

November 2017

# Gasoline Demand in Transport in Non-OECD Asia

## Background

Global oil demand is undergoing a structural shift. Over the last 15 years, while OECD demand decreased by 3 million barrels per day (mb/d) from 2000-15 – with the secular decline expected to continue to 2035 – demand in non-OECD countries grew by 21 mb/d (IEA, 2015; BP, 2016). This shift is characterised by the rapid growth in China's oil consumption from 2000-13, and the 'jump' in India's oil demand growth – which overtook China in 2015 to emerge as one of the main drivers of non-OECD Asian oil demand growth. The shift is particularly visible in gasoline. Previous expectations were for gasoline demand to decline as it was mainly driven by West of Suez markets, while East of Suez demand was distillate-heavy. However, gasoline growth is now being driven by non-OECD Asia, and Asian gasoline demand, which was growing at an average of 130 thousand b/d (kb/d) a year between 2005 and 2010, nearly doubled to 290 kb/d a year from 2011 onwards.

On the one hand, non-OECD Asian economies are expected to enter or continue along high-growth trajectories over the next decade, driven by significant expansions in infrastructure, output and income at the national level; examples include India's nationwide programme to add 30 km of roads/day, and its push to increase manufacturing's share of GDP from 15% to 25% by early next decade through focusing on energy-intensive industry, as well as China's 'One Belt One Road' initiative to create connecting infrastructure across Asia.

On the other, given the carbon constraint on economic growth arising from the ratification of the Paris Agreement, there is a push towards increasing the efficiency of energy use (through stricter fuel efficiency standards in transportation and eliminating fossil fuel subsidies from end-user prices), as well as a number of initiatives to curb environmental pollution (such as the adoption of Electric Vehicles (EVs), and bans on polluting vehicles). Notably, while the push to increase output is primarily occurring at the national level in most non-OECD Asian countries, the constraints to this expansion are currently being driven largely at the local/regional level. These counteracting trends and the complexity of policies underpinning them make it unlikely that non-OECD Asian economies will follow the same historical trends in gasoline consumption as the OECD. There are three potential arguments that can be made:

- One argument is that these economies will enter high-growth trajectories, but that these trajectories could be shorter, and consumption plateaus may come sooner than they have in the OECD.
- A second argument is that technological advancements (such as battery storage technologies) will facilitate a faster substitution of oil in its core consuming sectors (for example, gasoline in transport) regardless of the growth in car ownership.
- A third argument is that the fragmented nature of regional-level policy constraints will fail to have a significant impact on nationally-driven movements to industrialise.

Given this context, this Insight summarises findings from a new [OIES Paper](#) which investigates two research questions: first, what are the key drivers of gasoline demand growth in non-OECD Asia, based on historical trends? And second, what are the constraints to gasoline demand growth in this region? The first question, driven by historical trends, is investigated by applying statistical analysis to a dataset of 19 countries in the Asia-Pacific region, of which over half are non-OECD countries. The second question, driven by local and regional policies on mitigating climate change and environmental pollution, is investigated by discussing the cases of India and China.

## Transport – a key driver of gasoline demand

In consumer theory, the demand for gasoline is a ‘derived’ demand (Storchmann, 2005; Becker, 1965; Lancaster, 1966; Muth, 1966). It is not gasoline itself which gives benefit to the consumer, but the end-product – namely, mobility (Storchmann, 2005). The transport sector accounts for roughly 63% of global oil consumption, and has historically been the fastest growing oil-consuming sector (WEC, 2016). By 2035, it has been projected that 88% of the world’s oil demand growth will come from transportation, largely from developing economies (BP, 2016). Medlock and Soligo (2001) show that per capita energy demand in the transport sector steadily increases throughout the process of economic development, eventually accounting for the largest share of total final energy consumption. As oil demand for road transportation is closely linked with the number of cars and other road vehicles in use, projections of future growth in the vehicle stock can provide an insight into future fuel requirements (Dargay and Gately, 1999).

In OECD countries, the growth of the vehicle stock, measured in terms of vehicle (or more specifically, car) ownership, has followed a clear path, varying closely with changes in per capita income. This relationship has been formalised in the existing literature: vehicle ownership grows relatively slowly at the lowest levels of per capita income, then about twice as fast at middle income levels (estimated at \$3,000 to \$10,000 per capita in Dargay and Gately (2007)), and finally, about as fast as income at higher income levels, before reaching saturation at the highest levels of income; when plotted, the relationship resembles an ‘S’ shaped curve<sup>1</sup> (Dargay and Gately, 1999; Dargay et al, 2007; Medlock and Soligo, 2002; Storchmann, 2005; Button et al, 1993). The historical relationship between per capita income and vehicle ownership implies that *ceteris paribus*, as the developing non-OECD countries climb to higher levels of per capita income, vehicle ownership could follow a similar trajectory to the OECD, increasing oil demand for transportation. Historical data supports this argument – for instance, Dargay et al (2007) showed that this relationship held for 45 countries in which non-OECD countries comprised more than a third, and for three-fourths of the sample’s population, for the time period 1960-2002. In the 15 years since, some have entered lower middle-income levels (based on Purchasing Power Parity or PPP). A more recent dataset on vehicle (car) ownership and per capita income was assembled for this paper, covering the period 2002-2015<sup>2</sup> for 19 Asian countries (the majority of which are non-OECD).

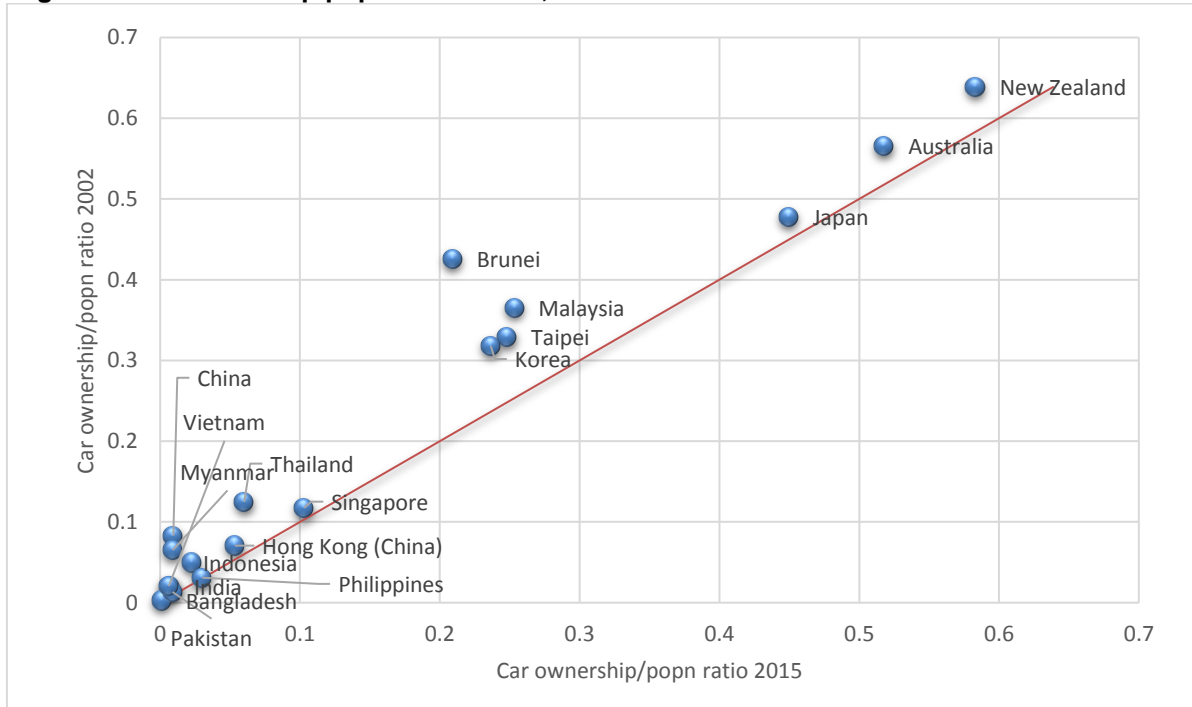
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<sup>1</sup> Based on a Gompertz distribution (an asymmetric sigmoid shape), which allows for asymmetry in the curve.

<sup>2</sup> Our analysis covers a shorter time period as public data on vehicle ownership across non-OECD countries is not easily available. Other notable studies have covered much shorter time periods (for instance Storchmann (2005) uses data for 7 years), and therefore a shorter time-series should not detract from our results. See [OIES paper](#) for details of the dataset.



**Figure 1: Car ownership/population ratios, 2002 vs. 2015**



Source: Authors

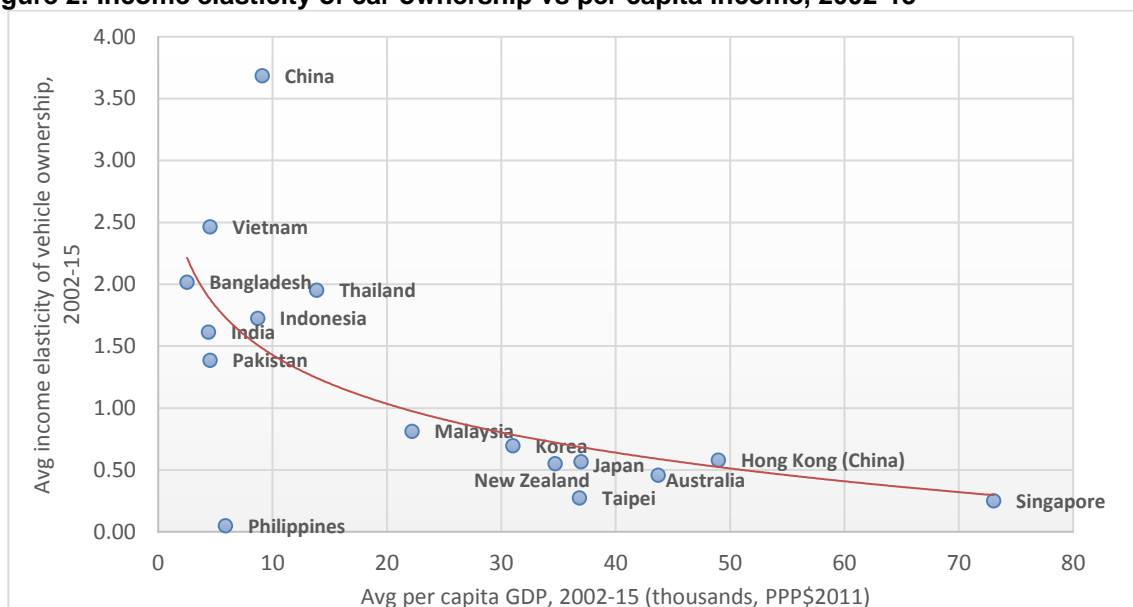
Figure 1 above summarises the changes in car ownership from 2002-15 for the countries in the dataset.<sup>3 4</sup> Each country's 2002 car/population ratio is plotted on the vertical axis and its 2015 ratio on the horizontal axis. The higher up the country is on the diagonal (1:1 line), the higher its car ownership levels. The greater its distance from the diagonal, the faster was its increase in car ownership relative to per capita income. For instance, Australia's car ownership ratio in 2015 was very high relative to most other countries, at approximately 0.565 (or 565 cars per 1,000 population); however, its average annual growth from 2002-15 was only 0.71% (up from 0.517 in 2002). China's car ownership ratio was relatively low in 2015 (approximately 0.083); however, the average annual growth from 2002-15 was 60% (from 0.009 in 2002). Similarly, India's car ownership ratio was only 0.02 in 2015, but average annual growth from 2002-15 was around 14%. In Vietnam, the corresponding figures were roughly 0.021 (2015) and nearly 18% annual average growth (2002-15). This is a very broad measure of the car ownership to per capita income relationship and does not consider the specific anomalies and circumstances of each country. For instance, Brunei (a resource-rich country) appears to have experienced a rapid increase in car ownership levels during the period in question despite being a relatively high-income country – this could be due to many other factors such as economic conditions, pricing/subsidies<sup>5</sup> or government policy. Or it could simply be due to issues with the reliability of published data.

<sup>3</sup> The figure is based on Dargay et al (2007) and Dargay and Gately (1999).

<sup>4</sup> The figure includes 18 countries, as sufficient data was unavailable on Papua New Guinea.

<sup>5</sup> Resource-rich countries have tended to subsidise fuel prices to citizens, leading to excessive increases in domestic fuel consumption and a potentially lower price-relative-to-income elasticity of car ownership. Due to high private consumption, the vehicle fleet tends to be dominated by private cars (IBP, 2015).

**Figure 2: Income elasticity of car ownership vs per capita income, 2002-15**



Source: Authors

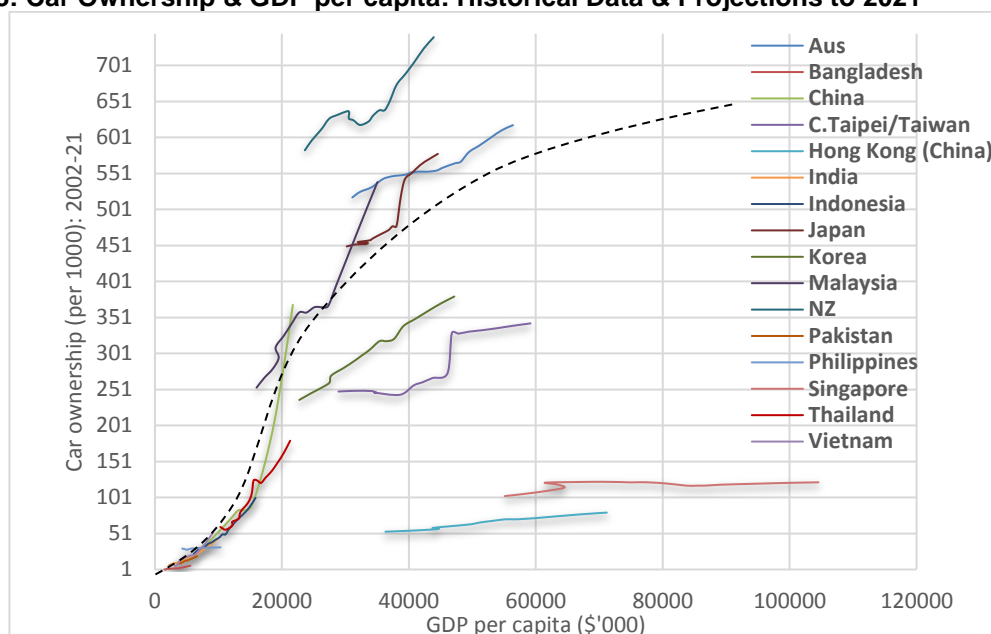
Figure 2 provides a more detailed picture of the responsiveness of car ownership to changes in income levels, as it plots the historical ratio of the average annual percentage growth in car ownership to the average annual percentage growth in per capita income, which is widely considered a broad measure/estimate of the income elasticity of car (or vehicle) ownership (Dargay and Gately, 1999). Growth rate ratios are plotted for the majority of countries in our dataset on the vertical axis, and compared with each country's average income (measured by per capita GDP on the horizontal axis) over the period 2002-15. The figure shows that car ownership grew almost twice as fast as income for the lower and middle-income countries (that is, income elasticity was around 2.0). For China, it grew 3.7 times as fast<sup>6</sup>, whereas for Vietnam it was nearly 2.5.<sup>7</sup> For India, it was around 1.7 times as fast. The figure also shows that the higher a country's income level, the lower its income elasticity of car ownership – at very high levels of income, car ownership begins to approach zero as saturation is reached.

These broad estimates (based on historical data from 2002-15) of income elasticity of car ownership can be combined with forecasts on GDP and population to project forward estimates of car ownership levels in both OECD and non-OECD Asian countries, holding constant all other factors that may be likely to influence the growth in the car (or vehicle) fleet. Accordingly, we used International Monetary Fund (IMF) forecasts for GDP to 2021 and UN Population forecasts to the same period to obtain simple projections for car ownership to 2021. Figure 3 graphs the historical data along with these broad projections, with car ownership plotted on the vertical axis and per capita income on the horizontal axis. The multiple series plotted represent both low and high-income countries and the trend can be seen as mimicking an 'S' curve (illustrated by the polynomial trend line).

<sup>6</sup> These high values are not limited to Asia. Eskeland and Feyzioglu (1997) for instance showed a similarly high-income elasticity (3.34) for Mexico.

<sup>7</sup> The figure shows the Philippines as an outlier in the dataset with very low-income elasticity; based on available data, its car ownership ratio grew by only 0.23% on average annually from 2002-15. The Nielsen Global Survey of Automotive Demand (2013) estimates that 47% of households did not own cars.

**Figure 3: Car Ownership & GDP per capita: Historical Data & Projections to 2021**



Source: Authors

Each solid line in the graph can be interpreted as representing a country time series (historical and projection) for car ownership levels vis-à-vis per capita GDP, between 2002<sup>8</sup> and 2021. To simulate the ‘S’ curve, we included data on both low and high-income countries (non-OECD and OECD) in the Asia-Pacific region (for instance, New Zealand and Australia are the two series at the top of the graph). Countries with relatively higher income elasticity of car ownership are clustered in the bottom left of the graph. Figure 4 below expands further upon these countries to give a clearer picture; it plots historical data and projections on car ownership levels (2002-2021) focusing on countries with an estimated income elasticity of car ownership between 1.0 and 2.0.

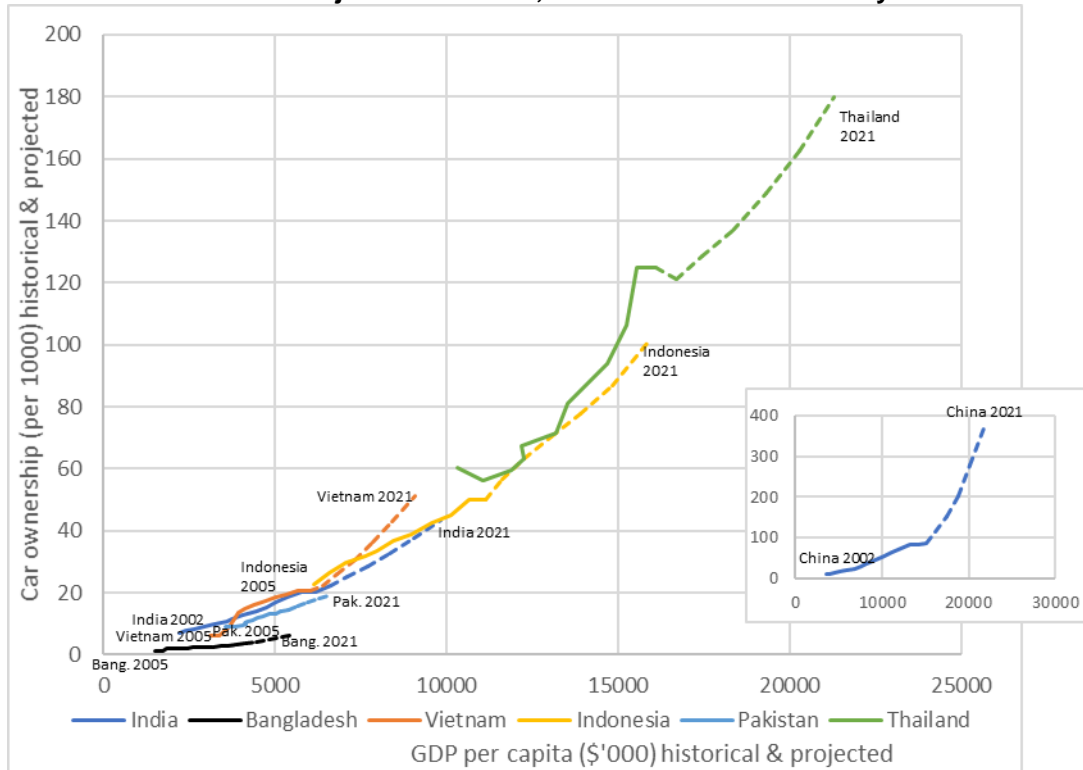
Some broad observations can be made here. Although Vietnam’s car ownership level in 2005 was lower than India’s, its projected car ownership levels rise much faster with its per capita GDP, as it has an estimated historical income elasticity of roughly 2.5 compared with India’s at 1.7. Thus, Vietnam’s projected car ownership level goes from roughly 6 per 1000 (in 2005) to 50 per 1000 people, compared with India’s which rises from 9 to around 44 per 1000 people by 2021. Thailand has the highest starting car ownership level among the group of countries, rising from roughly 60 to 180 per 1000 by 2021, at an estimated income elasticity of roughly 2.0. It is followed by Indonesia, which with an estimated income elasticity of 1.7 rises from 23 cars per 1000 people in 2005 to over 100 by 2021. Although Bangladesh similarly has an estimated income elasticity of nearly 2.0, its very low levels of car ownership (around 1 per 1000) and projected per capita income see car ownership levels rising to just over 6 per 1000 by 2021, according to this broad calculation. Car ownership levels in Pakistan rise from around 9 to 19 per 1000 by 2021 based on an estimated income elasticity of 1.4. The non-OECD Asian country with the highest income elasticity is China, and although it has not been plotted within Figure 4 to allow for a clearer scale, it is included as an inset (within the figure above), showing car ownership

<sup>8</sup> The starting year is 2005 for some countries which lacked historical data.



rising from very low levels (around 10 per 1000) in the early 2000s to well over 300 per 1000 by 2021, based on an estimated (historical) income elasticity of 3.7.<sup>9</sup>

**Figure 4: Historical Data & Projections to 2021; based on income elasticity from 1.0-2.0\***



Source: Authors; \*Inset graph shows China

The estimates in Figure 4 are broadly indicative of individual country projections on car ownership and per capita income. They are considerably higher than, for instance, Dargay et al (2007), who project vehicle ownership to 2030.<sup>10</sup> Figure 4 has interesting implications: non-OECD Asian countries represent around 60% of global population, two-thirds of the world's poor population and yet only 34% of global energy demand. Storchmann (2005) argues that the income elasticity of demand for vehicles in developing countries is higher than in developed countries because of the extremely high marginal rate of consumption of automobiles in lower-income countries. As opposed to developed countries, in lower-income countries cars are seen as a luxury good and their stock is far away from saturation – cars constitute a first purchase or necessity (i.e. citizens of developing countries purchase their first vehicles as their incomes increase, often moving up the ladder of mobility from two wheelers to four wheelers).

Previous empirical studies on oil demand using cross-sectional or time series data have focused on estimating the relationship between per capita income and vehicle ownership, using the latter as a key indicator for derived demand. This is based on the assumption that given the historical dominance of per capita income in determining vehicle ownership, this simplification should not detract from the validity of the projections obtained (Dargay and Gately, 1999). Within the stock of vehicles, passenger cars are the largest consumers of oil products and have the highest growth rate (Storchmann, 2005). Further, passenger cars increase more rapidly than goods vehicles (trucks), as the production of

<sup>9</sup> This is significantly higher than Dargay et al (2007) who base their projections on an income elasticity of 2.2 for China, but close to Wang et al (2011) who estimate an income elasticity of 3.96 for their projections to 2022. Some of Dargay et al (2007)'s projections for 2002-2030 have underestimated actual growth.

<sup>10</sup> For instance, Dargay et al (2007) estimate India's car ownership per 1,000 people at 17 in 2030. However, actual car ownership levels for in India even as early as 2015 were higher than the 2030 projection (20 per 1,000 people) implying that our projection is not implausible (albeit based on a simple statistical extrapolation).

services grows faster with income than the production of goods (Ingram and Liu, 1997).<sup>11</sup> The fact that cars are traded goods allows for the use of market exchange rates, also making comparisons of cross-country data easier. Yet, existing empirical literature using pooled cross-sectional or panel data also consistently identifies several other economic and demographic determinants of gasoline demand. Based on these, in our paper<sup>12</sup> we carry out a dynamic instrumental variable regression on our historical dataset of non-OECD Asian economies, with per capita income, vehicle ownership and the share of manufacturing in GDP as the main determinants of gasoline demand, while controlling for fuel prices. Results pointed to large increases in gasoline demand (by as much as 25%) resulting from a percentage change in vehicle ownership.

## The Coming Age of Electric Vehicles – a key constraint to gasoline demand in India and China

Statistical analyses of historical data (above) therefore point to large increases in gasoline demand in non-OECD Asian countries alongside economic expansion. However, many of these countries – notably led by China and India - have adopted policy measures to push their economies towards energy consumption trajectories that could potentially be met more sustainably, both in terms of economy and the environment. The two main policy measures most likely to curb gasoline demand in transport are fuel efficiency standards, and the electrification of the vehicle fleet – both leading to a potential drop in oil consumption. In the sections below, we examine these in greater detail for India and China.

### *India – the race to leapfrog to EVs*

India's oil demand has surged, with transportation accounting for 40% of demand. It is the world's sixth largest car market, with over 3 million units sold in 2016. From 2010-15, car sales have been increasing by around 2 million units annually, with the majority of new sales going to fleet expansion. Unlike developed markets where most new cars are replacing ageing vehicles, the average Indian car is roughly 5 years old. Most of the sales growth is accounted for by two-wheelers, reflecting the entry of new consumers into the passenger vehicle market. As the economy continues to expand and incomes rise, the number of cars is set to increase exponentially.

In an ambitious new plan, the Indian government aims to save the country an estimated \$60 billion in energy bills by 2030 and decrease carbon emissions by 37% by switching the country's transportation system towards EVs. To achieve this goal, government Think Tank NITI Aayog has recommended offering fiscal incentives to EV manufacturers, while simultaneously discouraging privately-owned petrol and diesel-fueled vehicles. The target is underpinned by India's low per capita ownership of vehicles, with the potential to 'leap' directly to a new mobility paradigm which involves shared, electric and connected cars. This could leverage India's inherent advantages in technology and favourable demographics, while offsetting pressures that would have otherwise developed from higher import bills as the country's oil resources are small.<sup>13</sup>

The current base for EVs is low, at 4,800 vehicles in 2016 representing 0.2% of the total fleet, having grown y/y by 450 cars (ICCT, 2016). The government is targeting 6 million electric and hybrid vehicles on the roads by 2020 under the National Electric Mobility Mission Plan 2020 and Faster Adoption and Manufacturing of Hybrid and Electric Vehicles (FAME) programme. The 2030 target implies a stock of over 50 million electric vehicles (HT, 2017), and although India's government seems committed to the target it will face many challenges in implementation. Currently, there is only one EV maker in India (Mahindra & Mahindra). It plans to expand production capacity for EVs to 5,000 units a month by mid-2019, from 500 units a month (PTI, 2017). However, other Indian automakers are also gearing up. The

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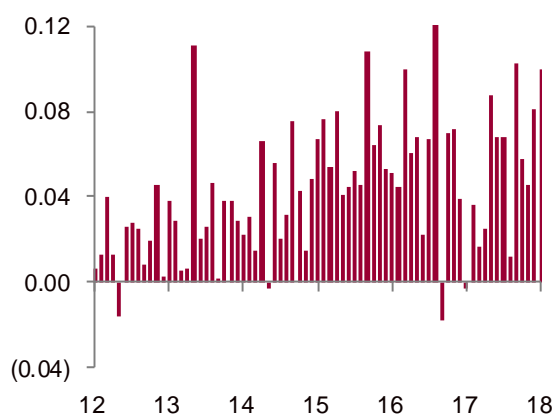
<sup>11</sup> Moavenzadeh and Gletner (1984) point out that passenger traffic grows at 2-3 times that of freight traffic in developing countries.

<sup>12</sup> Refer to the [OIES paper](#) for full results.

<sup>13</sup> India imports around 80% of its oil consumption of roughly 4.49 Mb/d.

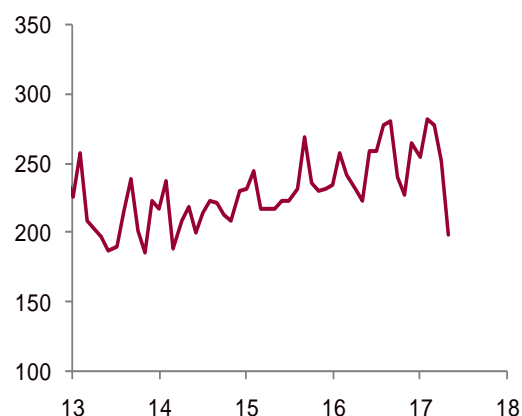
Tata Group is working on a comprehensive hybrid and EV strategy that includes developing lithium batteries as well as charging stations. Tata Motors is in the process of introducing the first batch of five diesel-hybrid buses to the city of Mumbai as part of an order for 25 such vehicles (Auto Today, 2017) and is also planning to trial its electric buses in New Delhi, Bangalore and Mysore as it aims to win more orders from state transport undertakings (Nikkei Asian Review, 2017). Overseas collaboration may also be needed to meet the target, as current supply chains are inadequate. But the government's 'Make in India'<sup>14</sup> policy and its preference for locally-made components could slow EV development.

**Figure 5: Indian gasoline demand, y/y, mb/d**



Source: PPAC (2017); APQ (2017)

**Figure 6: Indian car sales, ex-two wheelers, M**



Source: PPAC (2017); APQ (2017)

While automakers prepare to meet the challenge of new vehicle demand, the power sector needs to build capacity as well as improve Plant Load Factors (PLFs) and distribution networks. India has 330 GW of installed generating capacity, with 57 GW of renewables and 198 GW of thermal (Sen, 2017). Assuming an electric vehicle has a 100 kWh battery size, the annual additional power demand for 6 million EVs is expected to be 93 TWh, which would require 10 GW of power plant capacity in 2020. A lower number of 2 million EVs would take roughly 3 GW of power plant capacity, which represents 1% of installed capacity (EY, 2016; APQ, 2017).

While India is likely to have sufficient capacity to meet incremental demand from EVs, it will need to overcome a number of structural challenges that are keeping power capacity at low utilisation rates, particularly in the coal and gas sectors (Cornot-Gandolphe, 2016; Sen, 2017). Distribution infrastructure is inefficient with large transmission losses, and power theft is perennial, deterring private investments while leaving state utilities with poor finances that restrict their capacity to upgrade (Sen et al. 2016). Current power capacity is largely underutilized despite urban areas facing erratic power cuts, and the country is aiming to electrify more rural areas. PLFs for coal have declined from 77% in 2010 to less than 60% currently (Prasad, 2017). This implies that upcoming power capacity projects have already been earmarked for solving current challenges. Additional stress on the power grid from EVs will require a revamp of the sector to improve efficiencies at current power plants as well as the distribution network.

Policy makers could, however, see the utility in EVs not only for transportation but also for its benefits to the power sector. EVs offer an opportunity to encourage distributed generation, reducing dependence on electricity distribution companies and setting up commercially sustainable micro grids, especially in remote areas. Batteries used in EVs usually have a vehicle lifetime of 8-10 years, but they have significant potential after that for alternative uses, especially as cheap storage for renewable energy capacity. EVs could help improve utilisation of existing domestic coal capacity by providing demand assurance to sustain a certain baseload. With most of the charging expected to be done during off-peak

<sup>14</sup> Make in India campaign <http://www.makeinindia.com/policies>



hours, utilities could better manage their base load rather than rely on expensive sources for generating peak load. India's largest power generation utility (NTPC) aims to set up charging stations, with plans to halve the cost of setting these up to \$1,500 each, as a way to expand its market (PV Magazine, 2017). There is thus scope for baseload management at current capacity to improve plant load factors to over 70% and more, to absorb the strain of millions of EVs on the power grid. In order for the EV push to conform with India's COP21 commitments, electricity will need to be generated from renewables, of which the government plans to generate 175 GW by 2022 (100 GW from solar power).

While the power sector can accommodate the expansion of EVs by improving utilisation rates, the biggest infrastructure challenge comes from expanding charging infrastructure, much of which would have to be built from scratch. The challenge with expanding the retail fuel network has been the dearth of reliable power supply in small towns and remote highways. If such fuel stations were also to meet the demand of charging EVs, during power cuts and low voltage periods the owners would have to set up generators. To incentivise the build out of charging stations, the government is considering using a private retail method, using the same model for distributed charging as was the case for privately-owned phone booths, implying that anyone could set up a charging station and earn a small income from it.

The up-front price of the vehicle is also likely to be a limiting factor, as they currently cost more than those based on internal combustion engines (Shakti, 2017). Measures are being considered that could reduce the initial cost of buying an EV for the individual user by as much as 50%, if EVs are sold without batteries which will then be swapped out rather than embedded (NITI Aayog, 2017). One option being considered is to allow drivers to buy the car and lease the battery, which they can switch when they need to recharge (Froese, 2017). In order to build scale rapidly, India's government is considering an EV-based public transport system with auto-rickshaws and buses sold with batteries that can be swapped after a certain distance (QI, 2017). Auto-rickshaws travel between 80 km and 130 km daily, so batteries could, in theory, be swapped at around the 40 km-mark (QI, 2017). A swappable battery system is also being considered for city buses. With close to 95% of buses in the country traveling 30 km per trip routes, batteries can be swapped at the terminal point where the bus turns around for the return journey (QI, 2017). While this solves the challenge of having charging stations that need to charge the batteries rapidly, as well as the cost of buying an EV for the user, it would still require considerable investment to set up a battery swapping station, as well as a convergence in technology across the industry, which will have to be overcome with the right incentives for the sector, but is possible to achieve. Adopting a shared ownership model over an individual ownership model could bring down the cost of both ownership and travel. India's ride hailing companies are also partnering with manufacturers to grow its fleet (e.g. Ola with Mahindra) by offering discounts on the cars, vehicle financing and maintenance plans to drivers (ET Auto, 2017).

Currently, India has roughly 31 million passenger cars and 150 million two and three-wheeler vehicles. The country consumes an average of 0.5 mb/d of gasoline and 1.56 mb/d of diesel. EVs are unlikely to severely dent India's gasoline demand growth over the next five years, given the small starting base. The target of 6 million EVs by 2020, if realised, could potentially displace roughly 90,000 b/d of fuel demand in the country (APQ, 2017). Given the charging infrastructure limitations, and the challenges of ramping up domestic manufacturing, a lower achievement of say 2 million EVs is more likely, and would displace around 30,000 b/d of fuel demand (APQ, 2017). In the near term, EVs are unlikely to be big disruptors to an otherwise steady gasoline demand story, with growth set to rise by 8-10% year-on-year on average through 2020. It is the post-2020 timeframe where EV adoption is likely to pick up pace, once charging infrastructure grows. The impact on fuel demand could be large if commercial vehicles such as trucks are also electrified. The Indian government has already set in motion efforts to electrify the diesel-dependent railways, which will lead to further displacement of fuel.

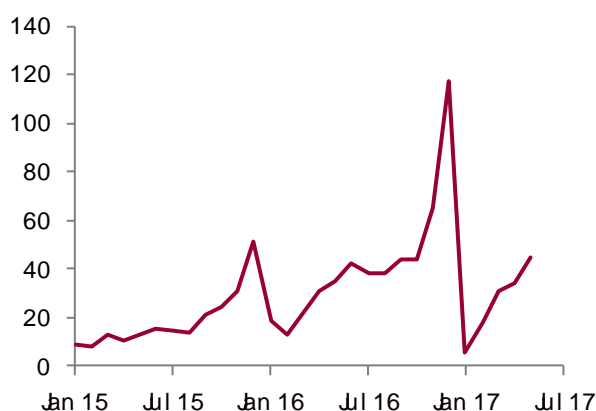
### **China – Implications of New Energy Vehicles and Fuel Efficiency**

Unlike India, China's ambitious efforts to tackle tailpipe emissions are already starting to slow gasoline demand growth, but the government's measures go beyond EVs to include policies to raise fuel efficiencies in internal combustion engine vehicles, promoting use of hybrid vehicles, as well as natural

gas vehicles (NGVs). Even the advent of bike sharing apps is chipping away at gasoline demand growth. In 2017, China's gasoline demand growth is expected to slow to 0.11 mb/d (3.5%), almost half of the 2016 growth rate (SCMP, 2017), as incremental car sales slow from over 13% in 2016 (China Daily, 2017b) to 5%<sup>15</sup> at best in 2017, and alternative energy vehicles begin to chip away at demand growth. Going forward, EVs alone could displace 45,000 to 55,000 b/d of demand growth, with measures to increase fuel efficiencies knocking off even higher volumes. In other words, had Chinese gasoline demand growth maintained the average growth rates seen between 2011 and 2015 (0.23 mb/d, or 11%), the country would have consumed an additional 0.25-0.30 mb/d of gasoline every year through 2020. At current rates, however, with car sales slowing, efficiency gains rising and NEV sales rising, gasoline demand growth could average 0.15-0.20 mb/d through 2020 (APQ, 2017).

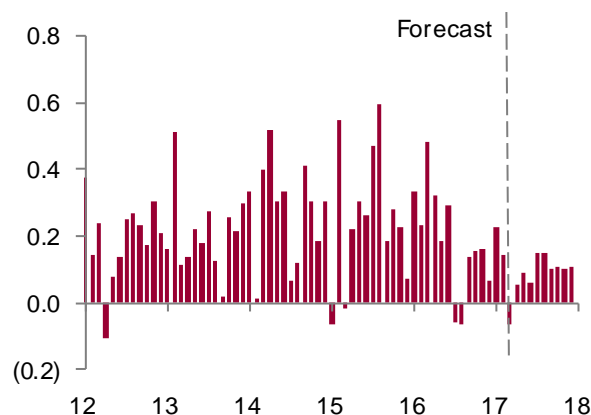
The country's NEV plan—which includes plug-ins, EVs and gas-fired vehicles—was rolled out in 2012 with goals through to 2020 (China State Council, 2012), and after some teething pains is now increasingly starting to gain traction. Electric cars make up 0.5% of China's fleet and the effects on fuel demand patterns are still marginal. Yet China's NEV push meets three distinct goals. First, to reduce some of the country's hefty oil import bill (Zheng, 2017). Second, to support the country's environmental goals, though as in India, it will require substantial progress on plans for renewables to take up a growing share of power generation given the predominance of coal in the energy mix. Third, NEVs are also part of the 'Made in China 2025' programme, China's industrial upgrading plan (SCC, 2015). This goal resonates with China's carmakers, the majority of which see this as an opportunity to leapfrog their western competitors.

**Figure 7: China NEV sales, thousand units**



Source: CAAM, Energy Aspects analysis, APQ (2017)

**Figure 8: China gasoline demand, y/y change, mb/d**



Source: CAAM, Energy Aspects analysis, APQ (2017)

By 2020, Beijing plans to have 5 million NEVs on the road. This target includes 4.3 million passenger vehicles, around 0.3 million taxis, 0.2 million buses and 0.2 million special vehicles. 'Made in China 2025' also highlights infrastructure development: it aims to install 4.3 million private charging outlets (essentially one charger per car) and 0.5 million public chargers for cars, 4,000 charging stations for buses, 2,500 for taxis, 2,500 for special vehicles and about 2,400 city public charging stations. At the end of 2016, China had 1 million EVs and 150,000 charging stations, or one for every seven cars. The government is aiming to add another 100,000 charging stations by the end of 2017 (IEA, 2016).

To encourage EV sales, China's Ministry of Finance has been providing subsidies ranging from RMB 30,000 to 60,000 (\$4,400-8,800) for electric passenger vehicles and subsidies of RMB 500-600,000 (\$74,000-88,000) for commercial vehicles (MoF, 2015), most of which are also matched by provincial governments. Local subsidies vary significantly as they tend to favour local carmakers. The city of

<sup>15</sup> According to the China Association of Automobile Manufactures (CAAM), cited in China Daily (2017b).

Beijing, for example, is home to Beijing Automotive Industry Corp (BAIC), which makes pure electric cars, so Beijing city offers high subsidies for pure electrics but no subsidies for plug-in hybrids. By contrast, Shanghai provides generous subsidies for plug-in hybrids, largely because the Shanghai government owns SAIC, which makes that type of vehicle. Localities therefore have a substantial say in NEV penetration rates and tailor their subsidies to fit only locally made cars, or direct city governments to purchase locally made electric cars for their fleets.

The central government has also waived sales tax and license taxes for EVs. Several of China's major metropolitan areas control the growth of their vehicle population in order to limit traffic congestion by employing a license lottery or auction system, from which EVs are generally excluded. In Beijing, EVs are also excluded from driving restrictions on heavily polluted days, making them increasingly appealing to local drivers. And to support domestic industry, the government scrapped a purchase tax on locally produced NEVs. On the supply side, the government has introduced multiple R&D programmes to promote battery technology development, and has been encouraging charging infrastructure development (MoF, 2016; IEA, 2016). These measures have helped accelerate adoption rates: from total production of just over 8,000 five years ago, new EV production in China grew to nearly half a million by 2015 with sales reaching 450,000. In 2016, that number surged again by 53% y/y to 507,000 units sold.<sup>16</sup>

At the same time, the government's generous subsidies led over 200 Chinese companies to enter the NEV space, some of which have utilized subsidies without producing commercially viable vehicles. In September 2016, the Chinese government fined five manufacturers that collected over \$120 million in subsidies but either failed to produce the vehicles, or sold vehicles with lower battery ranges than the models they received the subsidies for. The government subsequently launched a nation-wide investigation and reviewed its subsidy scheme, leading it to slash subsidies by 20% in January 2017 and plan to phase them out completely by 2020 (Cui et al, 2017). After the government cut subsidies, NEV sales plummeted in January 2017, compared to a 132% y/y increase in January 2016, but recovered in subsequent months. In May 2017, NEV sales totalled 45,000, up 28.4% y/y, while 51,000 NEVs were produced, a 38% y/y increase.<sup>17</sup> These growth rates have slowed compared to 2016 and could continue to decelerate as subsidies are phased out, but the government is drafting new regulations which will include a requirement that EVs account for 8% of total car sales, perhaps as soon as 2018, and 12% by 2020 (Bloomberg, 2017). Automakers that fall short of their production quotas can import EVs, or purchase credits from other EV makers. While the aim is to encourage EV production with both carrots and sticks, following the large subsidy scandals, Beijing is also looking to cut the number of players down to just 10. Those that survive the cull will benefit from subsidies designed to nurture a competitive domestic industry and create a vibrant consumer market for new energy vehicles.

In addition, sales of low-speed electric vehicles (LSEV: an indigenous Chinese innovation that looks a lot like an electric golf cart, used traditionally in rural China) have also grown considerably from under 100,000 in 2010 to 600,000 in 2015, skyrocketing to almost 1 million vehicles in 2016, because of their small size, cheap price and the fact that they can be driven without a license. Although initially popular in rural China, LSEVs have become common in China's third and fourth tier cities and are increasingly making inroads into the country's larger cities as an energy efficient alternative to traditional gasoline fired cars, public transportation and two-wheelers. That said, the lack of regulations on LSEV production and sales as well as rising safety concerns associated both with driving them and with the disposal of the lead-acid batteries will likely prompt the government to tighten oversight over LSEVs (IEA, 2016). This could lead to a slowdown in sales growth, but auto industry sources in China still expect sales to reach 2 million by 2020. Even though NEVs will not transform fuel demand patterns, they could shave off an estimated 40,000 to 50,000 b/d of gasoline demand by 2020 (APQ, 2017).

At the same time, NEVs—large or small—are only part of the reason for the softness in gasoline demand growth seen in 2017-to-date: the rise of electric buses and two-wheelers are further slowing

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<sup>16</sup> According to CAAM.

<sup>17</sup> Ibid.

gains in gasoline demand growth. China currently has an estimated stock of over 200 million electric two-wheelers, following a rapid uptick when conventional two-wheelers were banned in several cities in order to reduce local pollution. Electric bike sales began modestly in the 1990s and started to take off in 2004, when 40,000 were sold. In late 2016, that number had reached 20 million. China is also leading the global deployment of electric bus fleets, with more than 170,000 buses already circulating today. That said, many challenges remain: Chinese battery technology is relatively weak and the driving range for Chinese models, despite significant improvements, remains lower than Western carmakers, while charging times are still longer. Second, battery costs remain high and the fragmented nature of the Chinese automotive industry discourages economies of scale in R&D. The hefty subsidies currently in place reduce the urgency for carmakers to cut battery costs, but as the government begins to phase out subsidies, failure to trim expenses could impede EV penetration into the Chinese car fleet. Third, even though Beijing is focusing increasingly on infrastructure development, regulatory approvals for land acquisition or facility installation in residential compounds could slow the infrastructure rollout and increase the costs associated with it. Nonetheless, even though the government may fail to reach its 5-million-unit target in 2020, NEVs will become a larger component of the Chinese car fleet and will slow demand growth for gasoline. CNPC estimates that in 2015, NEVs shaved off roughly 80,000 b/d of gasoline demand and according to government estimates, by 2020 NEVs will displace 0.3-0.4 m/d of gasoline demand (CSD, 2017).

The biggest factor for gasoline demand, however, is fuel efficiency. Beijing has set out ambitious targets for reducing average fuel consumption from 6.9 litre/100km in 2015 to 5.0 litre/100km in 2020. In 2016, domestic passenger vehicle manufacturers claimed to have reached an average of 6.95 litre/100km and after including credits from NEV production, the average fuel consumption decreased to 6.6 litre/100km, suggesting that the government is on track to meet its goal (ICET, 2016). If these fuel efficiencies continue, they will be key in reducing gasoline demand growth—potentially displacing 50,000 to 80,000 b/d (with even further upside depending on the efficiencies implemented as well as the overall miles driven in the country) (APQ, 2017).<sup>18</sup> Beijing has equally ambitious targets for natural-gas vehicles (NGVs). The government is looking to increase the number of NGVs in China from 5.2 million in 2015 to 10.5 million units by 2020. NGVs have already benefitted from government support, including production subsidies as well as R&D funding for technology development. Highway tolls are also waived for NGVs. But there are constraints to promoting NGVs more rapidly. First, as demand growth is recovering, natural gas supplies are failing to keep up and are prioritised for industrial and residential use. Second, major gas producing regions such as Shandong, Xinjiang, and Sichuan, boast high levels of NGVs—the three provinces combined account for more than half of China’s NGVs—as they can supply gas for transportation at close to well-head price; but in other potential consumer hubs, especially along China’s coastal provinces where air pollution is at its most severe, prices for natural gas in transportation are higher (Hao et al, 2016). Moreover, the priority for natural gas in these provinces is phasing out coal-fired boilers so gas in transport will have a less prominent role. As more coal use is phased out through late 2017 and early 2018, incremental supplies in these provinces could start going into the transportation sector.

Finally, bike sharing apps are also denting gasoline demand growth. This latest craze picked up in mid-2016 and has since brought more than 2 million bikes to city streets, operated by around 30 companies. These rival companies offer bikes—at steep discounts as they compete for market share—around China’s largest cities that can be unlocked using mobile apps. But unlike similar initiatives around the world, bikes can be picked up and left anywhere by scanning a QR code on the frame, making them convenient for users, even though the piles of bikes left around the city has frustrated the authorities (Horwitz, 2017). An estimated 20 million people used these bike-share schemes in 2016 and that figure is expected to reach over 200 million by 2020, according to a report by research firm Research and Markets. There are some 30 operators deploying bike-sharing services since mid-2016. In light of the rapid expansion, large municipalities such as Beijing and Shanghai are tightening regulations over bike sharing, especially on parking standards (Jaganathan and Tan, 2017; Yifan, 2017).

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<sup>18</sup> Energy Aspects estimates.

All these measures combined start to affect China's gasoline demand patterns even though in a fleet of over 200 million conventional vehicles, the impact of 5 million units is extremely limited. The country's gasoline demand at 3.1 mb/d may still rise to around 3.6 mb/d in 2020 (APQ, 2017). Had the country continued on its 2011-2015 path, of 11% average growth rates, it would be adding around 0.25-0.30 mb/d of demand each year. But with NEVs denting demand at the margins and fuel efficiency gains reducing consumption, gasoline demand growth in China may hover around 0.10-0.15 mb/d going forward, or a more modest 3-4% (APQ, 2017).

### **Conclusion: between slower gasoline growth and new paradigms**

Asia is the world's second largest gasoline consumer after North America, accounting for 6.7 mb/d of demand in 2016 and with rising incomes and motorisation levels, Asia is expected to remain the most significant driver of gasoline demand growth. The two largest non-OECD economies, China and India, are expected to account for the majority of the increase in oil demand to 2035, so the growth models and motorisation paths that they adopt will be hugely significant for gasoline demand growth.

But while statistical analyses based on historical data suggest large increases in gasoline demand, they need to be strongly qualified by the fact that they do not account for country-specific policy interventions which are likely to change the outcome, suggesting that non-OECD Asian economies will follow different oil demand growth and/or vehicle ownership trajectories to OECD economies. Our case studies showed that China and India are both charting different courses. Both have seen rising oil imports take a toll on their foreign exchange reserves, and the need to tackle poor air quality is leading them to substitute traditional vehicles and improve efficiencies. While India's efforts may begin to displace around 15,000 to 20,000 b/d of gasoline demand around 2020, China's policies to encourage NEV penetration, combined with more stringent fuel economy standards, are already slowing demand growth, displacing around 0.1-0.15 mb/d of gasoline demand every year.

Returning to the three arguments set out at the beginning, it is evident that policy constraints on gasoline demand growth, while in many cases initiated at the regional or city level, are being consolidated at the national level. While these economies are entering or are already in high growth trajectories with car ownership levels rising, oil demand growth in transport is likely to slow relative to a baseline as policies to substitute away from oil in transport are implemented on a widespread basis and backed by strong political commitment. Oil demand growth could slow further if battery technologies continue to improve rapidly and costs come down, and if these countries transition to different mobility models with ride sharing gaining prominence – causing rapid and disruptive change in transport. Displacement of gasoline consumption will then be even higher—especially in India after 2020.

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