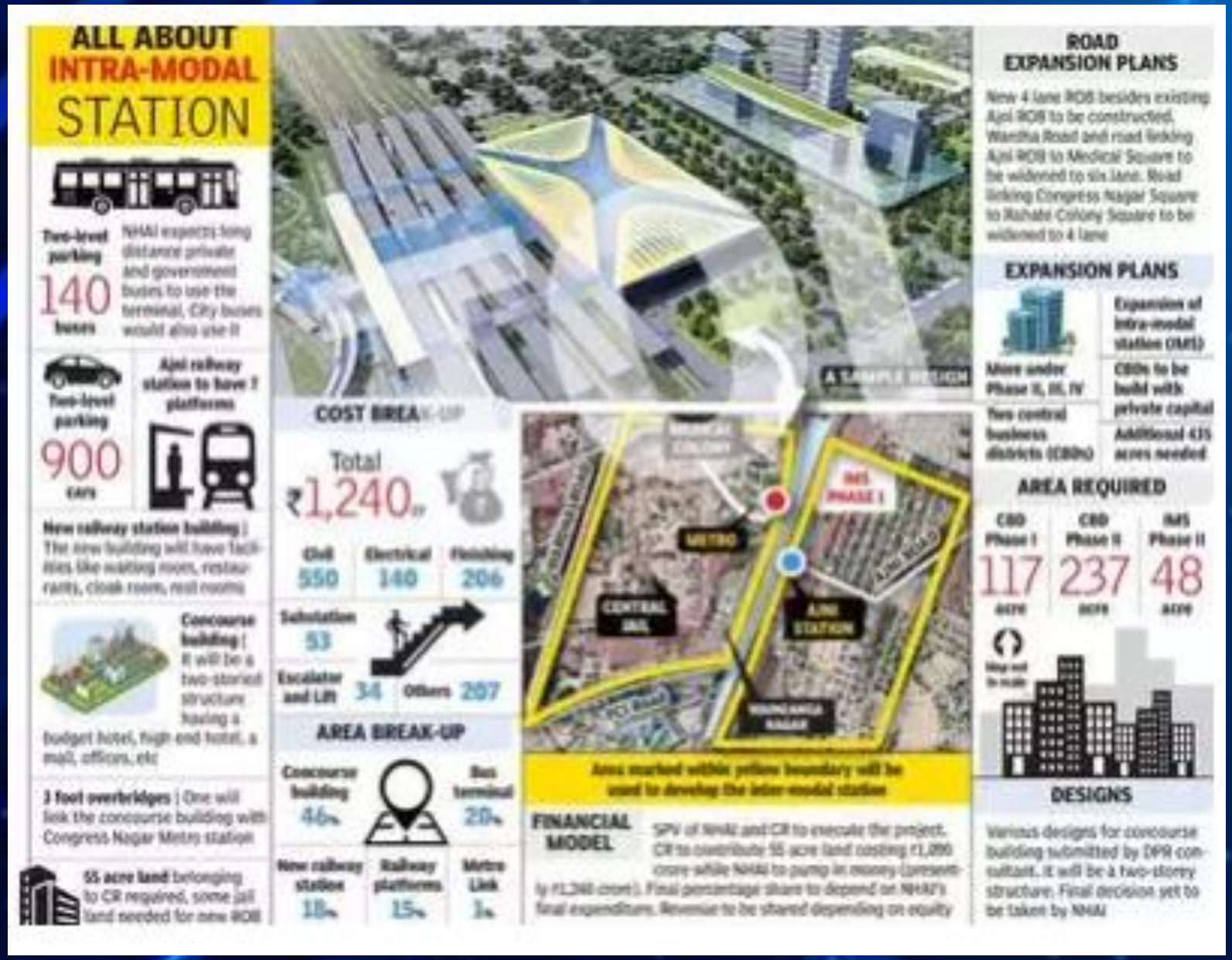
India - Nagpur Inter-Modal Project



Futuristic Ajni station, Nagpur

- Govt. sanctions Rs.1000 cr for Ajni inter-modal station
- Nagpur Metro will link the city airport to the station
- Bus terminal with 400 bays will be constructed and integrated with Metro station

Source: http://timesofindia.indiatimes.com/articleshow/68209072.cms?utm_source=contentofinterest&utm_medium=text&utm_campaign=cppst

11. 2 – 5 – 10 year Roadmap

Mobility, Tech & Interventions

Mobility – Next 10 years

Mobility

Short-term (2022)

- **Urban Mobility Framework**
  - Multi-modal transport solutions (Metro-Rail-Airport-Taxi-Bus)
  - Rapid Transit System (Metro)
  - Mobility solutions for last mile connectivity (Shared mobility – Bicycle – Walk)
- **Fuels - Policy, Framework & Infra:**
  - EV Charging infrastructure
  - CNG/LNG
  - Bio-CNG

Micro Mobility Vehicles

Medium term (2025)

- **Urban Mobility Solutions Maturity**
- **Fuels - Policy, Framework & Infra:**
  - EV Charging infrastructure
  - CNG/LNG
  - Bio-CNG
  - Hydrogen
- **Inter-city & Long Haul CV:**
  - Electric Trucks
  - Hydrogen
  - CNG/LNG
- **Investments in robust Power Grid** – Smart & Flexible to deal with Renewable Energy, Fast charging, Smart grid, V2G
- **Others:**
  - Battery disposal
  - Recycling of IC Vehicles

Long term (2030)

- **Urban Mobility Solutions Long term scale-up**
- **Autonomous Vehicles**
- **Fuels - Policy, Framework & Infra:**
  - EV Charging infrastructure
  - CNG/LNG
  - Bio-CNG
  - Hydrogen
- **Off-Highway Vehicles:**
  - Electric Dozers / Dumpers / Excavators
  - Hydrogen
- **Recycling of EV and Batteries**
- **Maturity scale-up for Mobility Eco-systems**

Technology – Next 10 years

Technology

Short-term (2022)

Electric Vehicles:

- EV battery tech – power density, cost $/kW, scaled-up manufacturing
- EV system aggregates:
  - Motors
  - Invertors
  - Controls & software
  - ECUs, DCUs
  - Semi-conductors

Alternate fuels:

- CNG/LNG
- Bio-CNG – waste to energy process tech scale-up
- Hydrogen storage tanks

Connected:

- AV sensors & voice recognition
- Adaptive sensors in smart traffic lights
- IoT
- AI/ML penetration
- Bid Data & Analytics, cloud-infra
- Cyber-security
- V2V, V2I , V2X

Medium term (2025)

Electric Vehicles:

- EV battery tech - New battery materials, power density, cost $/kW, scaled-up manufacturing
- Cells and Cell Component Manufacturing
- ECUs, MCUs (HW)
- Fast and wireless Charging technology
- High performance computing, GPU's

Alternate fuels:

- CNG/LNG
- Bio-CNG – waste to energy process tech scale-up
- Green Hydrogen production

Connected:

- ADAS – Sensors & Technology
- V2V (Vehicle to Vehicle)
- V2I (Vehicle to Infrastructure)
- V2X (Vehicle to everything)
- 5G
- Active Safety Systems

Long term (2030)

Electric Vehicles:

- Fuel Cells, Solid State Batteries
- Next Generation Cell Chemistries
- ADAS – Sensors & Technology

Autonomous Vehicles:

- LIDAR sensors & GPS
- Deep neural networks

Alternate fuels:

- Green Hydrogen production scale-up

Connected:

- V2V (Vehicle to Vehicle)
- V2I (Vehicle to Infrastructure)
- V2X (Vehicle to everything)

- **Maturity scale-up for Mobility Eco-systems**

Interventions

Government – Academia – Industry Ecosystem

Government

- Long Term Road Map – for emissions, fuels, vehicle regulatory framework
- Standards – CASE
- Incentives for buying Electric Vehicles – Personal Vehicles
- Facilitate seed funding for start-ups
- Invest in infrastructure
- Standards for Chargers, Swap Battery Standards
- Debottleneck mobility – toll booths, ports
- Legal and statutory framework to implement / exploit CASE
- Mechanism for startups, industry and academic eco-system
- Framing Test regulations & Policies
- Regulation on Scrapping the IC Engineer Vehicles, Shared Mobility Regulations, Human safety Regulations
- Recycling of outdated vehicles
- Kick-start Green Hydrogen Eco-system
- Supply Chain de-risked from Geo-Political scenarios
- Policy to deal with transition from ICE to EV & Others
- Develop & Drive Raw material eco-system to enable lower import content in New Technologies – Motors, Batteries, Hydrogen Tanks etc.
- Battery Disposal Protocol and Policies
- Regulation on Scrapping Electric Vehicles

Industry

- Set up a mechanism for industry to share focus areas
- Start-ups to present their ideas; industry and build start-ups eco-system
- EMI/EMC, RADHAZ, validation
- Vehicle safety , fail safe methods, Diagnostic trouble codes
- Commitment to Alternate Energy Options and Co2 reduction
- Engagement opportunities with Start-ups for co-innovation and development
- Virtual product engineering solution

Academia

- Mature eco-system between trio
- Framework for industry and academic institutions to identify, and work on technologies and products across TRLs
- Continuous updating of Tech courses embedded in curriculum
- Facilitate Academic institutions to collaborate with MSME technology centres
- Tech courses embedded in curriculum which includes above technologies

10. Key Actions & Recommendations Summary- Mobility

Mobility- Key Actions & Recommendations Summary

Mobility Roadmap	Academia	Industry	Government	Opportunity	Key Actions
Urban Integrated	• Framework for technology readiness levels	• Collaborate with Global players for blueprint and tech transfer	• Long Term Road Map for vehicle regulatory framework	• Seamless travel • Ease of movement	• Infrastructure for cycle lanes • Single ticket travel
IoT & Connected	• Collaborate with MSME tech centres	• Invest in manufacturing for future readiness of sensors & devices	• Set-up of IoT testing labs and collaboration with International labs	• Connected and shared multi-modal solutions for easy and faster travel	• Blueprint strategy • Invest in future manufacturing capability
Hydrogen	• Focus studies on Hydrogen as a fuel & fuel cells for future tech development	• Invest in R&D for future readiness on fuel cell technology	• Policy for movement of hydrogen fuel • Investments in tech development	• Target to achieve and comply as per Paris agreement	• Hydrogen Blueprint Roadmap • Hydrogen Mobility Sub-group by CII
Alternate Fuels	• Focus of research of Alternate fuels technology and management	• Increased R&D focus on Alt Fuel Vehicles - partnerships and alliances	• Incentives for setting up CNG, LNG stations & invest in renewable power	• Low TCO • Low emission levels	• Alt fuels Roadmap • Regulatory frame work for distribution, dispensing and usage
Electric	• Studies on future tech on EV's with focus on Battery tech	• Investments for future readiness of EV parts mfg and battery tech	• Incentives for buying Electric Vehicles • Investment in Charging Infra	• Global leadership in EV & components • Global leadership in Battery technology	• Review FAME policy to bring incentivization • Invest in Battery tech & material

Key Recommendations

- CII to propose to govt. for creating an inter-ministerial group to formulate India – 2030 National Mobility Transformation Strategy.
- Work with Niti Ayog for creation of Urban Integrated Mobility models, as blue print for cities of the future.
- Creation of Centres of Excellence – between Industry, Academia, and National Research Labs, for top 10 areas related to Mobility Tech. as summarized in the 10-year technology roadmaps.
- Review of existing FAME policies to bring a synchronized incentivisation, as well as boost research, public-private-partnerships, to boost EV and Battery Technologies and relevant eco-systems.
- Battery Tech, EV Components & Charging Infra Scale-up:
  - Invest in Battery Tech as well as clear roadmap for localized cell manufacturing as well battery modules.
  - Key investments and development of charge infra at multi locations, for boosting intra-city EV penetration.
  - Atmanirbhar Bharat - Manufacturing tech. and boost private investments for EV components for Global Leadership

Key Recommendations

- Alternate Fuels :
  - Need to develop a Hydrogen Strategy blueprint / National Hydrogen Energy Road Map. CII should form a dedicated “Hydrogen Mobility Sub-group” to create Hydrogen India strategy
  - LNG infra & long-haul distribution strategy
  - Incentivization for customers & OEM’s to shift to cleaner fuels
  - Incentivize existing City Gas Distribution players to expand pipeline infrastructure and retail stations- especially in Key Metro areas.
  - Single Window Clearance Mechanism to setup retail stations, on-time regulatory approval from PESO & local municipalities, etc. for encouraging Alternate fuel adoption

- 5 Policy papers for the National strategy for Climate Action, Energy, Mobility, IoT/Digital & Manufacturing Leadership

Confederation of Indian Industry

The Confederation of Indian Industry (CII) works to create and sustain an environment conducive to the development of India, partnering Industry, Government, and civil society through working closely with Government on policy issues, interfacing with thought leaders, and enhancing efficiency, competitiveness and business opportunities for Industry.

For more than 125 years, CII has been engaged in shaping India's development journey and works proactively on transforming Indian Industry's engagement in national development. The premier business association has over 9000 members, from the private as well as public sectors, and an indirect membership of over 300,000 enterprises from around 294 national and regional sectoral industry bodies.

With 62 offices, including 10 Centres of Excellence in India, and 8 overseas offices in Australia, Egypt, Germany, Indonesia, Singapore, UAE, UK, and USA, as well as institutional partnerships with 394 counterpart organizations in 133 countries, CII serves as a reference point for Indian Industry and the international business community.

Confederation of Indian Industry
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