Role of electric mobility in a sustainable, and energy-secure future for India

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Within the next decade, a set of four low-carbon technologies – LEDs, solar energy, wind energy, and electric vehicles are set to reconfigure the dynamics of several industries. While India is making significant progress in the first three, we hardly see any electric vehicles on our roads, though the National Electric Mobility Mission Plan (NEMMP-2020) was launched by the Government of India on 9 January 2013 with the aspiration of selling 6–7 million new electric vehicles in 2020 to achieve liquid fuel savings of 2.2–2.5 million tonnes, along with substantial lowering of vehicular emissions and a decrease in CO_2 emissions. In addition to these vital benefits, acceleration of electric mobility in India will also lead to higher job creation in manufacturing. In this article, key recommendations are proposed to accelerate the progress of electric vehicles as a much-needed move towards a more sustainable and energy-secure future for India and a healthier life for Indians.

Keywords: Battery storage, electric vehicles, energy security, low-carbon economy.

INDIA adopted the 17 Sustainable Development Goals (SDGs) on 25–27 September 2015 and entered into the Paris Agreement on 30 November 2015. The country ratified the Paris Agreement on 2 October 2016 and confirmed its Nationally Determined Contributions (NDCs) for the years 2021–2030 to the United Nations Framework Convention on Climate Change (UNFCCC)[1]. On 3 June 2017, the Prime Minister stated that environment protection is an article of faith and a centuries-old tradition for Indians. The Government of India (GoI) has launched the National Action Plan on Climate Change (NAPCC), comprising eight missions in specific areas, and announced a National Electric Mobility Mission Plan (NEMMP-2020) for promotion of electric vehicles (EVs) as part of the NAPCC[2,3].

India's per capita emission of 1.72 t CO_2 equivalent in 2016 was about 38% of the world average (4.49 t) and approximately one-fourth that of China (6.62 t). In 2015, the power sector was the largest contributor of CO_2 emissions in India, contributing about 50% (1066 Mt (Million tonnes)) of total CO_2 emissions from fuel combustion (2066 Mt), while the road transportation sector ranked third with 237 Mt of CO_2 emissions[4].

Transportation fuels – the Achilles heel in India's energy security

The consumption of petroleum products in India has been growing at a compounded annual growth rate (CAGR) of 4% during the 12th Five-Year Plan (FY12–FY17) to reach a level of 194 Mt in FY17 (ref. 5). In 2016, India was the world's third largest oil consumer with 4.8% of the total crude oil consumption, while holding only 0.3% of the world's proven oil reserves. Production of crude oil in India has declined from 38 Mt in FY12 to 36 Mt in FY17, largely due to the declining output of mature oil fields[5]. As a result, the share of imports in the country's consumption of petroleum products has increased from 75.6% in FY12 to 81.7% in FY17 (ref. 5).

Crude oil consumption in India is expected to increase at a CAGR of 4.4% during the 13th Plan[6]. However, due to the absence of fresh discoveries and exploitation of reserves from mature oilfields, the balance recoverable reserves of crude oil in India have declined from 660 Mt in April 2011 to 604 Mt in April 2017, leaving the country with a reserve/production ratio of 17 years at the current rate of production[5].

India imported 214 Mt of crude oil during FY17 valued at Rs 470,251 crores as against an import of 203 Mt valued at Rs 416,579 crores in FY16 – an increase of 5.46% in quantity terms and 13% in value terms compared to the import of crude oil during 2015–16 (ref. 5). Therefore, the increase in crude oil prices to US$ 60 per barrel[7] after averaging US$ 46–48 per barrel during FY16 and FY17 is a cause for concern, particularly in view of the fact that crude oil imports accounted for 22.6% of the total imports of India in FY17 after reaching an all-time high of 36.6% in FY14 (ref. 5).

While falling crude oil prices have driven the improvements in India's public finances over the past couple of years, a spike in oil price to around US$ 70 per barrel (from the current level of US$ 60) is enough to strain our

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public finances and increase GoI's fiscal deficit by 0.4% (ref. 8). As India will continue to depend on domestic sources (coal and increasingly renewable sources) for electricity generation, GoI has more control over electricity prices than on those of imported crude oil. It makes compelling economic sense for India to accelerate its move to EVs, rather than be held hostage to external forces controlling the crude oil market. In this regard, the country must study the set of energy policies adopted by China, which is the second largest oil importer in the world (consuming over 13% of the world's total consumption in 2016) and adapt them to suit our own situation.

Further, in May 2017, NITI Aayog and Rocky Mountain Institute recommended several initiatives for India's mobility, energy and environment needs, including offering incentives to EV manufacturers and discouraging privately-owned petrol- and diesel-fuelled vehicles[9]. According to this report, 'India can save 64% of energy demand from the road sector for passenger mobility and 37% of carbon emissions in 2030 through its EV program. This would result in a reduction of 156 Mtoe (million tonne of oil equivalent) in diesel and petrol consumption for that year. At US$ 52/bbl of crude, this would imply a net savings of approximately US$ 60 billion in 2030'. These projected savings exceed Rs 388,000 crores at the current exchange rate.

Electric vehicles – global scenario

UNFCCC has declared that, 'transport contributes almost one-quarter (23%) of the current global energy-related greenhouse gas (GHG) emissions and is growing faster than any other energy end-use sector. GHG emissions from transport are anticipated to rise from today's levels by nearly 20% by 2030 and close to 50% by 2050 unless major action is undertaken'[10]. The Paris Declaration on Electro-Mobility and Climate Change and Call to Action has emphasized the need to ensure that at least 20% of all road transport vehicles globally will be EVs by 2030 (ref. 10). In view of their much wider popularity[11], the scope of this article is limited to battery electric vehicles (BEVs), and plug-in hybrid electric vehicles (PHEVs), which are collectively referrred to as electric vehicles in this article.

While EVs continue to face challenges, they have caught on much faster than was thought likely just a few years ago, due to a potent combination of technological improvements, subsidies, tax breaks, government mandates and environmental awareness[12]. While just 1.1% of all cars sold globally in 2016 were EVs, two million EVs were plying on the world's roads in 2016, out of which 1.2 million were BEVs[11]. While the global EV stock corresponds to just 0.2% of the total number of passenger light vehicles in circulation today, this is projected to increase to 10% in 2030 in the 2° rise scenario[11]. During the first nine months of 2017, global EVs sales (including passenger cars, light trucks and light commercial vehicles) reached 764,000 units, a year-on-year growth of 46% over 2016 (ref. 13). During the last quarter (July–September 2017), BEVs accounted for 66% of EV sales worldwide with PHEVs forming the balance 34% (ref. 13). More importantly, in 2016, the number of publicly accessible charging points reached 320,000 units globally, representing a 72% growth since 2015 (ref. 11).

In 2009, the Clean Energy Ministerial (CEM) established a multi-government policy forum called Electric Vehicles Initiative (EVI) dedicated to accelerating the deployment of EVs worldwide[11]. The EVI has ten member governments (Canada, China, France, Germany, Japan, the Netherlands, Norway, Sweden, the United Kingdom and the United States) with International Energy Agency (IEA) as the coordinator[11]. China and the United States are co-leading EVI, while India is 'also engaged in the EVI's activities'. The EV30@30 campaign launched in 2017 has set the collective aspirational goal for all EVI members of a 30% share for EVs in the total sales of all cars and commercial vehicles in 2030 (ref. 11).

In 2016, China had the largest stock of EVs on the road, with about a third of the global total[11]. China was by far the largest electric car market in 2016, with 336,000 new EVs registered, more than double the number (160,000) registered in the United States[11]. Seventy-five per cent (257,000) of the 336,000 EVs sold in China during 2016 were BEVs, while PHEVs accounted for the balance 25% (ref. 11).

China's overall policies have created several favourable conditions for EV owners/operators. EV subsidies in China are the second most generous in the world after Norway[14]. For an EV with a range of 250 km or more, the total subsidy offered by the Central and City Governments in Beijing amounts to US$ 10,000 per vehicle[15]. Further, in six major cities, including Beijing and Shanghai, electric cars are exempt from license-plate lotteries and high registration fees that apply to cars with internal combustion engines[11]. As a result of these monetary and non-monetary incentives, while EVs accounted for 1.4% of the total number of cars registered in China in 2016, they had a share of 7.3% among all cars registered in Beijing during the same period[11]. After 2020, China will shift away from direct subsidies to the provision of non-monetary incentives, including the expansion of its already extensive public charging infrastructure with 150,000 public charging points[16].

While more than 200 companies (including global majors like Ford, Tesla and Volkswagen) have announced their intention to make EVs in China, some Chinese manufacturers have started selling their EVs globally. In 2016, a Chinese home-grown company, Build Your Dreams (BYD) sold approximately 100,000 EVs compared to

Tesla's sales of 76,000 BEVs[14]. Emboldened by its success in China, BYD (backed by the world's most famous portfolio investor, Warren Buffett), has now tied up with India's Goldstone Infratech to deliver 25 electric buses to Himachal Pradesh for plying on the steep gradients of the Kullu–Manali–Rohtang Pass route, in addition to six electric buses to Mumbai for use within the city[17,18]. As BYD is also the world's largest producer of EVs, it is well-placed to manufacture EVs in India if the business prospects are more conducive.

In the United States, a Federal income tax credit of up to US$ 7500 (Rs 485,000) is allowed for the purchase of a new qualified EV that is placed in service[19]. This amounts to 20% of the purchase cost of the Cheverlot Bolt (about US$ 38,000 or Rs 2,460,000), which was the second largest selling EV in the US during the first 10 months of 2017 (ref. 20). This tax credit (coupled with the proliferation of public charging points) continues to contribute to the popularity of EVs for intra-city commuting in the US, a country reared on internal combustion engine (ICE) vehicles. However, this tax credit will be phased out gradually for each auto company when it crosses the 200,000 mark in cumulative EV sales within the US[19].

The United Kingdom (UK) has approximately 13,000 public charging points spread across 4500 locations to cater to about 115,000 electric cars today[21]. The UK Government has recently committed £400 million (Rs 3450 crores) to increase the number of roadside chargers, and an additional £100 million (Rs 862 crores) to provide up to £4,500 (Rs 388,000) as a grant towards the cost of buying an EV till 2020 (ref. 22).

Despite Tesla's small size (approximately 76,000 cars in 2016 versus Ford's 6.6 million) and massive losses, it is perceived to be a future winner in the auto industry which is facing more change over the next few years than in the past century, thanks to new technologies such as electrification and self-driving systems. Therefore, Tesla has a market value of US$ 57.6 billion, compared with the US$ 48 billion valuation for a century-old auto company like Ford[23]. This is the key factor driving all global auto majors to diversify into EVs.

Electric vehicles – current scenario and way ahead for India

India is the fifth largest market for passenger cars in the world, with more than three million cars sold in FY17 (ref. 24). The country's car market is expected to grow at a CAGR of 9–11% over the next five years to become the third largest car market in the world by 2020 (ref. 24). As early as April 2011, GoI approved the National Mission for Electric Mobility, after which an apex mission structure with a National Council for Electric Mobility and a National Board for Electric Mobility was set up (ref. 25). In January 2013, NEMMP 2020 was unveiled by the then Prime Minister of India[26]. According to NEMMP 2020, '6–7 million units of new vehicle sales of the full range of electric vehicles, along with resultant liquid fuel savings of 2.2–2.5 million tonnes can be achieved in 2020. This will also result in substantial lowering of vehicular emissions and decrease in carbon di-oxide emissions by 1.3% to 1.5% in 2020 as compared to a status quo scenario'[26].

To realize these goals, a scheme entitled, 'Faster adoption and Manufacturing of (hybrid and) electric vehicles in India' or FAME-India scheme was also approved under NEMMP 2020, with a budget of Rs 13,591 crores over a five-year period (FY15–FY19), out of which Rs 12,471 crores was allocated to demand-side initiatives[25]. In June 2014, NEMMP 2020 was included in the National Action Plan for Climate Change (NAPCC), with an overarching aim of shifting road transportation in India towards sustainable development through greater emphasis on national energy security, and the use of renewable sources to mitigate the adverse impact of economic growth on environment and climate change[25]. However, EVs are yet to take off in India due to a variety of reasons, including lack of public charging infrastructure as well as financial and regulatory barriers, though NEMMP 2020 envisaged that, 'savings from the decrease in liquid fossil fuel consumption as a result of shift to electric mobility alone will far exceed the support provided, thereby making this a highly economically viable proposition'[26].

Specifically, under the FAME-India scheme[27,28]:

- The maximum incentive for an electric car is limited to Rs 138,000 which is about 12% of the ex-factory cost of the Mahindra eVerito sedan supplied to EESL recently.
- Between 1 April 2015 and 30 June 2017, out of a total amount of Rs 196.77 crores sanctioned as demand incentives for procuring 145,431 hybrid/EVs, the Ministry of Heavy Industry (MHI), GoI, could incentivize the procurement of only 2446 PHEVs and 1599 BEVs with a total incentive payout of less than Rs 37 crores[29]. The bulk of the incentive payout of Rs 196.77 crores has been used to procure about 96,000 mild-hybrid cars (which cannot be plugged into an electrical system), with an incentive payout of about Rs 125 crores, while Rs 31.4 crores has been used to procure approximately 42,000 low-speed two-wheelers with conventional batteries[29].
- While 25 charging stations have been installed at six different locations in Bengaluru by Mahindra REVA Electric Vehicles Pvt Ltd between August 2015 and June 2017, MHI has sanctioned proposals for installing only 435 charging stations (predominantly in New Delhi) under the FAME-India scheme[30].

The FAME-India scheme was envisaged with four thrust areas, viz. technology development, demand creation, pilot projects and charging infrastructure. However, the creation of charging infrastructure which is critical to facilitate adoption of EVs has been sadly ignored till recently[31]. Public charging infrastructure should therefore be deployed in advance in order to minimize the potential adverse effects of negative driving experiences using EVs. However, India has only 222 public EV charging stations[31] compared with the 150,000 public charging points already installed in China[16]. In 2014, the Lawrence Berkeley Laboratory (LBL), USA, had recommended the installation of 1270 charging points (including three fast DC chargers) at various locations to cater to 10,000 EVs in the NCR[32]. In contrast, it was only on 10 November 2017 that NITI Aayog released a proposal for 135 public charging stations in New Delhi at 55 locations[33]. This shortfall in availability of public charging infrastructure vis-à-vis the number of public charging points required to meet the needs of EV users has hindered the growth of EVs in India according to the roadmap laid out in NEMMP 2020.

In September 2017, MOP-controlled Energy Efficiency Services Limited (EESL) finalized orders for procuring 10,000 electric sedan cars to be used by various GoI departments and companies controlled by them[34]. While only 500 electric cars have been supplied in the first phase, the 9500 cars that will be procured during 2018 may be the game changer for EVs in India. As these 10,000 cars are for captive use by GoI and its companies, and charging stations will be connected to the electricity meter of government buildings, there is no reselling of electricity by non-licensee private companies, which is currently prohibited by the Electricity Act 2003 (ref. 34).

China is playing a lead role in the proliferation of EVs by promoting home-grown companies which have already mass-produced electric cars capable of travelling 200–300 km on a single charge[11]. In contrast, only two Indian auto companies could qualify to supply EVs against the EESL tender[34], which specified a minimum range of 130 km on full charge. Recently, Suzuki has entered into an agreement with Toyota to manufacture and sell electric cars in India by 2020, which will be fitted with Li-ion batteries produced locally in a JV with battery manufacturers, Toshiba and Denso[35].

India's Forum of Electricity Regulators (Forum) has studied the integration of EVs into the distribution grid and stated that EVs will not have a substantial impact on the grid voltages in residential, commercial and mixed feeders[36]. The Forum has recommended that Central Electricity Authority (CEA) notify additional standards for grid connectivity of public charging infrastructure[36]. Further, the use of smart chargers will also facilitate cost-effective renewable energy integration[37].

While NEMMP 2020 was announced by GoI in January 2013, the Electricity Act 2003 does not permit EV charging businesses to resell the electricity without specific licensing arrangements till today[36]. Therefore, the Forum has recommended several statutory interventions to ensure uniformity and harmony of regulations as well as suitable provisions in the rules, tariff policy, grid code, and standards to facilitate the goals of NEMMP 2020 (ref. 36).

If the growth of BEVs attains the trajectory recommended in a recent LBL study, they will constitute 44% of the projected active car stock (89 million) in 2030 (ref. 37). The proliferation of BEVs will reduce CO_2 emissions, in addition to reducing India's import dependence for crude oil while increasing the requirement of electrical energy by 46 TWh, which is only 1.8% of the total electrical energy demand of 2522 TWh projected in 2030 (ref. 37). In the NDC-compliant scenario of India's power sector, BEVs can reduce CO_2 emissions from cars by 40–50%, if their sale increases to 10 million in 2030 from the 2015 level of 20,000 (ref. 37).

Batteries for electric vehicles

As the number of parts in an electric car is approximately two-thirds of that in a petrol/diesel car, the ability to integrate production across several fronts, which is a key strength of conventional automakers, may be less important for electric cars[38]. Batteries form the most critical and single most expensive component of an EV today. Car makers are planning significant growth in EV sales – between 25% and 40% CAGR right up to 2025 (ref. 39). Battery producers are expected to match EV growth rate while responding to growing demand from other areas, i.e. stationary storage. In 2015, battery pack production volumes of over 200,000 packs per year were estimated to cost US$ 200/kWh or less, which was 33% lower than the US$ 300/kWh estimated for production volumes between 10,000 and 30,000 units[11]. Due to economies of scale, the cost of batteries fell by more than half between 2012 and 2016 (ref. 40).

EV batteries will also require a secure and sustainable supply of raw materials, including nickel, cobalt and lithium[38]. Tesla has identified nickel, cobalt, graphite and lithium as the biggest cost drivers of battery cost[41]. The EV sector is projected to consume 24% of total lithium output by 2020, up from approximately 7% in 2015 (ref. 38). To cater to this surge in demand, Goldman Sachs projects the global lithium supply to expand at a CAGR of 12% till 2020 to fuel the demand created by batteries during this period[38].

While the exact composition of the Panasonic/Tesla batteries is not known, typically cobalt represents about 0.22 kg/kWh in nickel–cobalt–aluminum (NCA) batteries used by Tesla, compared to 0.36 kg/kWh for nickel–manganese–cobalt (NMC) batteries adopted by most peers[42]. All major EV battery producers are moving to higher nickel-rich batteries (higher intensity NMCs and

NCAs) due to: (i) superior energy density; (ii) lighter weight for any given battery size; (iii) increased vehicle range and (iv) lower metal cost[39]. An NCA cathode (used in Tesla batteries) is comprised of 80% nickel and 15% cobalt[42]. Li-ion battery cells that contain cobalt have higher energy densities than those without it, which is why cobalt is in great demand by Li-ion battery manufacturers seeking the highest energy capacity in the smallest package[43].

The cascading impact of low-carbon technologies is exemplified by the significant expansion required in the production capacities of lithium, graphite, nickel and cobalt to cater to the rapidly increasing demand for batteries, both for grid-level storage as well as for EVs[38]. Each EV fitted with an NMC battery (~250 kg) is estimated to require approximately 138 kg of copper in addition to 11 kg each of cobalt and nickel[44]. Around 95% of the world's supply of cobalt comes as a by-product of nickel or copper processing, making cobalt supplies largely dependent on the production of these two metals. On the other hand, more than 60% of primary cobalt (electrode) is mined in the strife-torn Democratic Republic of Congo (DRC), which has raised fears among automakers over security of supply[45]. However, this has not stopped Chinese companies from acquiring control of the Tenke Fungurume mine in DRC, one of the largest known cobalt sources[42].

China, with the second largest reserves of lithium, is trying to secure strategic stakes in Australia and Chile, while American mining companies have already acquired mines in Chile in addition to stakes in upcoming lithium projects in Australia[46]. China will continue its efforts to secure cobalt and nickel mines and downstream assets.

Therefore, GoI must start working on securing key raw materials for EV batteries (lithium, nickel and cobalt) in India and/or abroad, since five companies produce 50–60% of the world's nickel and cobalt[39]. As India does not produce primary cobalt or nickel today[47,48], GoI must direct the Geological Survey of India (GSI), Mineral Exploration Corporation (MEC), National Mineral Development Corporation (NMDC) and Coal India Ltd (CIL) to dedicate well-resourced efforts towards proving the currently known resources of lithium, cobalt and nickel as well as the discovery of new reserves. The Council of Scientific and Industrial Research (CSIR), New Delhi must focus its R&D efforts in this direction, and develop cost-effective technologies for recovery of values from these reserves.

Summary and recommendations

Within the next decade, a set of four transformative low-carbon technologies – LEDs, solar energy, wind energy and EVs will reconfigure dynamics in several industries with parallels to other tech-driven developments like shale gas or e-commerce. While India is making significant progress in the first three, there is hardly any progress with regard to EVs.

EVs have a long way to go before reaching deployment scales capable of making a significant dent in the growth of global oil demand and CO_2 emissions, since the global EV stock constitutes just 0.2% of the total number of passenger light-duty vehicles in circulation today[11]. But electric car sales have grown at rates exceeding 40%/annum from 2010 onwards[11,13]. The economic, environmental, health and security-related benefits of replacing diesel/petrol driven vehicles with EVs in India have been documented in a number of studies[9,32,37], along with a listing of the key areas where substantial changes are required in some of our statutes, policies, standards and practices[9].

During December 2017–January 2018, two homegrown Indian automobile companies, Tata Motors and Mahindra & Mahindra have developed and sold a total of 500 electric versions of their popular sedan models (Tigor and Verito respectively) to EESL after testing and certification[49]. The balance 9500 cars will be supplied in 2018. Each of these cars has a range of over 100 km on full charge, which is sufficient for daily commute by most individuals. EESL's order includes the maintenance of these 10,000 EVs by the respective suppliers for five years.

EESL has also procured 200 numbers of 3.3 kW AC chargers (capable of charging an EV in 7 h) from two Indian companies, in addition to 25 numbers of 15 kW DC chargers capable of charging an EV battery in 40 min (ref. 49). While these chargers will be adequate to charge the 500 sedans already supplied, EESL has announced that it will be placing additional orders for EV chargers (which may be as high as 4000 numbers), as the balance of the order of 10,000 EVs is gradually fulfiled. EESL has also decided to place another order for 10,000 EVs next year[50]. On 21 November 2017, GoI also announced the standardized protocols for EV charging infrastructure[51]. This indicates that there is no technological barrier as such to the development of EVs or the critical charging facilities by Indian manufacturers, and that GoI has also developed the confidence required to place bulk orders.

However, in order to broadbase user acceptance of EVs in India, GoI must step up its public infrastructure development (including upgradation of local electricity grids to feed power efficiently to fast-charging stations), fiscal incentives and R&D efforts, to achieve the goal of NEMMP 2020. While NITI Aayog has been tasked with the development of a strategy for clean mobility solutions in a note to the Union Cabinet[52], the following recommendations are proposed to transition towards a low-carbon, greener and more energy-secure economy for India, consonant with NEMMP 2020:

- Range anxiety is a critical factor influencing the decisions of prospective EV owners. Creation of adequate

charging infrastructure for EVs will facilitate a significant reduction of tailpipe emissions within the top six cities in India, that are already facing high pollution levels leading to heightened health concerns of their residents. Therefore, GoI should develop business models and enact suitable policies based on international best practice to incentivize the installation of fast charging facilities in all parking lots (public or private) in the top six cities of India to start with.

- To achieve the goals of NEMMP 2020, GoI must amend Electricity Act and Rules, and remove all barriers hindering the private sector from setting up EV charging points. The Forum has recommended statutory interventions to ensure uniformity and harmony of electricity regulations as well as suitable provisions in the electricity rules and tariff policy[36]. GoI must implement these recommendations immediately.
- Introduction of EVs in captive fleets can reduce emissions and operation costs, while raising employee awareness for green technologies. The total number of vehicles used by GoI and its agencies is estimated to be 500,000 (ref. 34). Therefore, GoI should frame a policy to mandate and/or encourage procurement of EVs by Governments/PSUs as well as other authorities on the lines of the declaration by eight EVI countries during COP22 (ref. 53). In case EESL extends its services to State Governments (including its State PSUs) as well as public transport undertakings, this will ensure economies of scale through standardization, and reduce the need for subsidies to proliferate EVs and electric buses while improving the environment in our cities as the existing fleet of diesel-powered buses is progressively replaced and/or replenished. This will also enable the proliferation of EV charging infrastructure in several cities and promote better acceptance by other categories of EV customers (companies, institutions, and individuals).
- EESL must start selling EVs to the public as well with a package of fiscal incentives and maintenance packages to kickstart the electric mobility revolution by giving the Indian auto market sufficient consumer experience to start building a consumer base on a large scale. This strategy will help individual buyers to get access to the optimal technology and attractive commercial terms and conditions already secured by EESL, and therefore facilitate the broader acceptance of EVs according to NEMMP 2020.
- Shared mobility (ride-sharing) is becoming popular in India. Since the financial attractiveness of EVs is directly proportional to their daily usage, GoI must facilitate ride-sharing companies who are deploying EVs in different cities[54], by incentivizing them to install fast-charging infrastructure for EVs that can also be used by the public.
- Governments across the world offer substantial direct and indirect incentives to EVs. Direct incentives include purchase subsidy for EVs and subsidies for installation of public charging stations as well as smart chargers, while indirect benefits include access to reserved lanes and parking spots[11,36]. GoI should replicate such proven strategies starting with the six largest cities having reliable power supply and robust distribution systems.
- While the GST rate of 12% on EVs is significantly lower than that on petrol/diesel cars today[55], the incentives under FAME-India are not sufficient to ensure sales of EVs in India according to NEMMP-2020. Therefore, GoI must enhance and broaden the package of incentives till EV sales in India reach the NEMMP-2020 target of 6–7 million per year.
- GoI has recently declared that there is no proposal under consideration to incentivize manufacturers to set up facilities in India for making lithium-ion batteries[56]. However, GoI must provide attractive fiscal incentives for a limited period to companies investing in such facilities in the country to achieve the goals of NEMMP 2020. These batteries will also enhance the use of renewable energy in remote locations with autonomous micro-grids.
- In an earlier study based on a target of 100% EV sales by 2030, NITI Aayog and Rocky Mountain Institute have estimated that India's cumulative EV battery requirements between 2017 and 2020 will be at least 120 GWh, rising to a cumulative EV battery requirement exceeding 970 GWh between 2021 and 2025 (ref. 9). In their updated study published in November 2017, they have recommended the development of India's EV battery manufacturing industry in three stages, with progressively larger economic value capture at each stage[57].
- In a scenario with 100% EV sales by 2030, India's cumulative battery requirements between 2026 and 2030 will exceed 2410 GWh (ref. 9). Production volume is a key factor in determining the cost of battery packs. Therefore, GoI must take immediate steps to promote the creation of facilities to design and build solar cells/modules and storage systems in quantities commensurate with NEMMP 2020. Manufacturing EV batteries in India will enable Indian automakers to produce EVs at attractive prices and will potentially enable the country to become an export hub for batteries. Domestic manufacturing of batteries at this scale presents an enormous economic opportunity for India[57]. Therefore, GoI should make an effort to implement all enablers required to facilitate the domestic industry to put up advanced battery manufacturing capacities in the country.
- GoI must secure key raw materials for batteries (especially lithium, nickel and cobalt) in India and/or abroad with the same zeal dedicated to acquiring oil and gas fields earlier. GoI must also facilitate research in the recycling and reuse of used Li-ion batteries to

reduce the need for such imported minerals with limited global supplies today.

- GoI-controlled exploration/mining organizations like, Geological Survey of India, Mineral Exploration Corporation, National Mineral Development Corporation, and Central Mine Planning and Design Institute, must be directed to carry out exploration for cobalt and nickel in India, while the Council of Scientific and Industrial Research must set up pilot plants for optimal recovery of values from lithium, cobalt and nickel ores.

Finally, air quality is also a key driver for cities to encourage proliferation of EVs. GoI must therefore facilitate and incentivize the six largest cities of India which have reliable power supply and distribution systems, to proliferate electrification of all road transport as the economic and social benefits of a healthier population are immeasurable. Learnings from these cities can be replicated across the nation in consonance with NEMMP-2020.

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