India's Automotive Fuel Policies: Evolution and Challenges

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Key Points

India, like many other countries, is seeking to diversify its automotive fuel mix away from conventional petroleum fuels to alternate, cleaner fuels. The primary reasons for its diversification are energy security and public health due to harmful emissions from automotive fuels. At present, in India, diesel and gasoline are the most common automobile fuels. Increasing demand for these fuels could create serious concerns for the country's national energy security and air quality. This paper analyzes the government of India's past and present automotive fuel policy interventions, aimed at both mitigating harmful emissions and addressing the growing concerns of energy security and rising crude oil imports.

- Alternative fuel policies in India focus on public and private road transport. There is much less emphasis on freight transport, though road freight transport is responsible for 38% of India's diesel consumption.
- Crude oil imports look set to rise due to the rapid growth of India's economy and population.
- Judicial activism via the Supreme Court has achieved more than policy initiatives from elected officials, highlighting the lack of political will to change the status quo.

Figure 1. Consumption of primary sources of conventional energy in India.

* Electricity from hydro, nuclear and renewable energy sources.
Source: MOSPI.

Key Points

- The Indian government is promoting alternative fuel policies through subsidies and private sector participation. Nonetheless, there will still be substantial costs associated with new standards, technologies, and compliance programs.
- Even if India implements the strictest emission standards, vehicular emissions will continue to increase, especially in cities, because private vehicles remain the most convenient transport option for the public.
- A larger electric vehicle fleet will add significant costs not only to the transport sector but also to the power sector.

Summary

This paper analyzes India's automotive fuel policies. Its objective is to provide a historical overview of India's automotive fuel policy landscape and to serve as a reference for researchers engaged in quantitative modeling and analysis.

We begin by describing the conventional energy consumption pattern in India and the role of crude oil imports in the Indian transportation sector and economy and consider how automotive fuel policies and emission norms evolved in India. We investigate the linkage of fuel policy with environmental concerns and energy security. To explain the fuel policy landscape, we divided policies into two categories: substitution policies and environment policies. India's automotive fuel policy has evolved around the issue of energy security and the environmental effects of emissions. We have also elaborated the emissions standards adopted by India to address the issue of air quality. Even after the adoption of European (Euro) equivalent emissions standards, Indian cities still suffer from poor air quality.

The last section highlights the impact of automotive fuel policies on energy security, the environment, and infrastructure. The country's high economic growth rate, population, demand for vehicles, poor infrastructure, and lack of policy implementation have been, and continue to be, key barriers to achieving energy security and reduced emissions. Recently announced policies covering electric vehicles, biofuels and other alternative fuels suggest that India might need to invest heavily in passenger vehicle infrastructure such as electric charging stations, fuel transport, and biofuel blending infrastructure for a smooth implementation of passenger vehicle fuel policies in cities. Further, the country lacks policy interventions in the freight transport sector, the highest source of emissions in India's road transport sector. Our analysis of these automotive fuel policies and emission standards provides an opportunity for OPEC to estimate the future demand for crude oil in India.

Introduction

Indian crude oil imports have increased steadily over the past several years, as stagnating domestic production has barely kept pace with rising domestic demand. India and China are the two most promising markets for oil-producing countries, with the two countries, imports doubling from 2006-2016. China has now overtaken the United States (U.S.) to become the world's largest crude oil importer. Indian imports have also risen sharply, with the country overtaking Japan in 2017 to become the world's third-largest crude oil importer. This growth has implications for oil producers globally, especially those in the Middle East. Strong demand growth in the key import markets of India and China is critical to ensuring the revenue that these oil exporting countries need to finance their budgets. Understanding the economic drivers for Indian crude imports and the domestic policies

which affect demand growth is vital in helping oil producers plan for the next couple of decades.

This paper analyzes Indian automobile fuel policies and aims to help policymakers develop domestic fuel policies which, in turn, may have international impacts. The key driver of Indian demand has been India's overall economic growth, which has led to increasing energy demand, purchasing power, and demand for private transport.

As can be seen from Figure 1, the consumption of primary sources of energy in India has grown strongly over the past several years, with extremely robust growth in crude oil consumption as its gross domestic product (GDP) and per capita income have increased.

Figure 1. Consumption of primary sources of conventional energy in India.

* Electricity from hydro, nuclear and renewable energy sources.
Source: MOSPI.

As Figure 2 shows, India's domestic crude oil production has stagnated for several years, whereas crude oil imports have grown, with a compound annual growth rate (CAGR) of 6.59% from 1970-2017. Crude oil production has slowed due to the poor state of the country's upstream exploration and development. Consequently, India has become heavily dependent on crude oil imports (Figure 2), reaching a dependency level of 82.8%

at the end of the last financial year 2017-18 (The Economic Times 2018).

The growth in imports has driven India's policymakers to address the energy security issue – by diversifying supply sources, investing in overseas oil assets and also, importantly, by fuel substitution. This policy push has evolved over a period to form the bedrock of India's automotive fuel policies.

Figure 2. Crude oil – Indian production and imports.

Source: MOSPI.

Development of Fuel Policies

This section categorizes automotive fuel policies by their evolution pattern. They are divided into two broad categories: policies

concerning substitution and policies concerning environmental issues.

Figure 3. Fuel policy categories.

Source: KAPSARC.

Figure 4. Year-on-year automotive fuel policy trends in India

National Environment Policy (NEP), National Action Plan on Climate Change (NAPCC), National Mission on Sustainable Habitat (NMSH), Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

Source: Government of India and relevant ministries.

Fuel substitution policies

India's automotive industry is one of the largest in the world. In 2016, its turnover was equivalent to 7.1% of India's GDP (MoHIPE 2016). Concerns over India's energy security due to its high population growth and rising demand for vehicles will increase the relevance of fuel substitution policies. This section looks at substitution policies that address energy security and environmental impact.

India's national fuel policies originated in October 1970, in the aftermath of that year's oil shock, with the establishment of the Fuel Policy Committee, tasked with defining national fuel policy. The Committee submitted its initial "Fuel Policy for the Seventies" report in May 1972, which was followed by the more comprehensive "Fuel Policy Committee Report" in August 1974 (Government of India 1974). In 1974, the Committee produced a report on international oil prices and energy security,

the main objective of which was to establish an appropriate fuel policy mix for India up to 1990-91. The Committee also noted that imported oil used in sectors other than transport could be substituted by coal (Planning Commission 1974).

National Hydrogen Energy Road Map

In 2006, India's National Hydrogen Energy Road Map was initiated by the National Hydrogen Energy Board under the direction of the national Ministry of New and Renewable Energy (MNRE). The objective of the roadmap was to eventually offer long-term energy solutions to the country's growing energy problems. It also aimed to ensure the country's energy security, identifying the paths that would lead to a gradual introduction of hydrogen energy, accelerate commercialization efforts and facilitate the creation of the country's hydrogen energy infrastructure.

Figure 5. Substitution fuel policies in India.

*** National Electric Mobility Mission Plan (NEMMP).
Source: Government of India and relevant ministries.

The government developed two initiatives as part of the Road Map: Green Initiative for Future Transport (GIFT), to develop and demonstrate hydrogen-powered internal combustion (IC) engines and fuel cell-based vehicles, and the Green Initiative for Power Generation (GIP), to develop and demonstrate hydrogen-powered IC engines and fuel cell-based decentralized power generating systems. GIFT has set a target of 1 million hydrogen-powered IC engine vehicles on the road by 2020 (MNRE 2006).

As part of its efforts to diversify India's fuel mix, in 2002, the Ministry of Petroleum and Natural Gas (MoPNG) started a pilot ethanol blending program that made it mandatory in nine Indian states and four union territories for oil companies to blend 5% ethanol with gasoline. The Committee on Development of Biofuels was constituted in July 2002 by the Planning Commission. In its report of July 2003, it recommended that India should move progressively toward the use of biofuels (Bandyopadhyaya 2015).

National Policy on Biofuels

In 2009, the MNRE introduced its National Policy on Biofuels to promote alternative fuels. It aimed to mainstream biofuel so that it could play a central role in the transportation sector, ensuring that a minimum level of this fuel became readily available on the market to meet the country's energy demand at any given time. It proposed a target of 20% blending of biofuels in gasoline by 2017. Subsidies and grants provide a major impetus for research and development of biofuels and fiscal incentives (MNRE 2009). However, in 2018 the government revised its biofuel policy with the National Policy on Biofuel, the main feature of which was to provide viability gap

funding for second generation ethanol biorefineries of 50 billion Indian rupees (INR) over six years, in addition to tax incentives (MNRE 2018).

National Electric Mobility Mission Plan (NEMMP)

In 2011, the Indian government approved the National Mission on Electric Mobility. This was followed two years later by the National Electric Mobility Mission Plan (NEMMP), introduced by the Ministry of Heavy Industries and Public Enterprises. Its objective is to achieve national fuel security by promoting hybrid and electric vehicles, with the target of 6-7 million year-on-year sales of hybrid and electric vehicles. To achieve such an ambitious target, the government plans to provide fiscal and monetary incentives. As part of NEMMP, the government launched its Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) scheme, with an initial outlay of INR 750 million, to help create a market for hybrid and electric vehicles (MoHIPE 2013). Before NEMMP, Indian central and state government provided subsidies to promote electric vehicles.

Environmental policies

The increase in vehicle numbers has contributed to increased air pollution and poor public health in Indian cities (World Resources Institute 2014). India has recognized the need to address health and environmental issues and has taken steps to mitigate these externalities associated with the transportation sector. Figure 6 details the policies and initiatives taken by the government to tackle these issues.

Figure 6. India: Fuel policies focusing on environmental issues.

National Environment Policy (NEP), National Action Plan on Climate Change (NAPCC), National Mission on Sustainable Habitat (NMSH), Atal Mission for Rejuvenation and Urban Transformation (AMRUT).

Source: Government of India and relevant ministries.

Figure 7. Cumulative number of registered vehicles by year.

*Others include tractors, auto rickshaws, and agricultural vehicles.

Sources: MoRTH, KAPSARC analysis.

Since the early 1990s, the growth in private vehicle ownership in India has increased concern over the effect of emissions from vehicles on public health. In response to this and to public pressure for clean air, in 1998 the Supreme Court of India introduced multiple directives on air pollution. These directives required the replacement of all pre-1990 motorized three-wheelers and taxis with new compressed natural gas (CNG) vehicles by March 2000 and Delhi's entire bus fleet to be converted from diesel to CNG by March 2001. The Supreme Court also issued an order to the Gas Authority of India Limited to expand CNG outlets from 9 to 80 by March 31, 2000, with another order in 2002 which expanded the CNG program to more cities in India. To support these initiatives, state governments provided financial incentives and subsidies in the form of loan packages and exemptions from value added tax, sales tax and motor vehicle tax (Roychowdhury 2010).

After the series of Supreme Court orders and directives, in 2003 the Indian government produced an ambitious plan to tackle its air quality challenges through the implementation of vehicular emission norms and the corresponding Auto Fuel Policy, in phases, until 2010. The policy focused on reducing pollution from vehicles to minimize its social cost and also examined the issue of fuel security. Bharat Stage (BS) II fuel norms (Euro II equivalent) were introduced as part of the fuel policy, which also laid out a roadmap for Euro III equivalent fuel/emission standards for all private, public, and commercial city vehicles from April 1, 2005. The policy also recommended applying Euro IV equivalent emission standards for all private, service and commercial vehicles from April 1, 2010. Other recommendations included the use of CNG in cities with high vehicle numbers, a program for encouraging zero-emission vehicles, and promoting technologies producing biofuels (MoPNG 2003). The government

envisaged that this policy would undergo periodic revisions. In 2013, it set up an expert committee to establish a plan out to 2025, taking into account the achievements and experiences of the 2003 automotive fuel policy. The latest version of the policy also recommended a suitable mix of automotive fuels, according to the availability of infrastructure, logistics, and fuel processing economics. The "Vision" written in association with this policy also provides guidelines for automotive emissions standards for various categories, a plan for their implementation, fiscal measures for funding the requisite upgrading of oil refineries, logistics and the removal of inter-fuel distortions (MoPNG 2013).

In 2016, India had some 230 million registered motor vehicles (Figure 7), of which more than 70% were two-wheelers. In 2016, there were 169 million registered two-wheelers and 30.2 million registered cars, jeeps and taxis. From 1990 to 2016, the growth in the number of India's registered vehicles was substantial, with a CAGR of around 18%. As an emerging economy, India is experiencing increased demand for road vehicles and, consequently, increased consumption of gasoline and diesel will result in increased air pollution.

National environmental policies

To address growing widespread concerns, in 2006, the Ministry of Environment, Forest and Climate Change (MoEFCC) issued the National Environment Policy (NEP), laying out a national strategy for urban transport that would ensure adequate investment in low pollution mass transport systems (MoEFCC 2006). On June 30, 2008, India released its National Action Plan on Climate Change (NAPCC) intended to mitigate the effects of and adapt to climate change. The Indian government recognized that climate change is a global challenge and decided

to engage in multilateral negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). The action plan contained eight missions that promoted a greater understanding of climate change, adaptation and mitigation, energy efficiency and natural resource conservation (MoEFCC 2008).

In 2010, the Ministry of Urban Development launched the National Mission on Sustainable Habitat (NMSH) as one of the eight missions of the NAPCC. It provided strategies for reducing transport sector greenhouse gas (GHG) emissions. NMSH focused on the use of nonmotorized modes of transportation and encouraging a modal shift from private to public transport. NMSH is also focused on reducing passenger and freight kilometers, promoting railways for passenger and freight transport, strict fuel economy standards, the use of alternative fuels, and promoting battery operated and hybrid vehicles and alternative fuels. It also aimed to discourage the use of diesel-fueled personal vehicles (MoUD, 2010).

At the 2009 U.N. Climate Change Conference that resulted in the Copenhagen Accord, India pledged to reduce the emissions intensity of its GDP by 20%-25% compared with 2005. At the time, however, many experts believed the country could have done more. The government revised its nationally determined contribution (NDC) in 2015, aiming to reduce the emissions intensity of its GDP from 2005 levels by 33%-35% by 2030 and to have 40% of installed electricity capacity based on non-fossil fuels by 2030 (Bhatt et al. 2018). It also focused on policies and programs related to the promotion of clean energy, sustainable green transportation networks, energy efficiency, and the development of less carbon-intensive urban centers, reducing air pollution and creating carbon sinks through planting forests (Government of

India 2015). In June 2015, the Indian government launched the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), focused mainly on reducing pollution by switching from private to public transport and by promoting non-motorized transport (Ministry of Housing and Urban Affairs 2015).

In a joint initiative with the federal government, states in India also produced action plans for climate change focusing on compatible development. Because of increases in vehicle fleets and higher air pollution in cities and states, Indian states emphasized pollution control and a shift in transportation to public mass transportation through the bus rapid transport system and mass rapid transit system. States are also focusing on shifting to more environmentally friendly modes of transport, such as non-motorized transport, phasing out old vehicles and discouraging inefficient vehicles by imposing a carbon tax on the vehicles and other penalties (MoEFCC 2015). The Indian government has established a green mobility fund, directed at mass transit projects, non-motorized modes of transport, the use of non-fossil fuels, and the creation of last mile connectivity. Under India's smart cities mission, three of the eight criteria link directly to mobility solutions (NITI Aayog and Rocky Mountain Institute 2017).

Environmental concerns are the major factors driving these state action plans. As such, the plans also promote the use of CNG, electric vehicles (EVs), biofuel blending, and alternative fuels. A number of states have already begun using CNG in their public transport fleets. The state governments have also planned financial incentives and subsidies for the use of alternative fuels and vehicles and intend to apply Euro standard vehicle emission regulations to reduce emissions. They are also focusing on reducing fossil fuel use through efficiency improvements (MoEFCC 2015). Figure 8 details some of the state-level initiatives.

Figure 8. Initiatives under state climate action plans.

States promoting phasing out of new vehicles

States promoting electric vehicles

Sources: MOEFCC, KAPSARC analysis.

Development of vehicle emission control standards

Air quality is a social concern worldwide in the context of rising vehicular air pollution. Vehicle exhaust is one of the primary sources of pollution and there is an urgent need to keep it in check,

especially when the number of vehicles is growing. Emission standards set limits on the amount of pollutants that can be released into the environment. Many standards focus on regulating pollutants from automobiles and other powered vehicles, but they also regulate emissions from industry, power plants, and small machinery. This section analyzes India's vehicle emission control program (Bandivadekar 2013).

Development of Fuel Policies

Figure 9. India's emission standards by year.

* Introduced in the National Capital Region, ** Introduced in Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Secunderabad, Ahmedabad, Pune, Surat, Kanpur and Agra, *** Introduced Nationwide.

Source: Government of India and relevant ministries.

The Indian government's Air (Prevention and Control of Pollution) Act of 1981 set out the standards by which it would determine vehicular emissions regulations, in consultation with India's Central Pollution Control Board (CPCB). The law also gives Indian states the right to inspect, examine, and enforce air quality regulations set by their Pollution Control Boards (Parliament of India 1981).

India's first emission regulations were established in 1989. These were replaced by emission standards in 1991 and 1992 which set limits for gasoline and diesel vehicles, respectively. In 1999, Bharat Stage (BS) I standards for the National Capital Region (NCR) were decided on. These were introduced in 2000, based on European regulations. The Indian government introduced these emissions standards to regulate the output of air pollutants from internal combustion engine (ICE) machinery, including motor

vehicles. The Central Pollution Control Board set the regulations and the timeline for their implementation, overseen by the Ministry of Environment and Forests (DieselNet 2017).

Since 2000, progressively tighter fuel emission standards have been introduced. The Auto Fuel Policy proposed a phased program for introducing BS II-IV emissions and fuel regulations by 2010, with an emissions requirement for interstate buses originating or terminating in heavily populated cities. An expert committee was established under the Planning Commission of India (NITI Aayog) to establish emissions standards beyond BS IV and to formulate the updated Auto Fuel Policy. The Auto Fuel Vision and Policy 2025 was published in May 2014. Although these recommendations were not mandatory, they acted as a first step to establishing automotive emission standards, nationwide (DieselNet 2017).

In 2014, the expert committee report on Auto Fuel Vision and Policy 2025 recommended that BS IV fuel standards should be implemented nationwide, and BS V and BS VI should be implemented by 2020 and 2024, respectively. The Ministry of Petroleum and Natural Gas (MoPNG) supported the move from BS IV to BS VI, but the automotive industry opposed this. In November 2015, the Ministry of Road Transport and Highways published a draft notice announcing that BS V would be implemented across the country, starting in 2019

and BS VI starting in 2021. The ministry was asked in 2016 to advance the implementation of BS VI emission standards, following which the government announced a new proposal for implementation of BS VI by skipping the BS V standards and instead implementing BS VI by 2020. However, as a result of serious pollution levels in the NCR, MoPNG announced that introduction of BS VI fuel standards would be advanced to April 2018 in that region (The Economic Times 2017), (Appendix, tables 1-4).

Learning From Past Policies

This section details the outcomes of past and current fuel policies and emission standards, assessed in terms of energy security, environmental impacts and finances, and the infrastructure needed to implement the policies.

Energy security

Crude oil imports have always played a strategic role in India's energy security. In 1956, Prime Minister Jawaharlal Nehru said in Parliament that a country that does not produce its own oil is in a weak position (MoIB 1958). After the oil shock of 1973, the Fuel Policy Committee acknowledged the importance of energy security and alternative fuels, and subsequent fuel policies were designed around these issues. The government realized that energy security could be improved through

increased domestic production and import source diversification, but a significant gap remains between the growing need for energy and the country's declining domestic energy resources.

India imports around 82% of its crude oil demand. India consumed almost 227 million metric tons of crude oil in 2015 and that figure has been rising steadily, and it is today the world's third-largest oil consumer (Ministry of Petroleum and Natural Gas 2016). Despite its previous policy interventions, India's annual oil imports grew significantly, from 148 million barrels in 1990 to 1,661 million barrels in 2018, with a CAGR of 9%. In 2016, the Middle East accounted for around 60% of India's total crude oil imports, of which Saudi Arabia contributed around 34% (Figures 10, 11 and 12).

Figure 10. Crude oil imports by country and region in million barrels/day (MMbbl/day).

Source: Joint Organisations Data Initiative (JODI).

Figure 11. Crude oil imports to India from the Middle East.

Source: MOPNG.

Figure 12. Share of Indian crude oil imports by region 2016.

Source: MOPNG.

The growth of India's crude oil imports from April 2006-March 2016, was attributable to factors such as the stagnation in its domestic oil industry, delays in commissioning new exploration and production projects, declining production from existing oil fields, the lack of a comprehensive supply side policy, and rising demand (FICCI 2012).

As of the fiscal year 2016, India had 4.7 billion barrels of proven crude oil reserves, or 0.3% of total world oil reserves (MoPNG 2016). In 2012, the Planning Commission of India forecast that India's oil reserves would last for less than 20 years at a production rate of 763,000 bbl/day. India currently has 23 domestic refineries with an annual capacity of about 247.57 million metric tons (mt), more than enough to cater to the country's needs. In 1976, in response to increasing fuel prices, India nationalized the country's oil industry, so only state-owned companies were allowed to drill in India's hydrocarbon basins. However, eventually production declined, and by 1993, as a result of fuel subsidies and petroleum products pricing, there was no funding left for new exploration by state exploration companies. The situation changed in 1999, however, when privately owned Reliance Industries commissioned its green-field refinery of 27 million mt capacity. Following this capacity addition, India's imports of crude oil increased significantly, mainly because of its high refining capacity and demand along with an increase in exports of petroleum products (Helman 2006).

However, India's increased use of alternative fuels was mainly driven by environmental concerns and had a limited impact on crude oil imports. Despite the introduction of CNG regulations, there were only about 3.04 million CNG vehicles as of March 2017 (Figure 16), or around 1% of total registered motorized vehicles. Out of this total, most CNG vehicles are three-wheelers (public transport).

Prime Minister Narendra Modi committed the country to reduce crude oil imports by 10% by 2022. Minister for Petroleum and Natural Gas Dharmendra Pradhan has announced India will boost domestic oil and gas production, improve energy efficiency, promote alternative fuels, renewables and demand substitution, and improve the refining process by increasing the complexity of refineries. In 2013, India introduced the National Electric Mobility Mission Plan (NEMMP) (MoHIPE 2013) for EVs. A presentation by Lawrence Berkeley National Laboratory estimated that electric vehicles could reduce India's annual crude oil import bill by \$14 billion per year by 2030 and \$100 billion per year by 2050 (assuming a constant oil price of \$40/bbl) (Lawrence Berkeley National Laboratory 2017).

At present, as a result of the FAME-India program, there are 180,000 registered EVs in India (National Automotive Board 2019). However, greater EV penetration will help reduce crude oil imports, even if they create new challenges and dependencies on other imports.

Environmental impact

Though India's fuel policy has historically been mainly concerned with energy security and energy access, in recent years attention has shifted to environmental issues. India's policymakers know that the country is vulnerable to climate change and have targeted a reduction in GHG emissions intensity and promoted alternative fuels to replace fossil fuels so as to lower carbon intensity (Government of India 2015).

India ranked third in global GHG emissions in 2016, with 7% of total global emissions, behind China and the U.S. In addition, the country's transportation sector was responsible for about 232 million mt of carbon dioxide emissions (World Resource Institute

2015). Transportation sector CO₂ emissions grew from 64.6 million mt of CO₂ in 1990 to 232 million mt in 2014, with a CAGR of 9.56%. With high population and robust GDP growth, India's CO₂ emissions are expected to increase at a higher rate (Figure 13).

India has progressively improved its vehicle emissions standards. According to the country's new National Ambient Air Quality standards (NAAQs), the annual air quality standards are 50 micrograms (μg) per cubic meter for sulfur dioxide and 40 μg per cubic meter for nitrogen dioxide. These standards are more relevant in cities with a higher density of vehicles. Figures 14 and 15 show that India significantly reduced sulfur oxide (SO_x) emissions from 1997 to 2014 in its major cities. Nitrogen oxide (NO_x) emissions increased but were still inside the recommended limit. However, Delhi and Kolkata remained above the recommended NO_x emissions standards (Figures 14 and 15).

In addition to tighter emission standards, the number of CNG buses and three-wheelers has

increased steadily since the late 1990s following the Supreme Court ruling. At the end of the 2016 financial year there were around 3.04 million CNG vehicles in India, with about 2 million in Gujarat and Delhi, NCR (MoRTH 2015). Nonetheless, in the absence of future policy interventions, rapid growth in the overall vehicle population could negate the efforts already made.

The current Indian government's EV policy could lower future GHG emissions. About 42,000 EVs were sold in financial year (FY) 2012-13 and around 20,000 hybrid and EVs in FY 2013-14. According to FAME-India data, there has been a cumulative reduction of 53.3 billion mt of CO₂, with a daily reduction of 104.5 mt of CO₂ to date (National Automotive Board 2019). However, the country's ambitious EV plan is based on a comparison between the carbon footprint of EVs and that from internal combustion engine vehicles (ICEV). An EV that charges at night may result in worse emissions than an ICEV, since in India renewables still lack large-scale storage capacity and baseload

Figure 13. India, China and U.S. transportation sector emissions by year.

Sources: World Resources Institute, KAPSARC Analysis.

Figure 14. SO_x emission in highly polluted cities in India.

Sources: CPCB, KAPSARC analysis.

Figure 15. NO_x emissions in highly polluted cities in India.

Sources: CPCB, KAPSARC analysis.

Figure 16. CNG vehicles in India, by year.

Sources: MoRTH, KAPSARC analysis.

power is generated from coal-fired power plants with much higher CO₂ emissions. The country's plan to achieve its intended UNFCCC commitment through alternative fuel policy intervention could be a success, but there are other policy implementation issues in India, related to infrastructure and finance which could slow down the progress (Ali and Tongia 2018).

Financial support and infrastructure

India's automotive fuel policies have been directed toward low carbon transportation in recent years due to increasing environmental concerns. But to implement these policies, the country needs to overhaul its road sector infrastructure, and for that a substantial investment is required.

There was a need to develop the country's CNG network after the 1998 Supreme Court orders to implement CNG passenger transport programs,

to secure an uninterrupted supply of transport fuel. By October 2017, India had 1,273 operating CNG stations (MoPNG 2018). India is also pushing for more two-wheelers to run on CNG, with pilot schemes launched in 2016 for major cities including New Delhi and Mumbai. To make two-wheelers retrofitted with CNG systems work, efficient infrastructure and more CNG stations will be required since two-wheelers represent the majority of motorized Indian road transport (Jaganathan 2018).

India took the initiative on biofuels with the aim of improving energy security. To promote biofuels, the government is providing viability gap funding totaling INR 50 billion over six years, in addition to tax incentives for second generation ethanol biorefineries. Additional infrastructure investment will be required for second generation biorefineries in rural areas. The future of biofuels looks promising, but the lessons from the past need to be analyzed (MNRE 2018).

The initial research and development phase of the government's hydrogen roadmap has been estimated to cost around INR 250 billion. MoPNG and the Indian Oil Corporation have also created a corpus fund of INR 1 billion for hydrogen research activities. One of the government's biggest challenges will be to reduce the price of hydrogen at the point of delivery, to the level of Indian gasoline and diesel prices, in order to justify consumer switching (MNRE 2006).

The Indian government is showing a lot of interest in electric mobility, with national and sub national policies. To promote EV penetration, the FAME-India scheme is providing an initial outlay of INR 750 million. In May 2018, the government provided financial support of INR 90 billion for the roll out of the second phase of the FAME-India program for five years (Financial Express 2018). Besides government interventions, the growth of EVs requires a consistent and accessible network of EV charging infrastructure. There are only a few charging stations in India at present,

and those are in the pilot phase. It is estimated that the NCR region alone may require between 800-1,000 charging stations (Modi 2018). Thus, to accommodate EVs into the system requires advanced planning and policy interventions in urban development, manufacturing, investments and consumer behavior.

EVs will not only affect the transport sector but will also strongly impact the power sector, possibly adding up to 50% to peak demand. By 2030, even if all automotive sales were EVs, their electricity demand would be around 100 terawatt hours, which represents less than 400 megawatt hours per EV on an average annual basis. Even at 33% sales penetration, EVs will constitute the most significant power load sector in the country, higher even than the steel sector or other industrial loads. This will require huge infrastructure financing in the power sector. India's EV aspirations appear ambitious, but they have sparked interest in industry and research (Ali and Tongia 2018).

Conclusion

India consumes more diesel than any other petroleum product. Commercial vehicles account for 38% of the country's diesel consumption, while private and public transport accounts for 22.7% (three-wheelers are not counted in freight and passenger transportation). However, India's alternative fuel policy push focuses on public and private transport. The majority of India's private vehicle fleet consists of two-wheelers, which consume mainly gasoline (Petroleum Planning and Analysis Cell 2013).

India is one of the fastest growing economies in the world, sixth in nominal GDP (The World Bank 2019). This growth will create demand for commercial goods and increase the share of freight transport. Domestic oil production is still flagging and, without government efforts to develop an alternative freight transport fuel policy, India could experience an even higher rise in crude oil imports. India will have to enhance its energy security by buying energy supplies at affordable prices. While the country has surplus refining capacity and is a net exporter of petroleum products, it will have to make major investments in the domestic upstream industry and to acquire hydrocarbon reserves abroad. India's population growth and ever increasing purchasing power capacity will further increase crude oil imports from OPEC member states, especially those in the Middle East.

India's push for clean fuels in its energy mix through policy interventions will require state-of-the-art

infrastructure and financial support. Although the Indian government is encouraging private sector participation through subsidies and nodal support, financing of these clean energy fuels will remain a challenge. A recent push for EVs will create additional infrastructural and financial burdens on the country's power sector.

Over the past decade, India has taken numerous measures to reduce harmful transportation sector emissions. Continuing this progress with further action will improve air quality, public health and quality of life. Assuming fast future growth in older vehicle stockpiling, India might wish to tighten emission standards and introduce cleaner fuels. However, there will be substantial costs associated with new standards, technologies and compliance programs. Even if India implements the strictest standards for emissions and cleaner fuels, vehicular emissions will continue to rise, especially in cities, since private vehicles remain the most convenient transportation option for the public. Similarly, India might have to consider the effects of its fuel subsidy programs on vehicle emissions, otherwise it may create a mismatch between vehicle emissions and its own fuel standards.

If India developed a comprehensive and stringent roadmap, this could provide certainty to the country's crude oil suppliers. It could also help mitigate air pollution and improve air quality in many cities. This remains an aspiration. For now, India's growth will mean a greater reliance on crude oil imports.

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A green geometric graphic consisting of several overlapping triangles and polygons, located in the top-left corner of the page.

Notes

Appendix

Table 1. Indian emission standards for four-wheeled vehicles.

Standard	Reference	Year	Region
India 2000	Euro 1	2000	Nationwide
Bharat Stage (BS) II	Euro 2	2001-2005	NCR, Mumbai, Kolkata, Chennai (2001), NCR and 13 cities (2003), nationwide (2005)
BS III	Euro 3	2005-2010	NCR and 13 cities (2005), nationwide (2010)
BS IV	Euro 4	2010-2017	NCR and 13 cities (2010), nationwide (2017)
BS V	Euro 5	(to be skipped to implement BSVI)	
BS VI	Euro 6	2020	Nationwide

Source: DieselNet.

Table 2. Indian emissions standards for two- and three-wheelers.

Standard	Reference	Year
BS II	Euro 2	2005
BS III	Euro 3	2010
BS IV	Euro 4	2017
BS VI	Euro 6	2020

Source: DieselNet.

Table 3. Two Indian emissions standards for passenger cars.

Stage	Year
Gasoline vehicles	
India 2000	2000
BS II	2005
BS III	2010
BS IV	2010
BS V	Proposal changed to BS VI
BS VI	2020
Diesel vehicles	
India 2000	2000
BS II	2005
BS III	2010
BS IV	2010
BS V	Proposal changed to BS VI
BS VI	2020

Source: DieselNet.

Table 4. Indian emissions standards for heavy-duty engines.

Stage	Year
India 2000	2000
BS II	2005
BS III	2010
BS IV	2010
BS V	Proposal changed to BS VI
BS VI	2020

Source: DieselNet.

About the Authors

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Yagyavalk is a research associate at KAPSARC. His research interests include analysis of energy policies, with a focus on alternate fuels and its impact on energy security. He previously worked as a researcher, providing sustainable development and decentralized renewable energy system solutions to rural areas of north India. He holds a master's degree in renewable energy engineering and management from TERI University, India.

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About the Project

As the pace of economic growth in China moderates, India looks set to become the world's largest fast-growing major economy and is likely to see its demand for oil and gas imports grow. The domestic availability of coal resources will likely support coal demand growth, but there is no guarantee that a societal push for clean air will not result in an expansion of renewable and natural gas-based energy systems at the expense of coal. The move toward low carbon public transport and the pace of adoption of smart mobility will influence India's oil demand growth, as will its adherence to global climate commitments.

KAPSARC is engaged in understanding the primary catalysts for India's changing energy demand, and evaluating the significance of its energy policies and security strategies for Saudi Arabia and the global community. This analysis will help provide a deeper and more comprehensive understanding of domestic Indian energy challenges and the policies needed to address these challenges. This research project aims to investigate the global consequences of changes to energy markets within India, thus enabling the assessment and analysis needed to obtain policy-relevant insights. In line with KAPSARC's overall objectives, the project aims to assist stakeholders outside India to understand the consequences of decisions taken by Indian policymakers.

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