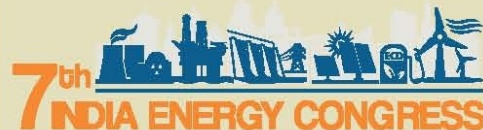


McKinsey & Company



ENERGY 4.0: ENERGY TRANSITION TOWARDS 2030
1-2 FEBRUARY 2018 | NEW DELHI, INDIA



ENERGY 4.0 | Energy Transition Towards 2030

SUSTAINABLE MOBILITY

EXECUTIVE SUMMARY

Sustainable mobility is the need of the hour as India strives for self-sufficiency in oil and battles vehicular pollution on its streets. A gradual shift towards sustainable transport could create possibilities for stakeholders in newer business areas, such as charging infrastructure or integrated transport.

SUSTAINABLE MOBILITY OPTIONS FOR INDIA TODAY

Shared mobility, gas-powered vehicles and electric vehicles (EVs) are all potential solutions in India's quest for sustainable mobility. EVs emerge as a particularly promising option—their market could grow rapidly, especially with the government's aspiration to have only electric cars by 2030¹. Many Indian companies are investing to manufacture EV and related infrastructure in India, offering an attractive, more cost-effective alternative to traditional vehicles.

PUTTING MORE EVs ON INDIAN ROADS

While EVs will penetrate across vehicle segments, faster uptake is expected in the two-wheeler and three-wheeler segments, both very big markets in India². Even so, EVs are likely to add only around 3 to 7 percent of power demand in India³. They could address important current concerns—reducing oil imports and pollution, cutting logistics costs, and fuelling the Make in India initiative.

Despite their advantages, some concerns constrain the uptake of EVs⁴:

- **Economic viability:** Cost concerns predominate in people's assessment of EVs, especially the high acquisition cost.
- **Access to charging infrastructure:** Ready access to charging infrastructure determines the EV experience. With growing EV penetration, India will need much more than its current 500 charging stations⁵.

¹<http://www.livemint.com/Industry/JvyUPmrumUS832KL5BKzhN/India-eyes-allelectric-car-fleet-by-2030-says-Piyush-Goyal.html>

²<https://economictimes.indiatimes.com/industry/auto/news/industry/two-wheelers-to-lead-electric-vehicle-market-in-india/articleshow/60739035.cms> and [http://www.ey.com/Publication/vwLUAssets/ey-standing-up-india/\\$File/ey-standing-up-india.pdf](http://www.ey.com/Publication/vwLUAssets/ey-standing-up-india/$File/ey-standing-up-india.pdf)

³ Calculations based on vehicle sales numbers from SIAM, CMIE; energy data taken from the Ministry of Power, and EV penetration data taken from NITI Aayog

⁴ Industry roundtables organized by McKinsey Center for Future Mobility in August 2017

⁵ <http://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf>

- **Power supply to meet charging demand:** Fortunately, this is unlikely to be a concern—even assuming a peak penetration scenario, EV charging demand is likely to consume between 3 to 7 percent of all power generated by 2030⁶.
- **Consumer perceptions:** While potential customers are attracted to EVs as a status symbol, they worry about the limited driving range and speed as well as the time taken to charge the cars.

The government’s support could be invaluable in overcoming these concerns. It is already supporting EV uptake through programs such as National Electric Mission Mobility Plan and FAME (Faster Adoption and Manufacturing of [Hybrid] and Electric Vehicles), and plans to spend around INR 1,800 bn on EV infrastructure⁷. It could also consider the following initiatives:

- Setting ambitious targets for reduced CO₂ emissions
- Amending the Electricity Act of 2003 to ease the process for private companies offering charging stations
- Offering financial and non-financial incentives such as tax breaks, free parking, toll exemptions, etc. to strengthen the fledgling EV ecosystem
- Promoting R&D innovations such as those that could lower battery prices
- Supporting domestic manufacturing of electric vehicles
- Prompting regulatory clarity for the changing market

HOW EVS COULD CHANGE THE SCENARIO FOR STAKEHOLDERS

As EVs gain momentum and penetrate the Indian market, the shift could impact not only the mobility and transportation industry but also the energy sector. For example, while energy infrastructure companies might have to rethink their long-term investment focus and explore new partnerships, oil companies may need to reassess their capacity planning, accounting for a fall in diesel and petrol demand. Similarly, if solar rooftop panels become more popular, they could threaten power distribution companies.

With EVs likely to play an important role in the future of mobility in India, a newer, sustainable transport landscape might emerge. All stakeholders could benefit from thinking about ways to tap the new possibilities.

⁶ Calculations based on vehicle sales numbers from SIAM, CMIE; energy data taken from the Ministry of Power, and EV penetration data taken from NITI Aayog

⁷ <https://powerline.net.in/2017/12/10/big-ev-opportunity/>

SHIFTING GEARS: FROM OIL DEPENDENCE TO SUSTAINABLE MOBILITY

The rapid pace of urbanization in India is choking the air and streets of its cities. High vehicle emissions and traffic affect the environment and people alike. Traditional internal combustion engines are unsustainable in the long term—drawing on diminishing fuel reserves and polluting the air⁸, besides running up a rising bill through the country's persistent dependence on oil imports⁹.

As India strives towards self-sufficiency in oil, sustainable mobility has become the need of the hour—it could serve the environment, meet people's transportation needs and, in the case of shared vehicles, bring down the sheer number of cars clogging the roads.

SUSTAINABLE MOBILITY OPTIONS FOR INDIA TODAY

India is the world's fastest growing oil consumer—the number of petrol pumps grew from 41,947 in 2011 to 60,799 by October of 2017¹⁰. This consumption and dependence on oil is unsustainable. If oil remains the primary fuel for vehicles in India, petrol consumption could grow at 9 percent CAGR from the current 25.9 MMT and diesel consumption could grow at 4.5 percent CAGR from the present 79.4 MMT—requiring an additional 5 percent of crude oil consumption. This could propel oil imports even higher than the current 81 percent¹¹.

As India strives to break free of this reliance on oil, different mobility options, which are also green and sustainable, become more attractive. Most countries have adopted some combination of three broad forms of sustainable mobility:

- **Shared transport**, such as app-based shared cabs, help the environment by reducing the number of vehicles adding to carbon emissions on the streets.

⁸ A NITI Aayog report highlighted that transport emits 170 mn tonnes of CO₂ in India

⁹ Around 215 MMT of India's crude consumption of 245 MMT is imported; in 2017–18, India's oil import bill is likely to rise a third to touch USD 85 to 90 bn; economictimes.indiatimes.com/articleshow/62310849.cms?utm_source=contentofinterest&utm_medium=ext&utm_campaign=cppst

¹⁰ <https://economictimes.indiatimes.com/industry/energy/oil-gas/over-60000-petrol-pumps-in-india-45-jump-in-6-years/articleshow/61848680.cms>

¹¹ Based on expert interviews and calculations using numbers from <http://ppac.org.in/WriteReadData/Reports/201712201009314742733ReadyReckonerNov2017.pdf>

- **Gas-based vehicles** run on compressed natural gas or CNG. They have lower running costs, use a cleaner source of energy and reduce dependence on fossil fuels.
- **Electric vehicles** can be battery-powered electric vehicles, hybrid electric vehicles, or plug-in hybrid electric vehicles. These are eco-friendly and, with time and technological advancements, their total cost of ownership (TCO) could also drop, making them commercially viable.

Given the government's aspiration to have only electric cars by 2030¹², e-mobility or EVs seem to be an increasingly attractive avenue for India, and hence this form of mobility is discussed in the greatest detail. While four-wheelers could gradually shift towards electric mobility, two- and three-wheelers may possibly get there even faster¹³. With their lower TCO and faster breakeven, EVs could also become attractive to cab operators as shared mobility gains momentum¹⁴.

One concern often cited about EVs is around India's ability or readiness to meet the heightened demand for power to run them. Fortunately, EVs are likely to add only between 3 to 7 percent to the overall power demand in the country¹⁵, making them an attractive alternative to traditional oil-guzzling vehicles.

Shifting modes of mobility could launch business opportunities in newer areas—such as charging infrastructure service or integrated transport—attracting interested parties from all sectors and blurring traditional boundaries for a more dynamic, exciting space worldwide. In India, an energy player has entered the mobility industry, some traditional power companies are exploring possibilities in charging infrastructure, and infrastructure companies are seen entering the batteries business.

Across all forms of mobility, the Indian government could support the gradual development of a viable energy ecosystem that helps shift away from oil dependence and ensures an environmentally sustainable paradigm of transport for growing Indian cities.

Shared mobility

Shared mobility, which includes all forms of shared transportation such as public transport, car pools and radio taxis, is an increasingly attractive and cost-efficient mobility option worldwide. In 2016, its total market size was nearly USD 54 bn across the US, Europe and China. It is likely to grow steadily, with around 15

¹²<http://www.livemint.com/Industry/JvyUPmrumUS832KL5BKzhN/India-eyes-allelectric-car-fleet-by-2030-says-Piyush-Goyal.html>

¹³ <https://www.rushlane.com/indian-vehicles-electrification-ev-12254230.html>

¹⁴ <https://www.bloomberquint.com/business/2017/11/24/mahindra-to-supply-electric-cars-to-uber>

¹⁵ Projections based on data taken from NITI Aayog and Ministry of Power

percent annual expansion by 2030, offering convenience and economy. And if customers willingly adapt to using robo taxis (autonomous vehicles or AVs)—causing high demand for self-driving taxis or shuttles in low-density locations and in cities that take steps to enable them—the market could grow 28 percent annually from 2015 to 2030¹⁶.

In India, radio taxis dominated the shared mobility market (72 percent) with rental taxis at 28 percent in 2016. However, ride sharing or cab pooling was estimated to be less than 0.5 percent of this market¹⁷, primarily due to three factors. First, regulatory limitations affect the profitability of the business model—such as the absence of a clear policy for ride sharing charges and tax implications for private vehicles operating as shared vehicles, and the lack of more incentives such as parking privileges and tax breaks. Second, many customers avoid cab sharing due to safety concerns about travelling with a stranger. This links with the third factor—the Indian mindset, which is only gradually growing accustomed to ride-sharing as a mode of transport.

Indian radio taxi operators do have some supportive foundations in place to grow their shared mobility business:

1. **Regulatory support:** Despite some regulatory limitations, government support for the aggregation model by resolving licensing issues and price caps has spurred the growth of shared mobility.
2. **Operational efficiencies:** Most cab operators have multiple offerings like share, mini vehicles, micro vehicles, etc. Pooling enables increased per seat utilization, and shift operations allow for better utilization per vehicle.
3. **Technical advancements:** Navigational reach has improved significantly, especially in non-metropolitan areas such as Agra, Allahabad, Chandigarh, Guwahati, Kochi, Mysore, Madurai and Visakhapatnam. Customers have also adopted automated billing methods and hassle-free payments through online wallets. These developments sit well with the shared mobility model.

Shared mobility could remain a convenient and economical alternative to taxis and other public transport. Or it may even transform mobility as we know it today, replacing car ownership and public transport. It might encourage EV adoption—with higher mileage per year over time helping to break even faster, EVs could be attractive for cab companies. The cab company Ola has launched a fleet of 200 EVs (including taxis, buses e-rickshaws and autos) in Nagpur, where

¹⁶ <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry>

¹⁷ This remaining section on shared mobility draws insights from the EMIS database; company websites; analyst reports and a press search

it is also setting up 50 charging points. And it has launched a battery swapping facility in collaboration with solar power developer ACME¹⁸.

Whatever the future of shared mobility, it is likely to help reduce India's oil dependence, which makes it an attractive avenue for further exploration and investment.

Gas-based mobility

With governments worldwide favouring the use of CNG, the global market for CNG vehicles is expected to grow at 5 percent over the next five years. Iran, for example, currently leading the global CNG vehicle market, has incentives for dual-fuel capacity and has removed petrol subsidies. Infrastructure for the CNG vehicle market is also growing rapidly, e.g., Italy, which currently holds second position in the global CNG vehicle market, has more than 1,000 CNG stations (the number grew by 67 percent over 7 years)¹⁹. CNG has entered other categories like luxury bi-fuel cars and pickup trucks.

In India, the running cost for CNG is 50 percent cheaper than petrol and 25 percent cheaper than diesel²⁰. The recent odd-and-even car-rationing scheme in Delhi²¹ did not restrict the movement of CNG vehicles. Some regulatory measures and policies have even prompted public transport to switch to CNG vehicles, such as the shift to CNG autos and DTC buses in Delhi.

However, the CNG vehicles market in India has seen downward trends:

- Inadequate infrastructure: India has only about 1,273 CNG filling stations to cater to demand from around 2,937,995 CNG vehicles²². This is quite inadequate for a country the size of India.
- Driving range anxiety: The driving range with a full cylinder is only about 150 to 250 km²³.
- Unorganized aftermarket for CNG vehicles: Retrofitting of CNG conversion kits is somewhat unorganized, with safety and lack of certification being particularly problematic.

¹⁸<http://www.hindustantimes.com/india-news/nagpur-becomes-first-city-with-electric-mass-mobility-gets-200-e-vehicles/story-hwPoGHv8eNxVoDTHQrzaM.html>

¹⁹Technavio report

²⁰ Expert insights

²¹ In Delhi, private vehicles could only be on the road on certain days depending on their license plate number, beginning on January 1, 2016. The scheme aimed to reduce pollution and smog in Delhi. Sources: <https://www.ndtv.com/india-news/odd-even-heres-what-happened-when-delhi-adopted-odd-even-scheme-in-the-past-1773371> and <http://indianexpress.com/article/india/delhi-air-pollution-odd-even-rule-who-all-are-exempted-4930753/>

²²<http://ppac.org.in/WriteReadData/Reports/201712201009314742733ReadyReckonerNov2017.pdf>

²³ Expert insights

- Unavailability of gas: There is a question mark on the availability of gas to manage demand, given the steadily decreasing production of liquified natural gas (LNG) and the growing share of imports in its consumption—production fell from 97 MMSCMD in 2013–14 to 89.7 MMSCMD in 2017, and LNG imports rose from 47 to 68 MMSCMD in the same period²⁴.

Electric mobility

In April 2017, Power Minister announced the aspiration to not sell a single petrol or diesel car in India by 2030²⁵. The National Electric Mobility Mission Plan 2020 (NEMMP) launched in 2013 aims to establish fuel security for India, through targeting sales of 6 mn to 7 mn hybrid and electric vehicles in India year on year, 2020 onwards²⁶. A 2017 report indicates that there could be 75 mn EVs across Indian roads by 2030²⁷.

Besides this government thrust on electric vehicles, spiking vehicular emission levels due to India's increasing urban population (which could grow to 590 mn by 2030²⁸) will also call for solutions such as EVs. India's overall macroeconomic growth could create EV customers who see it as a status symbol, regardless of the higher acquisition cost. In addition, shared vehicles and fleets could emerge as a profitable sales channel for EVs.

EVs can be divided into three broad categories based on the degree of electricity they use as their energy source—**Battery Electric Vehicles; full hybrids** which use a gasoline engine as their primary source of power, with an electric motor generating additional power; and **mild hybrids**, which incorporate battery support for start/stop cycles.

India is the world's largest two-wheeler market, and a leading market for three-wheelers—both kinds of vehicles are heavily used for quicker mobility and for transporting smaller cargo across the country. These two segments offer a huge opportunity for electrification in India, and are likely to move towards e-mobility faster than four-wheelers. Their EV versions are attractive due to lower running costs and easy charging at the workplace or at home. Several two-wheeler manufacturers have already invested in electrification or have announced plans to start producing electric models. With the dropping cost of lithium-ion

²⁴<http://ppac.org.in/WriteReadData/Reports/201712201009314742733ReadyReckonerNov2017.pdf>

²⁵India eyes all-electric car fleet by 2030, says Piyush Goyal, PTI, Live Mint, April 2017, <http://www.livemint.com/Industry/JvyUPmrumUS832KL5BKzhN/India-eyes-allelectric-car-fleet-by-2030-says-Piyush-Goyal.html>

²⁶<http://pib.nic.in/newsite/PrintRelease.aspx?relid=116719>

²⁷<https://powerline.net.in/2017/12/10/big-ev-opportunity/>

²⁸<https://www.mckinsey.com/global-themes/urbanization/urban-awakening-in-india>

batteries, vehicular performance has improved, and as more models hit the market in 2018, consumers could choose from a range of electric two-wheelers²⁹.

Three-wheeled e-rickshaws are also increasing on Indian roads. These attract customers as they move faster than manual rickshaws but are cheaper transport options than traditional auto-rickshaws. For operators, these are also significantly cheaper to maintain, making it quite a win-win proposition³⁰. PGCIL has collaborated with DMRC for 500 e-rickshaws for last-mile connectivity in Gurugram. The Ministry of New and Renewable Energy will be providing battery swapping facilities for these vehicles—the first such facility in the world for e-rickshaws³¹.

Intra-city buses, too, might be relatively easy to electrify—their fixed routes could simplify setting up easy-to-access charging infrastructure along bus routes and at depots. However, the higher cost of e-buses due to heavier and more expensive batteries remains a challenge. Trucks could also be attractive options for electrification—with fixed and long routes—but again, the high battery capacity requirements could pose a challenge³².

Many Indian companies are investing in manufacturing EVs or related infrastructure, such as batteries. For example BHEL is exploring the possibility of using batteries developed by ISRO for EVs³³. JSW Energy has signed an MoU with the Government of Gujarat to set up an EV manufacturing facility in the state worth INR 40 bn³⁴. Bosch has announced setting up manufacturing units for EV components and parts. Both Toyota and Suzuki plan to introduce EVs in India by 2020³⁵. Ashok Leyland and TVS have also declared their intention to foray into EV territory³⁶.

There is a move towards setting up the necessary charging infrastructure for this uptick in EV usage. Mahindra has already set up 25 EV charging stations in

²⁹ <https://economictimes.indiatimes.com/industry/auto/news/industry/two-wheelers-to-lead-electric-vehicle-market-in-india/articleshow/60739035.cms>

³⁰ [http://www.ey.com/Publication/vwLUAssets/ey-standing-up-india/\\$File/ey-standing-up-india.pdf](http://www.ey.com/Publication/vwLUAssets/ey-standing-up-india/$File/ey-standing-up-india.pdf)

³¹ <http://indianexpress.com/article/india/dmrc-launches-500-e-ricks-for-metro-commuters-in-gurgaon-4828790/>

³² <http://www.autocarpro.in/news-national/-wheeler-fleets-ev-adoption-india-ey-study-26867>

³³ <http://www.livemint.com/Industry/RCtwimVIT8cLT2mOllu1WJ/Batteries-developed-by-Isro-may-be-used-in-electric-vehicles.html>

³⁴ <http://www.thehindubusinessline.com/companies/electric-vehicles-jsw-inks-mou-with-gujarat-to-invest-rs-4000-cr/article9874239.ece>

³⁵ <https://economictimes.indiatimes.com/industry/auto/news/toyota-suzuki-to-introduce-electric-vehicles-in-india-in-2020/articleshow/61687544.cms>

³⁶ <https://inc42.com/buzz/ashok-leyland-electric-vehicles-maruti-suzuki/>) (<http://www.autocarpro.in/news-national/exclusive-bajaj-auto-foray-evs-wheeler-25238>

Bengaluru³⁷. Hero Future Energy plans to enter the business of battery storage and charging infrastructure³⁸. IOCL, NTPC and HPCL have all announced their interest in putting up large-scale charging infrastructure³⁹. BSES and Tata Power have installed 31 and 5 charging ports respectively across the capital city of Delhi, with Tata Power announcing plans to set up 1,000 more⁴⁰. In October 2017, the state-owned NBCC signed an MoU with Fortum Oyj to set up charging infrastructure across all NBCC projects⁴¹.

THE GLOBAL SHIFT TOWARDS ELECTRIC VEHICLES

At the country or local level, governments are encouraging a move away from traditional transport towards sustainable mobility options. Many countries have tried to promote e-mobility through multiple initiatives—stringent regulations and lucrative consumer tax incentives for using EVs. While these create a supportive ecosystem to foster EV adoption, monetary incentives alone cannot drive EV penetration. Examples across China, Norway, California and Berlin show that regulatory mandates, infrastructure support and non-monetary incentives could also help significantly.

China

China aims to have 5 mn EVs on the road by 2020. To manage the heightened demand for charging, the government of China plans to build 5 mn charging poles by 2020—one per EV (Exhibit 1). Based on regional economic affordability and EV sales potential, the entire country has been divided into three zones for inner-city charging network development—Acceleration, Demonstration and Promotion, each with its own target. The regional government will receive fiscal incentives (or fines, as the case may be) based on their performance against these targets.

Inter-city EV charging networks are already being developed, with facilities complete alongside the key “vertical” expressways. By 2020, more of China’s “horizontal” expressways will also offer charging facilities.

³⁷<https://energy.economictimes.indiatimes.com/news/power/25-charging-stations-installed-in-bengaluru-for-electric-vehicles-on-a-pilot-basis-piyush-goyal/59795672>

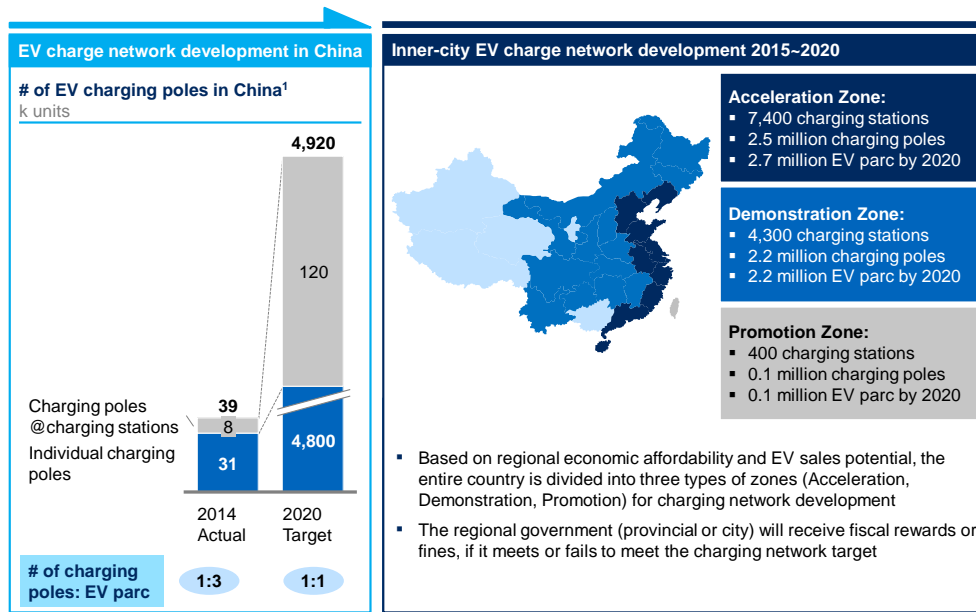
³⁸<http://www.herofutureenergies.com/hero-future-energies-set-solar-charging-stations-electric-vehicles/>

³⁹<https://timesofindia.indiatimes.com/business/india-business/nptc-forays-into-electric-vehicles-charging-stations/articleshow/58975961.cms> and <https://energy.economictimes.indiatimes.com/news/oil-and-gas/indian-oil-corp-set-to-foray-into-energy-storage-business/59137995>

⁴⁰<https://powerline.net.in/2017/12/10/big-ev-opportunity/>

⁴¹<https://timesofindia.indiatimes.com/business/india-business/fortum-partners-nbcc-to-set-up-ev-charging-infra-in-projects/articleshow/60943907.cms>

China aims to build 5 mn charging poles by 2020, easing EV operations



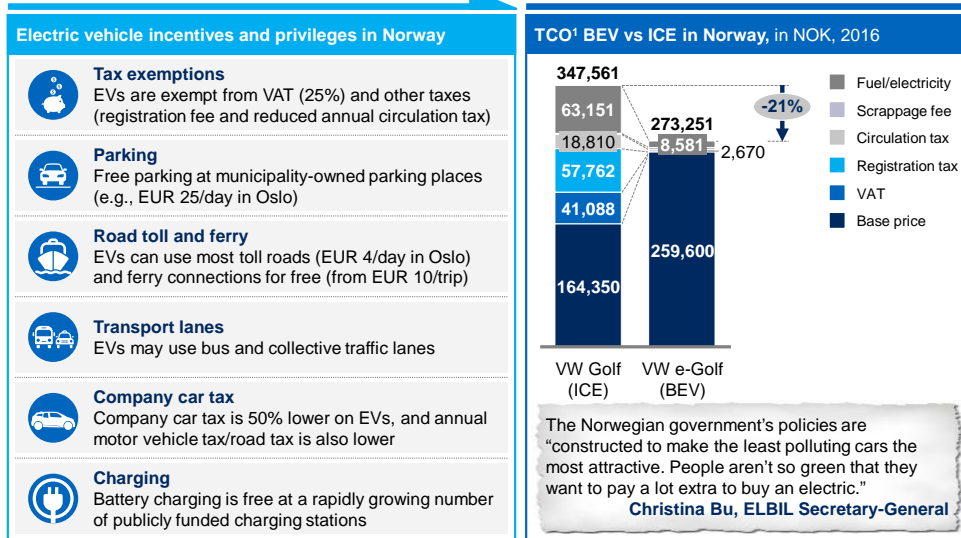
¹ Assuming 1 charging station has 10 charging poles
SOURCE: Government announcement, literature research

Norway

Norway, which is one of the market leaders in EV adoption⁴², has adopted a strategy of ensuring that the greenest cars are also the most attractive options. It offers a range of incentives for EV owners, from tax and toll exemptions or reductions to lane sharing and parking privileges. Battery charging, too, is free at an increasing number of publicly-funded charging stations. It also helps that the TCO of an EV is lower than that of an ICE vehicle by 21 percent (Exhibit 2).

⁴²Ministry of Transportation and Communications, Norway; press search

Market leader in EV adoption, Norway applies tax exemptions and certain privileges for EV users that yield significant cost savings



¹ 6-year ownership; 15,000 km mileage per year; premium unleaded gasoline (95 RON)
SOURCE: Ministry of Transportation and Communications Norway, Press search

California

The US state of California is an example of successful EV penetration despite offering relatively few monetary incentives. About half of all EV sales in the US happen in California. In 2015, California's major metropolitan areas had three to 13 times the average US EV uptake. The high penetration of EVs is due to comprehensive policy support—OEMs receive Zero Emission Vehicle (ZEV) credits based on the types of vehicles they produce and deliver in the state. In addition, persistent local action promotes EVs across aspects such as parking, utilities, education and workplace charging. The government has invested heavily in ensuring robust EV infrastructure. Local electric utility agencies are also expanding the public charging network to keep pace with the growth in EV usage⁴³.

⁴³California dominates US electric car sales—30 California cities show why, James Ayre, September 25, 2016, Clean Technica, <https://cleantechnica.com/2016/09/25/icct-analysis-ev-market-development-californian-cities/>

Berlin

The city government of Berlin has formed industry partnerships to roll out standardized charging infrastructure across the German capital, aiming to have more CO₂-neutral urban traffic. Charging stations are being built by a company that won a public tender. The charging infrastructure will be accessible to all customers, regardless of their car brands or charging infrastructure company. Other partners are helping to manage infrastructural requirements such as billing, customer care, etc.

At the outset, this effort is subsidized by the city government. Users pay a flat service charge of around EUR 0.48 and some charge per minute that they are connected to the charger. Phase 1 of this initiative was completed in late 2016, with around 400 charging stations selected based on predicted needs. In Phase 2, around 700 charging stations will be added by 2020, selected based on user data, use projections and customer requests⁴⁴.

An important common factor across these examples from around the world is a proactive and supportive push from the government to boost EV penetration. Such an emphasis could prove beneficial for India as well.

HOW PROMOTING EVs COULD HELP INDIA

Electric vehicles could be the answer to many current concerns across India's economy and society—reduced oil imports, solutions to pollution and better health outcomes, cheaper logistics and renewed vibrancy in the Make in India initiative.

Reduced oil imports

India is eager to outgrow its heavy dependence on oil imports. The country consumes around 245 MMT of crude oil, of which 215 MMT is imported. Road transport (especially cars, two-wheelers and trucks) accounts for 99 percent of all petrol consumption in India, and two-thirds of diesel consumption⁴⁵.

With passenger traffic set to increase by 8 to 10 percent in the coming years, cutting down on road transport—led consumption of oil could help reduce overall demand for oil in India. The NITI Aayog estimates that greater EV penetration across personal and commercial cars as well as intra-city buses could reduce oil

⁴⁴Senatsverwaltung Berlin

⁴⁵ Ministry of Petroleum and Natural Gas; Department of Commerce

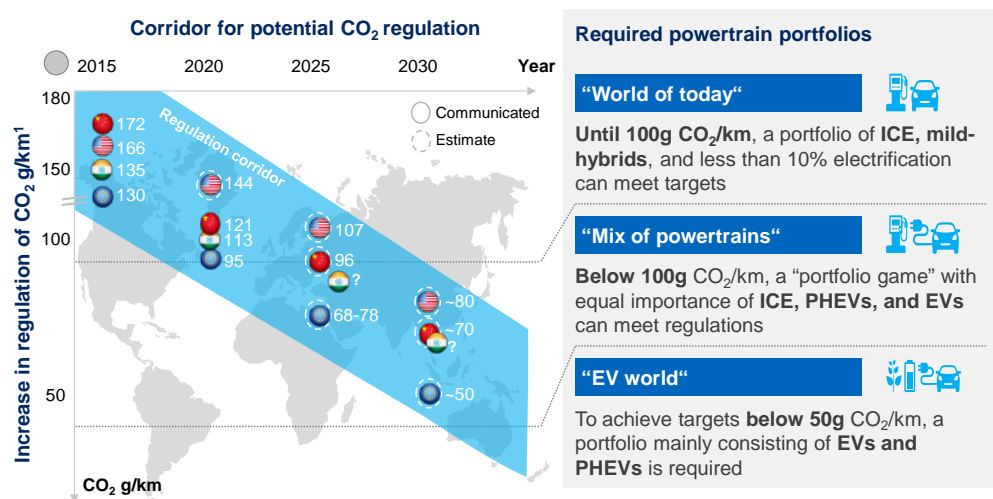
consumption by around 156 MMT by 2030, slashing India’s oil bill by INR 3.9 lakh cr⁴⁶.

Solution to pollution—reduced emissions and better health

A shift away from vehicles that emit noxious fumes towards the cleaner technology of EVs could rejuvenate the tired lungs of India’s cities and their residents. Stricter government regulations are emerging around the world for acceptable levels of CO₂ emissions. From a high of 180 g of CO₂/km in 2015, the limits are dropping and could go down to around 50 to 80 g of CO₂/km by 2030. These new stringent measures could boost EV growth worldwide and in India (Exhibit 3).

EXHIBIT 3

CO₂ regulation is a key factor for EV penetration and can trigger the shift to an EV dominated world



› In addition, for India, regulations could also be driven by the strategic intent to reduce crude oil imports

1 To ensure comparability, CO₂ figures are cycle-adjusted and normed (to NEDC)
SOURCE: The International Council on Clean Transportation; McKinsey Sustainable Mobility Initiative

Motor vehicle emissions contribute significantly to outdoor air pollution—studies that evaluate the sources of PM_{2.5} in our environment find that vehicles

⁴⁶India leaps ahead: Transformative mobility solutions for all, NITI Aayog, May 2017, http://niti.gov.in/writereaddata/files/document_publication/RMI_India_Report_web.pdf; bill reduction assumes oil price at USD 52/bbl of crude, and EV penetration of 40 percent and 100 percent respectively in personal and commercial cars, 40 percent in 2-wheelers, 100 percent in 3-wheelers and intra-city buses

contribute up to one-third of observed PM2.5 (a fine particulate matter present in polluted air) in urban areas⁴⁷. A shift to EVs could be a boon for respiratory health, especially in some of the bigger cities, where respiratory ailments like asthma and bronchitis are now inescapable hazards of urban life.

Drop in logistics costs

A study by Assocham–Resurgent India suggested that India could save USD 50 bn if it could bring down its logistics costs from the high of around 13 percent of GDP to 9 percent of GDP. As a comparison, logistics costs in the US and Germany are 9 percent and 8 percent of GDP respectively⁴⁸.

A large chunk (nearly one-third) of the cost of any logistics chain lies in transport services. Since around 60 percent of freight cargo in India travels by road⁴⁹, adopting new and cheaper vehicle technologies such as EVs could significantly slash transport costs, helping to bring down logistics costs and translating into lower product prices which could benefit everyone.

More power to the “Make in India” program

The thrust to promote EVs in India will also boost the manufacturing of EVs and related equipment and infrastructure. To keep prices in check, it could be crucial to locally manufacture the vehicles and their equipment, including batteries (the greatest component of cost). Such demand for more, domestic manufacturing, and proposed financial incentives to EV manufacturers⁵⁰ could benefit companies across the value chain, and prove a shot in the arm for Make in India—the vision to transform India into a global design and manufacturing hub.

An example of such a boost is the tender floated by India’s Energy Efficiency Services Limited (EESL) for procuring 10,000 EVs—the world’s largest single electric vehicle procurement—setting off a flurry of bids and driving up manufacturing momentum in the country⁵¹. EESL has also invited bids for 4,000 EV chargers.

⁴⁷ *Evaluation of the Public Health Impact of Traffic Congestion: A Health Risk Assessment*, by Jonathan I. Levy, Jonathan J. Buonocore, & Katherine von Stackelberg, 2010

⁴⁸ *Cargo and logistics industry in India*, a joint study by Assocham and Resurgent India, 2016

⁴⁹ <http://www.thehindubusinessline.com/opinion/addressing-indias-high-logistics-costs/article9732208.ece>

⁵⁰ <https://economictimes.indiatimes.com/news/economy/policy/niti-aayog-proposes-incentives-subsidies-to-push-sales-of-electric-vehicles/articleshow/58651668.cms>

⁵¹ <http://www.livemint.com/Industry/ji96zXi5dZz3L1XUSkiZxM/Indias-electric-vehicle-drive-Challenges-and-opportunities.html>; EESL is a joint venture of four PSUs under the Ministry of Power: the National Thermal Power Corporation, the Rural Electrification Corporation, the Power Finance Corporation and Powergrid

Gradually, as EV manufacturing revs up in India, more and more foreign investors could flock to be part of the India manufacturing story across vehicles, equipment and charging infrastructure. Finnish energy utility company Fortum and a few other international companies are just some of the entities actively exploring partnering with Indian companies to have only EVs zipping on India's roads by 2030.

PUTTING MORE EVs ON INDIAN ROADS

India is determined to make electric vehicles the norm by 2030, partly as a bid to escape its oil dependence but also to move to the sustainable mobility options of the future. Illustrating this focus, the capital city Delhi banned high-powered diesel vehicles in 2016⁵². The government is backing its ambitions with funds to the tune of INR 1,800 bn, which it plans to spend on EV infrastructure⁵³. At the same time, there are some challenges holding up EV penetration in India. So, what can the Indian government do to ensure EVs are soon the norm rather than the exception on India's roads?

Challenges to EV adoption in India

An automotive industry roundtable in 2017 had respondents discussing the greatest hurdles to doubling EV penetration rates by 2030—high upfront acquisition cost was the biggest concern, with 54 percent citing that as the biggest stumbling block. Availability of adequate charging infrastructure was the second most important concern—23 percent of participants admitted that people worried about the availability and reliability of chargers and power (Exhibit 4)⁵⁴.

These concerns lead to identifying four crucial focus areas that are barriers to EV adoption, and where penetration efforts could be strategically directed.

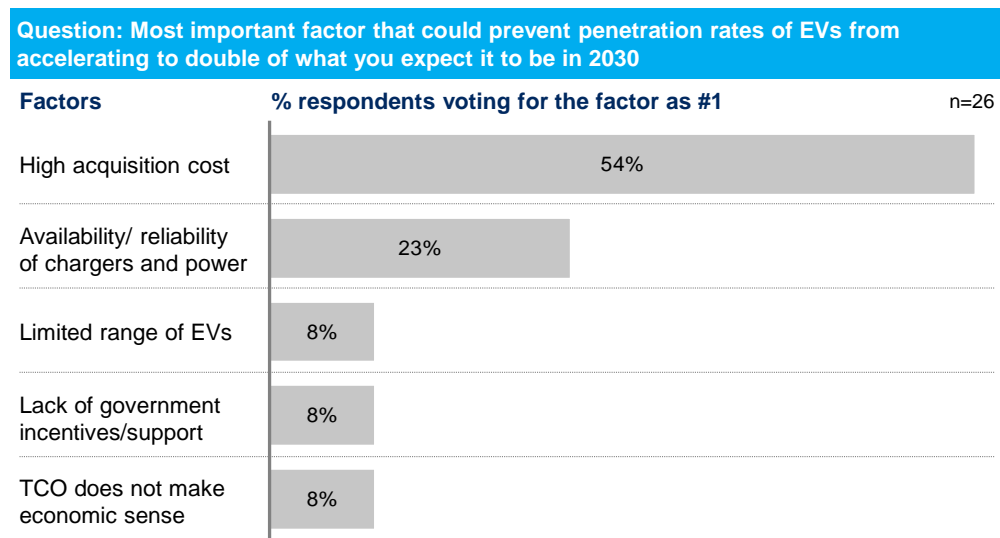
⁵²SC extends ban on high-end diesel cars, SUVs, The Hindu, April 2016, <http://www.thehindu.com/news/cities/Delhi/sc-extends-ban-on-highend-diesel-cars-suvs/article8419244.ece>

⁵³<https://powerline.net.in/2017/12/10/big-ev-opportunity/>

⁵⁴Industry roundtables organized by the McKinsey Center for Future Mobility for automotive industry experts and executives in August 2017

EXHIBIT 4

High acquisition cost and (lack of) availability/reliability of chargers and power were cited as the top 2 reasons preventing higher penetration of EVs in a recent industry roundtable



SOURCE: McKinsey (Industry roundtables organized by the McKinsey Center for Future Mobility for automotive industry experts and executives in August 2017)

1. The economic viability and total cost of EV ownership

Given that cost concerns predominate in people’s assessment of EVs, it is important that EVs become more economically feasible over time. Two focus areas could help have an impact towards this goal—reducing battery prices, and achieving adequate manufacturing scale in India which can bring down product cost.

Battery costs are a major factor in the high overall costs of EVs. Dropping battery prices in China and Europe have been seen to help EV sales go up (Exhibit 5)⁵⁵. Goldman Sachs estimates that the total battery cost of USD 272 per kWh will fall to USD 197 by 2020 and to just around USD 100 by 2025, thanks to technological advancements⁵⁶. Lithium-ion battery technology already offers the highest energy density and efficiency—with more breakthroughs, material cost could drop, leading to better economies of scale, prompting further cuts in battery prices.

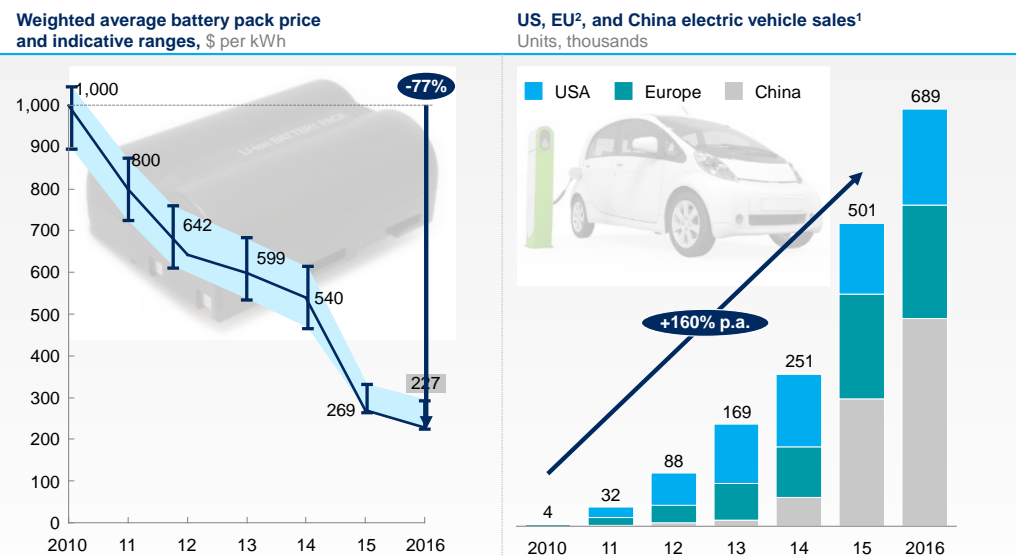
⁵⁵ IHS, Bloomberg, New Energy Finance

⁵⁶ http://www.automotivenl.com/images/November_2016/Goldman_Sachs_On_Batteries_-_2016.pdf

In India, it will be important to ensure that battery imports do not replace the oil dependence the country is eager to shake off. With EV battery cost expected to drop through advancing technology, consumers could benefit from a reduced TCO over the next five to seven years, making EVs more economically viable.

EXHIBIT 5

Rapid decreases in battery prices have helped accelerate EV sales, especially in Europe and China



¹ Plug-in hybrid electric vehicles and battery electric vehicles; excludes low-speed vehicles and hybrid electric vehicles without a plug
² Includes Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, Portugal, Spain, and the UK
 SOURCE: IHS, Bloomberg, New Energy Finance

2. Access to charging infrastructure

The existence and sophistication of charging infrastructure varies worldwide. In 2014, the US had 22,000 charging points, with 12.6 registered EVs per point; China had 30,000 charging points and 2.8 registered EVs per point. In comparison, Germany had only 3,000 points but 8.7 registered EVs for each⁵⁷. By 2020, installed charging infrastructure is expected to grow 5 to 10x, with particular growth in fast chargers⁵⁸. These are already seen across Europe, the US and Japan.

⁵⁷ Data on charging points dates to 2014, from IEA Global EV Outlook 2015

⁵⁸ IHS Automotive

India has fewer than 500 EV charging stations across the entire country, with the highest concentration (over 100) in Bengaluru, then in Delhi (50 to 100) and the fewest (under 50) in Mumbai and Kolkata. In Mumbai, Tata Power is providing free EV charging at its recently installed charging stations⁵⁹. The NEMMP estimates the need for 175,000 to 227,000, 300 to 500 and 11,000 to 18,000 charging points for four wheelers, e-buses and e-rickshaws respectively⁶⁰. The Indian government has sanctioned proposals to set up 300 EV charging stations under the FAME (Faster Adoption and Manufacturing of [Hybrid &] Electric Vehicles) India scheme to encourage the use of EVs in the country⁶¹. A defining factor in the EV experience could be the availability (or lack) of ready access to charging infrastructure—on highways, at malls, office spaces and hospitals.

The early adopters rely mostly on home charging; as their numbers gather momentum, infrastructure investment would be likely to follow, helping to reduce downtime for EV owners. Most charging technology is “AC Slow”, which typically takes around six to eight hours to fully charge an 11–15 kWh battery⁶². This means that besides access, charging time is also a concern—EV vehicle owners need to get their cars back on the road faster. A notable exception is the option of “DC fast” highway chargers set up on key traffic routes that can charge an 11–15 kWh battery in around 90 minutes⁶³. It is not yet clear how viable such chargers could be, given that this is expensive technology and not accessible for home charging, where only AC power is available.

Another possible alternative to long battery charging times could be the option to replace or exchange batteries at charging stations.

3. Power supply to meet charging demand

There seems no reason to worry that EVs will strain India’s power resources. Globally, EVs may represent up to 3 percent of the electricity demand worldwide by 2030, with some regional variations (Exhibit 6).

⁵⁹ <https://www.tatapower.com/media/PressReleaseDetails.aspx?id=MTM5OQ==>

⁶⁰ <http://dhi.nic.in/writereaddata/Content/NEMMP2020.pdf>

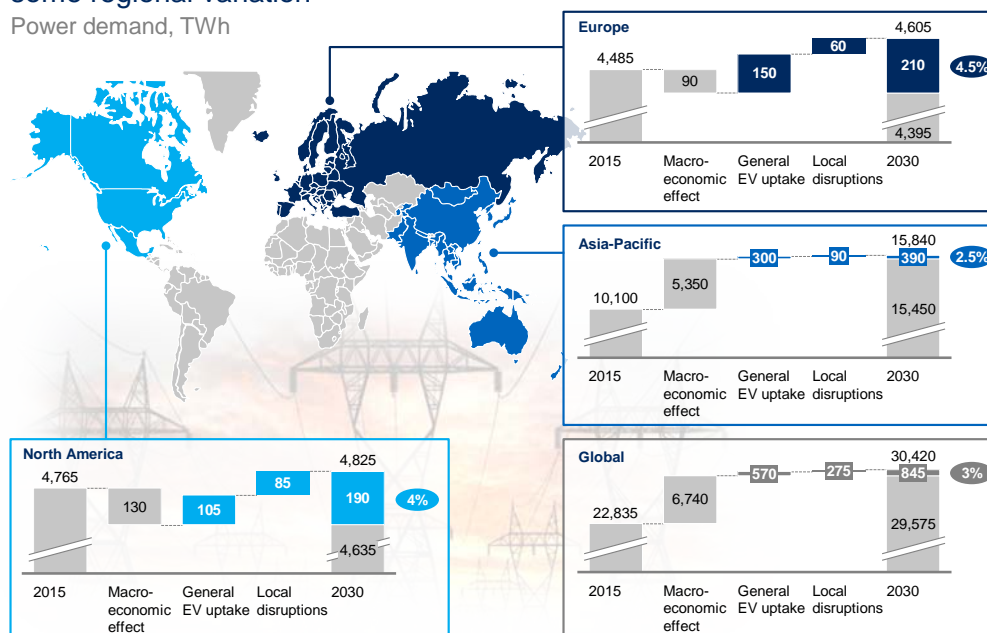
⁶¹ <http://indianpowersector.com/2017/07/government-sanctions-setting-up-of-300-charging-stations-for-electric-vehicles/>

⁶⁵ <https://www.mahindrae2oplus.com/pages/buyers-guide/specifications>

⁶³ Expert interviews

By 2030, EVs may represent up to 3% of the global electricity demand with some regional variation

Power demand, TWh



SOURCE : Bloomberg New Energy Finance

In India, even in an alternate scenario anticipating aggressive and peak penetration levels, EV charging demand is likely to consume only 3 to 7 percent of all power generated by 2030. Off-peak charging of EVs (such as late night) could also help in balancing overall grid capacity, while giving a boost to power plant utilization. These calculations account for the assumption that two- and three-wheelers could lead EV adoption in India (with 100 percent penetration), followed by commercial cars and intra-city buses⁶⁴.

4. Consumer perceptions

Seen as the “next big thing” or the new frontier of mobility, EVs are attractive to many Indians as a status symbol. At the same time, potential customers also worry about undeniable concerns around limited driving range, the time taken to charge the cars and their driving speed. For the long term, it could be important for the government to encourage technology players to focus on the following:

- **Improved driving range:** Current EV models, particularly BEVs, lack the driving range of gasoline cars, and need to be plugged in to charge more

⁶⁴ Calculations based on vehicle sales numbers from SIAM, CMIE; energy data taken from the Ministry of Power, and EV penetration data taken from NITI Aayog

frequently. Range expectation also depends heavily on vehicle end-use, which is mostly correlated with the vehicle segment. In the case of passenger cars, the average driving range is expected to go up to 300 to 500 km within 10 years⁶⁵.

- **Quicker battery charging:** Improved charging time will also make EVs more attractive. Currently the charging time for EVs available in India is around seven hours, with 3 KW single phase 16 AMP Charger, which is very high for passenger and commercial end-use applications. The automotive industry has already seen technology evolving from AC slow chargers to DC fast and ultra-fast chargers.
- **Faster vehicle speed:** EVs like the Mahindra e2O Plus have top speeds of 80 km per hour⁶⁶. As EV manufacturing and performance technologies improve in India, the top speeds could be even higher, further encouraging people to switch to EVs in India.

While the first wave of people investing in EVs could be high-end buyers who look for luxury and new technology⁶⁷, over time EVs will appeal to “risk-averse” green technology adopters, and second-vehicle budget buyers, gradually to the in-town mobility seekers and mass premium seekers and, eventually, young families seeking practical transport solutions may get behind the wheel of electric vehicles. So, the many automobile manufacturers stepping in to produce EVs in India also need to manage consumer perceptions—building up EVs as being not just a high-end, luxury possession, but (despite the higher acquisition cost) economical in the long term.

How the government can promote EVs in India

As seen in the global examples, government support is an important, inevitable enabler in the shift towards EVs. There is much the Indian government is already doing to ensure that EVs gain traction. In addition to the NEMMP, the FAME India Scheme launched in April 2015 aims to support the development of the hybrid and EV market and manufacturing ecosystem through subsidies to the tune of around INR 795 cr. In addition, the government plans to award INR 1.05 bn to every smart city in India towards the purchase of electric vehicles⁶⁸.

Another push to replace traditional vehicles with EVs on Indian roads is through the EESL, a joint venture of four PSUs under the Ministry of Power that aims to substitute the 500,000 cars deployed in government agencies/departments and

⁶⁵IHS Automotive, press coverage, announcements by original equipment manufacturers

⁶⁶<http://www.indiancarsbikes.in/electric-vehicles/mahindra-reva-e2o-electric-car-gets-a-rs-1-77-lakh-price-drop-118446/>

⁶⁷ Expert interviews

⁶⁸ <http://www.livemint.com/Politics/2GS3iKHq6dykzX19BsR9MP/Centre-to-provide-grants-to-cities-buying-electric-vehicles.html>

public sector undertakings (PSUs) with electric vehicles over a three- to four-year period. EESL has embarked on the world's largest single electric vehicle procurement by announcing its plan to source 10,000 EVs from Indian automakers after due bidding⁶⁹. Early in 2017, the EESL also invited bids for 4,000 EV chargers—yet another step towards charging infrastructure readiness in the country⁷⁰.

Besides these, the government could consider the following steps to encourage EV adoption in India:

- **Ambitious targets for reduced CO₂ emissions** and incentives from the government could be important enablers in growing and strengthening the powertrain technology portfolio. The Ministry of Road Transport and Highways (MORTH) has leap frogged to BS VI norms for regulating vehicle emissions in the country⁷¹. Government regulations on vehicle emissions could guide industry players as they make their business plans.
- The government is also considering **amendments to the Electricity Act of 2003** that will ease the process for private companies offering charging stations. To encourage the development of charging infrastructure facilities in India, such entities could be recognized as deemed licensees, and will be exempt from the requirement of applying for a separate license to sell electricity⁷².
- A range of **financial and non-financial incentives** such as tax breaks, free parking, toll exemptions, etc. could strengthen the fledgling EV ecosystem.
- Promote **lower battery prices** to help control overall EV costs and boost adoption. The government could encourage R&D innovations that enable manufacturers to produce batteries locally, reducing costs. Mandating some level of standardization in battery cables, sockets, etc. could also make battery swapping possible, again bringing down costs. In addition, India could take a leading role in the global exploration of newer battery technologies. The government could encourage battery makers to enter into joint ventures (JVs) with technology firms to bring cutting-edge battery technologies. These might over time bring down battery costs and help position EVs as a feasible option.

⁶⁹<https://www.eeslindia.org/DMS/98b2a99e-45e9-4930-8cd0-4236ac50e77a.pdf>;
<http://www.livemint.com/Industry/ji96zXi5dZz3L1XUSkiZxM/Indias-electric-vehicle-drive-Challenges-and-opportunities.html>; <http://www.livemint.com/Industry/ZsbtjLa3A7EUobW8qDj9uK/EESL-to-float-tender-for-10000-additional-electric-vehicles.html>

⁷⁰<https://economictimes.indiatimes.com/industry/auto/news/government-invites-snap-bid-for-electric-vehicle-chargers/articleshow/61327195.cms>

⁷¹ <http://pib.nic.in/newsite/PrintRelease.aspx?relid=155892>

⁷²<https://www.bloombergquint.com/law-and-policy/2017/11/24/private-firms-may-soon-be-allowed-to-set-up-electric-car-charging-stations>

- **Government support to manufacture electric vehicles**—in the form of setting up special economic zones (SEZs), waivers on duty, tax breaks, etc.—could go a long way to attract automotive manufacturers to this segment.
- **Regulators could help to bring about clarity in this fledgling market as new business models and services emerge.**
 - Current conditions do not allow for reselling of power, so perhaps there could be a deemed distribution model, or a need to formulate new license type.
 - Over the next few years, regulatory bodies could help to delineate different roles, such as charging infrastructure owner, real-estate owner, charging infra operator, energy provider.
 - Standardizing guidelines on aspects such as quality requirements, tariff regulations and other norms could also help to create a fair and competitive marketplace for all companies eager to enter the segment but uncertain about the rules and regulations that govern it. Early efforts in this direction consist of the government setting up the Committee for Standardization of Protocols for EV Charging Infrastructure in 2017, and adopting its recommendation to select the European combined charging systems (combined AC and DC charging) as suitable for Indian standards⁷³. This will make it possible to charge all EV models at all charging stations. As new variants of EVs hit the Indian market, the Central Electricity Authority (CEA) is working on framing charger and grid standards for EVs in India⁷⁴.
 - Tariff regulation could also emerge as an important focus area—should home charging be billed at the usual residential tariff or should there be a special EV tariff with a separate meter? Similarly, should the state electricity regulatory commissions (SERCs) regulate power prices for public charging? Should surge pricing be permitted? How could the government regulate the use of power for EVs if service providers self-generate electricity using rooftop solar panels?

At the state government level, various parts of India have come up with separate policies to support the adoption of EVs. In September 2017, Karnataka became the first state to roll out an Electrical Vehicle and Energy Storage Policy, which incentivizes EV and battery manufacturers in the state and mandates the provision of charging infrastructure in highrises. Andhra Pradesh has signed an MoU with Toyota Kirloskar to manufacture high-end EVs in the state, with the first set of cars due to be delivered in 2018. The Delhi Electricity Regulatory Commission (DERC) introduced a flat rate of INR 5.50 per unit for EV charging

⁷³<https://economictimes.indiatimes.com/industry/auto/news/passenger-vehicle/cars/panel-moots-uniform-standard-for-ev-charging-stations-in-india/articleshow/61759087.cms>

⁷⁴ Expert interviews

stations⁷⁵. The Himachal Pradesh Transport Corporation has started running a fleet of around 20-plus, zero-emission electric buses⁷⁶.

HOW EVs COULD CHANGE THE SCENARIO FOR STAKEHOLDERS

As EVs gain momentum and penetrate the Indian market, the shift could impact not only the mobility and transportation industry but also the energy sector. Companies that wish to enter the EV charging market could opt for one of three possible business models as per the framework of the Electricity Act of 2003⁷⁷:

- Distribution companies can act solo to set up charging stations or operate through franchisee agreements.
- Companies setting up charging infrastructure could be considered deemed licensees so that they can freely sell and buy power.
- They could set up battery swapping shops, through which they would be selling charged batteries and not directly selling electricity.

As such new possibilities emerge, the implications vary for various stakeholders and demand deep thought:

- **Energy infrastructure companies** may need to fundamentally rethink their long-term investment focus, infrastructure planning, business model innovations and explore potential new partnerships with growing traction for electric vehicles. The sale of power could form an additional source of revenue for power companies, especially if the Electricity Act is amended as per current discussions. The growing number of EVs represents a potentially large quantum of energy storage which could be connected to transmission and distribution grids, affecting energy flow patterns.
- **Power utilities** could find new opportunities across the value chain through the anticipated uptake in adoption of EVs. Power generation companies could see an increase in demand and therefore be prompted to better utilize capacity. To manage the demand for power, they could set up vehicle-to-grid (V2G) connected storage, allowing charging at off-peak hours such as night-time.
- As sustainable mobility grows, so could the demand for sustainable energy—the options of using solar-powered public charging infrastructure could create a domestic market for **rooftop solar panels**. If rooftop solar prices keep falling and customers move towards self-generation and consumption, it could pose a threat to distribution companies.

⁷⁵<https://powerline.net.in/2017/12/10/big-ev-opportunity/>

⁷⁶<http://www.thehindubusinessline.com/news/national/goldstone-electric-buses-flagged-off-by-hp-transport-corporation/article9868484.ece>

⁷⁷<https://economictimes.indiatimes.com/industry/auto/news/industry/cerc-lists-3-models-for-electric-vehicle-charging-segment/articleshow/60487083.cms>

- **Oil companies** may need to think about long-term capacity planning for their refineries if a large-scale transition from liquid fuels to electric power becomes imminent, eventually impacting the demand for petrol and diesel.
- **Oil marketing companies** that run large networks of retail outlets could repurpose their retail stations to offer retail charging. They might partner with infrastructure players to set up the necessary equipment, explore tie-ups with fleets and cab operators as regular customers, and set up charging infrastructure on major highways to attract passing vehicles. They may also need to use their surplus area for retail/hospitality purposes to bring in customers who wait as their cars charge.
- **Energy metering companies** could attain the benefit of additional charging stations being set up each year as the need for charging infrastructure expands.

The shift to sustainable mobility is a crucial enabler in India's bid to outgrow its dependence on oil imports. As the most attractive option among shared, gas-based and electric mobility, EVs could be the future of transport. The government could provide invaluable support in powering this transition from traditional mobility to electric vehicles.

WEC India (World Energy Council India) is the country member of World Energy Council, a global and inclusive body (estd.1923 with over 90 country members) for thought leadership and tangible engagement in the pursuit of sustainable energy. WEC India functions under the patronage of Ministry of Power and with the support of all energy ministries and leading organisations in energy sector of the country.

India Energy Congress, an apex congregation of energy professionals from across the sector, is the flagship event of WEC India. Now into its 7th edition, the Congress is a joint event of **Ministries of Power, Coal, New & Renewable Energy, Petroleum & Natural Gas, External Affairs and Department of Atomic Energy**. The theme of the 7th edition, “ENERGY 4.0: ENERGY TRANSITION TOWARDS 2030”, will centre around transition led by disruptions that are fundamentally changing the way we live, work and relate to one another. Energy sector is going through a **grand transition** and as sector boundaries get blurred in this transition, the Congress seeks to have insights from Industry leaders on the challenges and response of subsectors.

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