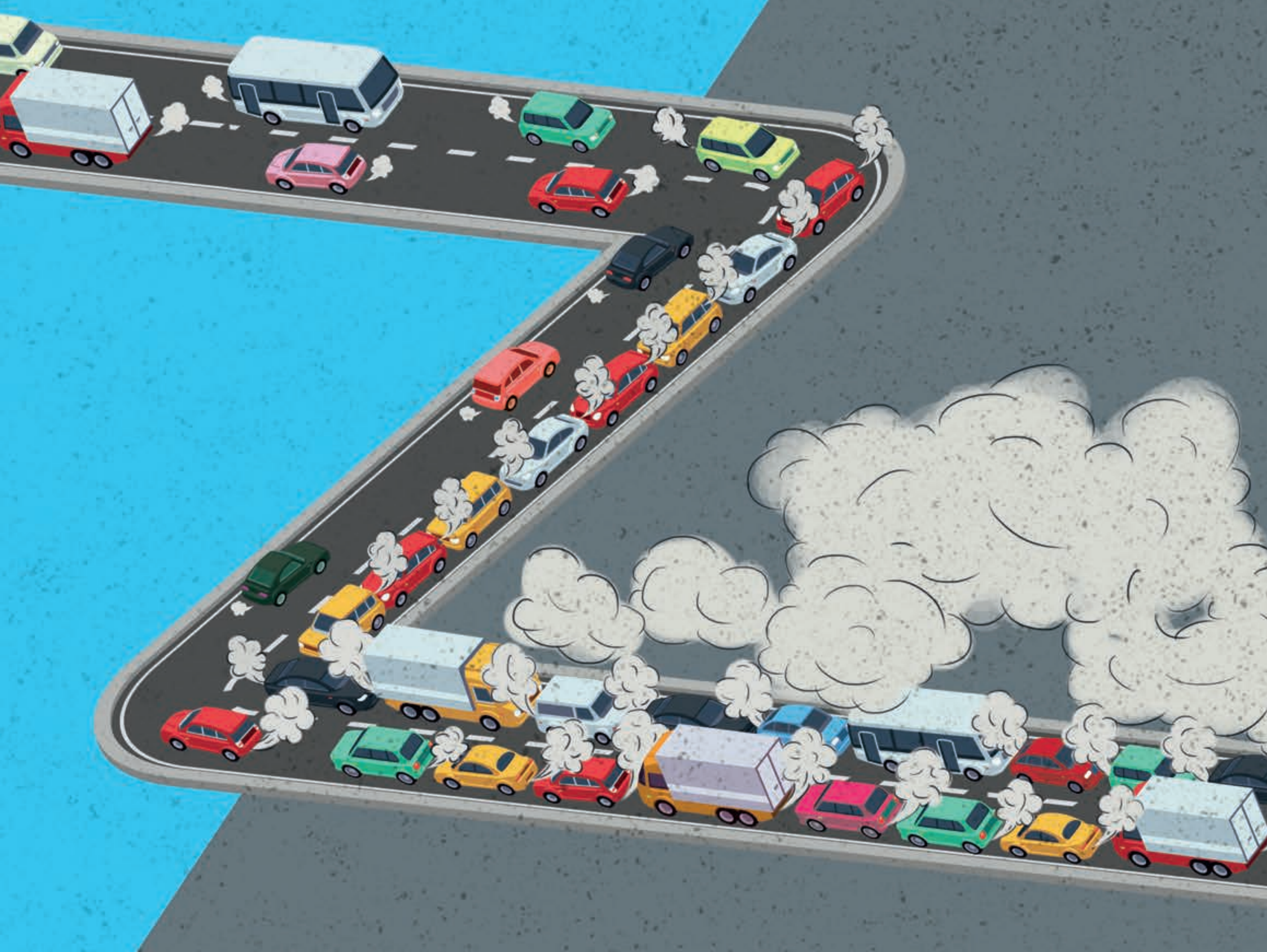
THE URBAN COMMUTE

AND HOW IT CONTRIBUTES TO POLLUTION AND ENERGY CONSUMPTION

A CSE analysis and ranking of 14 cities in India



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MacArthur Foundation

We are grateful to the MacArthur Foundation for institutional support in preparing this document

Citation: Anumita Roychowdhury and Gaurav Dubey 2018. *The Urban Commute: And how it contributes to pollution and energy consumption*, Centre for Science and Environment, New Delhi

Published by:
Centre for Science and Environment
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A SUMMARY

WHY RANK CITIES?

How do our cities fare when it comes to energy use and pollution from urban commuting?

This is a compelling question today as travel demand grows in cities, and motorization explodes on them with growing automobile dependence. Cities are facing the daunting challenge of meeting clean air standards, climate mitigation targets *and* the Sustainable Development Goals. The urban commute—a city dweller's use of vehicles and transportation modes for daily travel—has become one of the most energy- and pollution-intensive activities; arresting and reversing the trends in emissions and energy consumption now pose a difficult challenge. Yet, without addressing this, no city can meet its sustainability targets.

While some cities have begun taking mitigation action, there is no clear policy yet about the level of stringency and the cuts in emissions that are needed. Are cities on the right track to achieve reduction in emissions and energy guzzling? Even the extent of cuts needed across cities varies, as this depends on the level of lock-in of energy intensity and the toxic pollution that have already happened in a city due to motorization, nature of daily commuting practices and transportation infrastructure. Any review of mitigation action on urban commuting in cities shows very small and cosmetic efforts that are incapable of effecting any major shift towards sustainable modes of travel—use of public transport, walking and cycling and restraint on personal vehicle usage—or even the retention of these modes. Are cities even prepared to at least first protect the current ridership of these sustainable modes, and then to double their modal share?

At this stage, there appears to be a clear mismatch between the scale and depth of action and the magnitude of the problem. The difference in the scale of the problem depends on the volume of travel demand in cities, how people travel, distances they travel, how much they travel, and the quality of vehicle technologies and fuel they use. These factors ultimately determine the pollution and energy intensity of urban commuting and decide the level of differences in transport-related emissions across cities. This also means that urban transport policies can deliver only if these parameters are understood and factored in, evaluated and monitored while planning and designing urban transport.

But such conscious and deliberate tracking of these factors are not done while framing and implementing urban transport policies in cities. So far, policies on sustainable transport have taken shape at the Centre as well as at the state government level. Central government actions include smart city policies, transit-oriented development policies, national habitat standards for transport, service-level benchmarks for bus transport, decongestion plans for cities like Delhi, etc. Many state governments have adopted strategies and policies to modernize and expand public transport, carry out infrastructure development for non-motorized transport, and enforce street design guidelines and elements of parking policy that can have some demand management impact. But these are not adding up to ensure a sizeable shift to sustainable modes, reduction in travel distances, and reduced volume of travel by personal transport in cities. In fact, neither the Central government nor the state administrations track changes or generate evidence based on these parameters.

From a public policy stand-point, it is important to recognize the fact that the difference between cities in terms of transport-related emissions and energy consumption is not a matter of chance, but of choice. This is the result of conscious decision-making and prioritization related to urban road design and transportation planning, with the aim of influencing commuting choices of the masses. Transport infrastructure-related intervention and fiscal policies have overpowering influence and impact on commuting choices people make in cities. This, in turn, has a strong bearing on pollution and energy consumption.

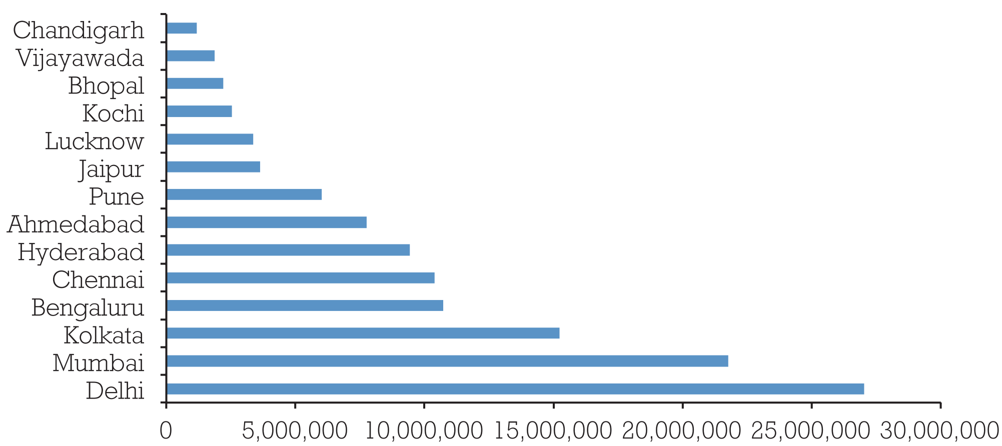
If this fundamental principle of policy-making is not recognized, cities will continue to opt for policy choices and initiate infrastructure development that may not deliver on the intended mitigation goals or achieve sustainability. The starting point of this debate and policy action, therefore, has to be the reason behind the wide difference in transport sector emissions and energy consumption across cities, the factors responsible for this difference, and how these factors could potentially be the basis for disruptive action. This is also important for public conversation as often, public understanding of the relative strengths and weaknesses of cities is sketchy.

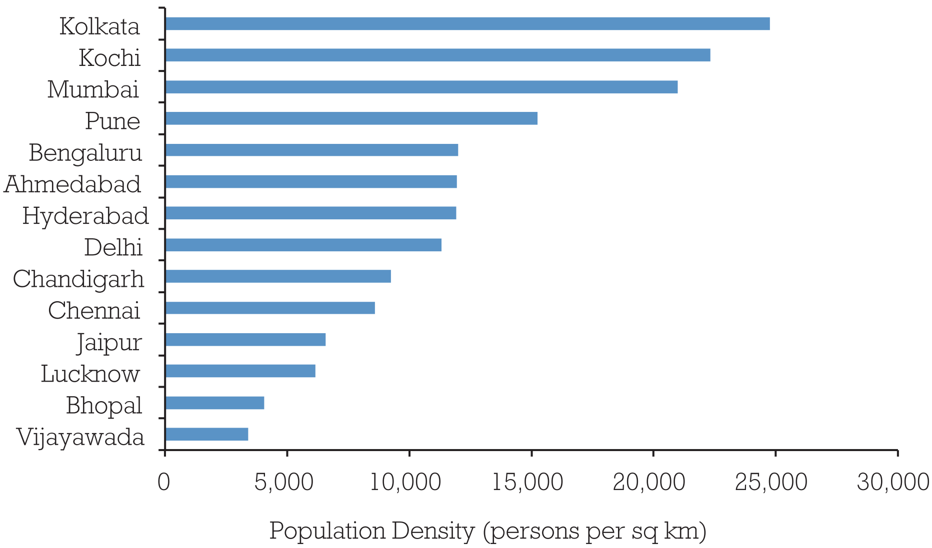
Therefore, Centre for Science and Environment (CSE) has carried out this quick **comparative and diagnostic analysis of key cities of India** to check how some cities, which hold sizeable shares of India's urban population, are positioned in this race for clean and low carbon mobility. Who pollutes and guzzles more than the others, and what is influencing this difference?

Fourteen cities have been covered in this rapid analysis. They have been adjusted for geographical representation, and include Delhi, Mumbai, Kolkata, Chennai, Bengaluru and Hyderabad which, henceforth, will be termed in the common parlance as **megacities**; and Ahmedabad, Pune, Jaipur, Lucknow, Kochi, Bhopal, Vijaywada and Chandigarh which will be referred to as **metropolitan cities**. The level of population and population density that has a bearing on the overall travel demand and volume of travel, vary across these cities (*see Graph 1 (a & b): In terms of population*).

Graph 1 (a & b): In terms of population

Population and population densities (2017) of the selected 14 cities under scanner—they are key factors in determining the travel volume and demand in the cities





Source: UN Population Projections, 2017

THE RANKING: WHO GUZZLES AND POLLUTES MORE?

Ranking based on aggregated overall emissions and energy use from the urban commute

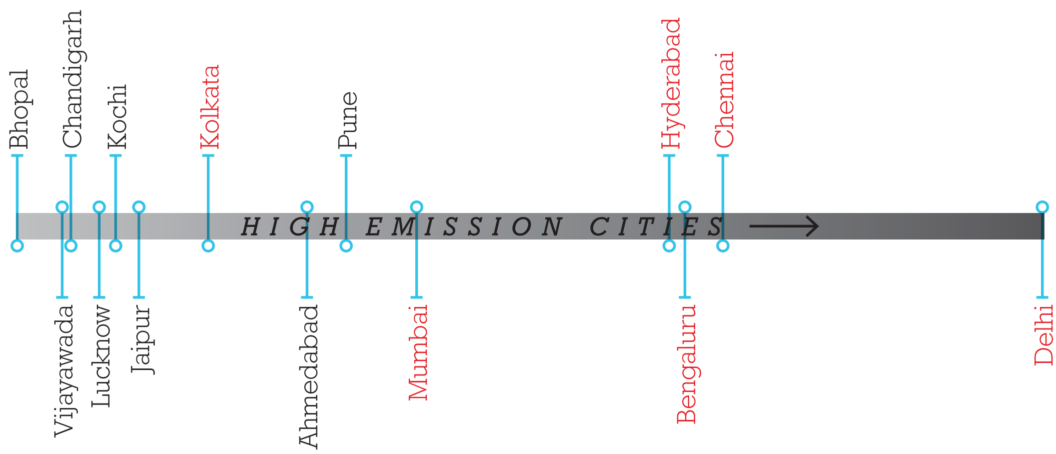
A combined score has been attributed to the overall quantum of aggregated toxic emissions of particulate matter (PM) and nitrogen oxides (NOx), heat-trapping carbon dioxide (CO_2) and energy consumption from urban commuting practices. As emissions and energy use vary widely, values have been statistically converted into scores to make them comparable. The scores for the four parameters have been added to rank cities according to the aggregates. This helps capture the combined effect of total travel volume and vehicles, travel distances of different modes, and level of technology and fuel quality.

Ranking based on per trip emissions

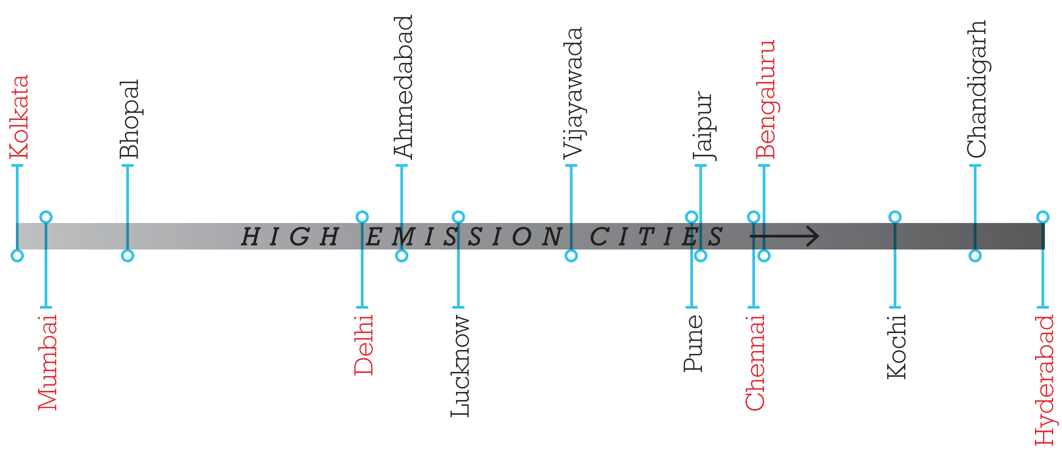
Ranking based on only overall aggregated emissions and energy use is heavily influenced by population, and can mask problems or merits in terms of actual usage pattern of modes and its links with vehicular emissions. Pollution and energy guzzling from each travel trip will depend on the mode of travel and distance. That gives a better idea about how sustainably people travel in a city, and how much they affect their ambient as well as the larger environment every time they take a trip. Small cities may have lower overall emissions, but may have high emissions per trip if modal share of cars is higher than public transport. If not corrected in time, it can turn these cities into big toxic chambers and climate rogues.

Graph 2: The final tally: Winners and laggards

(a) Ranking based on overall emissions and energy consumption



(b) Ranking based on per-travel trip emissions and energy consumption



Source: CSE analysis

Note: Typically, across the four parameters there are variations in terms of values of emission levels across the 14 cities. These variations can be high or low—cities might be clustered together with the difference between any two pairs of cities being small, or they may be spaced out and be widely different from each other. The statistical scores allow these variations across four parameters to be conserved while aggregating them into a single score; therefore, in the final output, a long gap between any pair of cities means that there is a huge variation in the values of emissions or energy consumption for the two cities. For example, Delhi is so widely spaced out with the rest of the cities in the graph of aggregated score for total emissions, because its total emissions and energy consumption across the four parameters are significantly higher than the others

Thus, the key factors that influence emissions and energy guzzling have been tracked—level of motorization, travel demand based on population, share of different modes of transport (public transport, walking cycling and personal vehicles), average length of daily travel trips, and quality of vehicle technologies and fuels. Unfortunately there is no official mechanism of tracking this data on a regular basis. Most data is from mobility plans prepared during 2010–12, Census of 2011 and other studies; wherever possible, the data has been adjusted and extrapolated for more recent years based on newer evidence. Even if the data sets are modified and the ranks are revised, the key message does not alter. Cities that have taken steps to reduce distances and personal vehicle usage, promoted usage of public transport, and walking and cycling, and improved technology and fuel quality are on a winning streak.

This assessment has found that cities that have a decent public transport spine, compact urban form, short travel distances, lesser number and usage of personal vehicles, and lesser vehicle miles travelled, emit a lot less greenhouse gases and toxic pollutants and consume less energy. If these parameters that influence emissions and energy use are not properly understood, reducing emissions and energy consumption from urban travel will become increasingly difficult.

From a public policy stand-point, it is important to recognize that the difference between cities in terms of emissions of toxic and warming gases and transport energy use, is not a matter of chance, but choice—a result of conscious decision-making and prioritization related to sustainable modes, compact urban form and road design, and transportation planning, that influence commuting choices of the masses.

LESSONS FROM RANKING CITIES BASED ON OVERALL EMISSIONS AND ENERGY USE

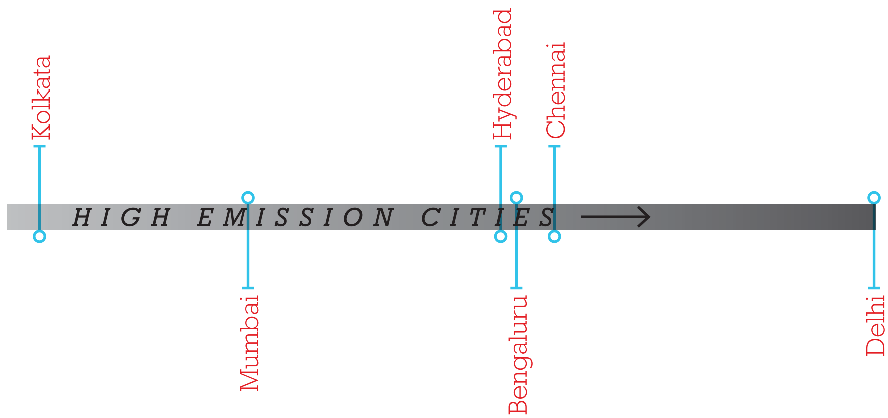
Bhopal ranks best—advantage of early action

Bhopal is among the eight metropolitan cities ranked along with six megacities. It obviously has an advantage in terms of lower population, and much lesser vehicle numbers and vehicle miles travelled compared to the megacities, but among the metropolitan cities of Jaipur, Kochi, Lucknow, Hyderabad, Vijayawada and Pune, it holds other advantages. Even though its personal transport usage is higher, its average trip length of different modes is second lowest among all cities and its average distance travelled by different modes is also the lowest among all cities. Vehicle numbers are also among the lowest. This has given Bhopal an edge over other cities.

Bhopal has taken early action to improve its public transport usage—its city bus system (that already accounts for 23 per cent of modal share for public transport)—and its high share of personal vehicle trips has not eroded the advantage of its compactness and low vehicle miles travelled. Thus, Bhopal has the lowest particulate matter, nitrogen oxide and CO_2 load from the urban commute. Bhopal has worked on building its bus and bicycle programmes with an enhanced bus fleet, a bus rapid transit system and public bike sharing schemes. Even transit-oriented development policy has progressed here.

Graph 3: Position of six megacities

Based on overall emissions and energy consumption



Source: CSE analysis

Kolkata wins among six megacities

Kolkata ranks sixth among all the 14 cities but it wins among the six megacities and does better than even some metropolitan cities like Pune and Ahmedabad. Even though Kolkata generates the third highest volume of trips due to its large population, it still has the lowest average trip length for different modes because of compact urban form. The average distance travelled by different modes in Kolkata is lowest among all megacities. Kolkata also has the lowest vehicle stock among the megacities and second highest share of public transport. This shows that only high population, high travel volume and economic growth need not necessarily lead to higher automobile dependency. Early investment in diverse and connected public transport, and physical restraints can help.

Kolkata's public transport culture, compact city design, high street density, short travel distances and restricted availability of land for roads and parking are among the good practices. About 60 per cent of all its travel trips are within 3–4 km. This is exactly the model that Japanese cities and Hong Kong have followed. It helps reduce overall emissions and guzzling. Kolkata has the most diverse public transport system for urban commuting—buses (now upgrading to electric buses), metro, trams, suburban rail, para-transit and waterways. If the share of public transport and para-transit are combined, they constitute 88 per cent of the total trips in the city.

Mumbai stays ahead with a solid public transport spine despite staggering growth pressures

Mumbai ranks 10th among all the 14 cities, indicating toxic and warming impacts of its urban commute. But among the six megacities, it is ahead of all except Kolkata. Given the staggering size of its population, Mumbai has the highest volume of trip generation among all the 14 cities. Average trip length of all modes is also the second highest. But average distances travelled by different modes are comparatively smaller than six other cities. Its vehicle stock is higher than Kolkata but much lower than other megacities.

Mumbai's winning streak is a result of its public transport spine—primarily its suburban rail system. Public transport and para-transit add up to 89 per cent of all motorized trips in Mumbai. Interestingly, Mumbai has one of the highest trip length for personal vehicles and yet its overall guzzling and emissions are comparatively lower as its suburban rail, which has zero local emissions, meets 52 per cent of the travel demand in the city. Thus, despite having highest trip generation and volume of travel Mumbai could reduce negative impacts by adopting an intelligent public transport strategy.

Mumbai has also proved that economic growth need not necessarily translate into high personal vehicle dependence. Even with highest per capita GDP among the six megacities and highest volume of trip generation, use of personal modes is lowest in Mumbai. This has helped Mumbai to have lower emissions and guzzling compared to most other megacities.

Delhi's dilemma—ahead and yet a loser

Delhi presents a rather paradoxical case at a first glance. Most of its parameters are better than most other megacities, such as rate of trip generation, average trip length, and public transport modal share and so on. And yet, it's the worst in terms of overall toxic emissions, heat-trapping emission and energy consumption. Delhi's rate of trip generation is lower than Kolkata, Mumbai, Chennai and Bengaluru. Delhi's average trip length for different modes is lower than Chennai, Mumbai, Bengaluru, Vijayawada, Kochi, and Hyderabad. Delhi's public transport share is the third best among all cities. Delhi is seventh in per trip pollution generation. Despite these relatively better overall stats, why is Delhi at the bottom rank?

First of all, Delhi has the highest vehicle stock among these cities. Moreover, Delhi's per capita trip rate is comparable with Bengaluru and Chennai. (Trip rate is a function of workforce participation, unemployment, workforce participation of women, young and old persons, participation in other recreational trips, safety of travel at different times in the day and so on). Intuitively, Mumbai comes out on top because of this. Per capita trip rate is not a bad or good thing in itself. It's the consequences of the choices associated with those trips that need to be taken care of and regulated. So, while Mumbai has a very high trip rate, from an environmental perspective it doesn't matter as the trips are mostly carried out on public transport, walking and cycling. (From a strict transport perspective, it does not matter if a city has a high trip generation as long as the trip lengths are short and trips happen on modes that occupy less space.

Delhi's poor rank is an effect of its relatively higher population compared to other megacities. Delhi has the highest population among these cities. Its population in 2017 was1.25 times that of Mumbai, 2.5 times that of Bengaluru, 1.8 times that of Kolkata, 2.9 times that of Hyderabad and 2.6 times that of Chennai. This means that per day Delhi generates over 20–30 million more trips than the cities of Kolkata, Chennai, Hyderabad and Bengaluru. This is happening even though trip generation rate per person in Delhi is lower compared to other mega cities due to the economic and gender profile of its work force. Delhi, given its huge and burgeoning population, generates more trips per day than Kolkata and Chennai combined. And, therefore, despite shorter trip length, small per capita rate of trips and so on compared to other mega cities, the total vehicle kilometres generated in Delhi far exceeds that of any other megacity. With current abysmal level of walking and public transport, it results in a massive scale of overall emissions, pollution and energy guzzling.

This sheer effect of population, volume of travel and highest vehicle stock eclipses the benefits of having CNG and better travel parameters than other cities, and thus Delhi comes out to be the worst in terms of total emissions per day. Delhi also has the highest vehicle

DELHI—UNFLATTERING STATS

1. **Based on total PM emission load from urban commuting**
   - Delhi emits 5 times more than Kolkata, and 3 times more than Mumbai.
   - In comparison to metropolitan cities, Delhi emits 13 times more than Bhopal, 9 times more than Chandigarh and 8 times more than Vijayawada

2. **Based on CO_2 emission load from urban commuting**
   - Delhi emits 4 times higher than Kolkata, 2.3 times higher than Mumbai, 1.7 times higher than Hyderabad
   - Comparing it with metropolitan cities, Delhi emits 26 times more than Bhopal, 15 times more than Vijayawada and 11 times more than Chandigarh

3. **Based on energy consumption for urban commuting**
   - Delhi consumes 5 times more energy than Kolkata, 2.4 times more than Mumbai, and 2 times more than both Hyderabad and Bengaluru
   - Compared to metropolitan cities, Delhi consumes 28.4 times more than Bhopal, and 15 and 13 times more than Vijayawada and Chandigarh respectively

4. **Based on per trip PM emissions**
   - Hyderabad and Kochi emit 3 times more than Delhi

5. **Based on per trip CO_2 emissions**
   - Chandigarh and Hyderabad emit approximately 2 times higher than Delhi

6. **Based on per trip energy consumption**
   - Approximately 2 times more consumption of energy per trip in Chandigarh and Hyderabad as compared to Delhi

AVIKAL SOMVANSI / CSE

stock—much higher than the other megacities. Thus, given the magnitude of the scale of the emissions and guzzling problem in Delhi, much more ambitious and harsh measures will have to be rolled out.

Chennai, Bengaluru, Hyderabad—weighed down by growth and automobility

Chennai, Bengaluru and Hyderabad bring out a different story, Chennai and Bengaluru, with large populations, have high trip generation and volume of travel. Their average trip length for different modes, particularly that of cars, is among the highest. Average trip length of cars in Chennai is the highest. Among all the megacities, the share of public transport ridership in these two cities is lower than Mumbai, Kolkata and Delhi. In these cites, the average distances or total vehicle miles traveled by different modes are among the highest. These are signs of urban sprawl that is increasing distances and dependence on personal vehicles and inciting more pollution and energy guzzling.

Though these cities have lesser number of vehicles than Delhi, they have recorded highest annual average growth rate for vehicles among all megacities. The only reason why total emissions in these two cities are lower than Delhi is due to their comparatively lower population which results in comparatively lower overall number of trips and, therefore, lesser kilometres travelled by vehicles. However, their higher trip rate, trip lengths and low modal share of public transport means that their emissions per trip are high and worse than Delhi. What this means is as the population increases in these cities and they sprawl even more, air pollution, carbon emissions and energy consumption will get far worse, leaving behind even Delhi in good time.

Hyderabad is also experiencing similar challenges. Its average distance travelled by cars and two wheelers is among the highest. Its public transport ridership is lowest among all megacities.

THE BIG LESSONS

Cities at crossroads can turn for the better or for worse

Ahmedabad, Lucknow, Vijayawada, Pune and Jaipur are at an inflection point. Their per trip emissions are in the middle of the spectrum, and depending on what direction their mobility policies take over the next years and decades, their pollution levels may increase or decrease accordingly. They need to take corrective measures now and avoid the fate of the megacities.

Metropolitan cities may rank better than megacities. But they are more car-dependent and are at serious risk

Some smaller cities may have lower overall emissions due to lower volume of travel and vehicles, but may still have very unsustainable patterns of travel because of high emissions per trip due to high car usage.

Overall, Vijayawada, Chandigarh, Kochi, Lucknow and Jaipur have performed better than megacities because of their smaller population, lower volume of trip generation, lower number of vehicles and vehicular trips and shorter travel distances. But this also hides a dangerous trend in which metropolitan cities have much higher modal share of cars than noted in megacities. Share of car usage can be as high as more than 60 per cent in Pune to close to 80 per cent in Chandigarh where as in Delhi personal vehicle modal share (of cars and two-wheelers) is 22 per cent. These metropolitan cities have also recorded very high growth rate in vehicle registration—15 per cent in Bhopal, 26.5 per cent in Kochi, 17.8 per cent in Lucknow and 18.3 per cent in Pune. This is in contrast to 9.9 per cent in Mumbai, 11 per cent in Delhi and 14 per cent in Bengaluru. This deadly combination can erode their strength. These cities need much stronger roadmaps.

Chandigarh, which is among the top performing cities for overall emissions and energy use, is one of the worst performing in terms of per-trip emissions due to very high car usage. Every time a trip is made in Chandigarh where per capita car ownership is highest, it is likely to have a much worse impact than cities with better public transport systems.

Per trip emissions across the 14 cities show Kolkata and Mumbai are the best while Chandigarh and Hyderabad are the worst. Kolkata and Mumbai's per-trip emissions are lowest among all cities. This indicates a high modal share of public transport and non-motorized transport with low trip lengths, which is helping these cities to mitigate their overall emission caused by the sheer amount of their population and trips in the city. Kolkata and Mumbai can take respite in the fact their population growth is not likely to affect their overall emissions levels significantly in the near future, especially if steps are taken to ensure this advantage is not lost. Bhopal ranks well both in terms of overall emissions as well per trip emissions. But other cities may see very rapid deterioration in times to come as their dependence on personal vehicles is already very high.

Important to combine sustainable mobility strategies with clean vehicle technology and fuels

This is showing up in the rating based on per trip emissions. While total emissions and energy use from the urban commute helps with city-wide assessment, per trip emissions is a better indicator of which trips are causing more emissions. Each trip, if it is by a motorized mode, causes more toxic and warming emissions, and consumes more energy. This shows how sustainably people are travelling in a city, how clean emissions are based on quality of fuel and vehicle technology and how much they affect their ambient as well as the larger environment every time a trip is made by them.

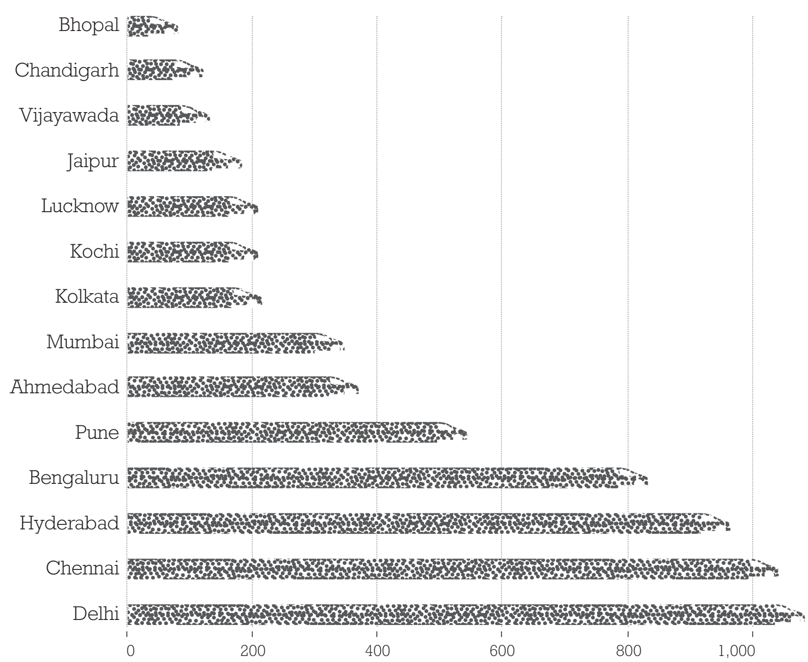
Lucknow, for instance, that otherwise has a very low share of public transport ridership, has still scored comparatively better because of its high usage of CNG that has reduced particulate matter emissions substantially, and also the overall emissions load from urban commuting. Similarly, Delhi has otherwise scored very poor on overall emissions but better on per trip emissions because cleaner emissions from massive transition to CNG as well as comparatively better public transport modal share.

STEPS FORWARD

Cities have locked themselves in a difficult race. While some have stayed ahead others have slipped. But both the groups are facing the challenge of protecting the current level of usage of sustainable modes, reverse the slide and then surging ahead to decarbonize and minimize toxicity of urban commuting significantly.

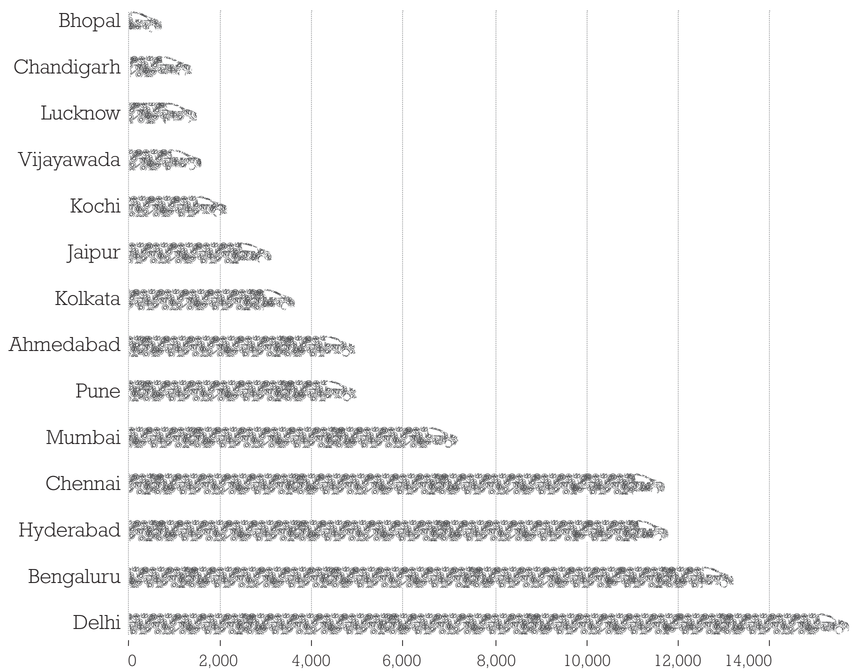
- Set time-bound targets for improving modal share of public transport, walking and cycling
- Integrate urban planning with transportation planning and adopt transit-oriented planning to reduce distances and motorized trip generation and also to improve sustainable modes
- Create restraint measures for personal vehicle usage through parking policy, low emissions zones approach, tax measures and congestion pricing approaches
- Integrate urban mobility strategies with fuel-efficient vehicle technologies and clean fuels
- Link funding strategies with reforms in public transport sector
- Apply sustainability indicators for evaluating progress of interventions from the perspective of lowering emissions and carbon, and inducing modal shift towards sustainable modes

Graph 4: Total particulate emission load from urban commuting in the 14 cities (kg per day)



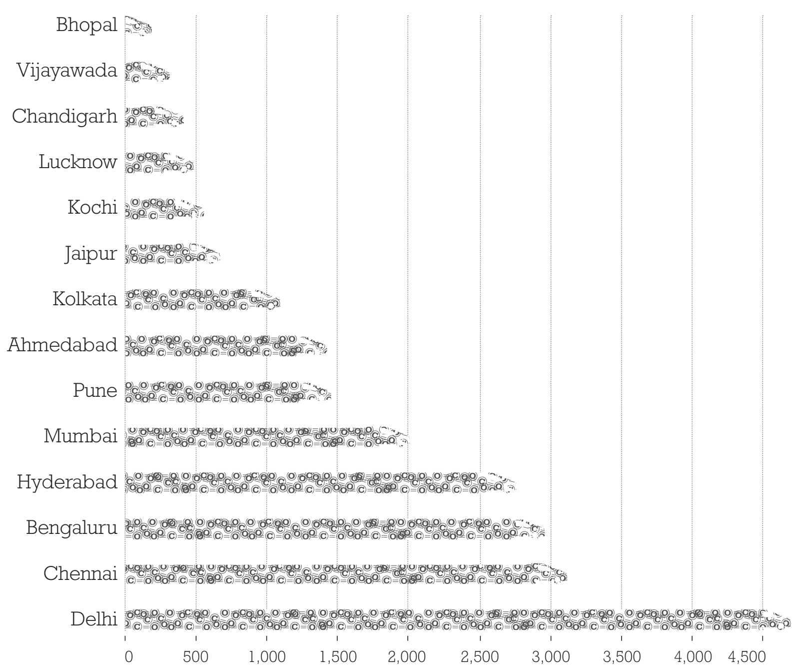
Source: CSE analysis

Graph 5: Total NO_2 emission load from urban commuting in the 14 cities (kg per day)



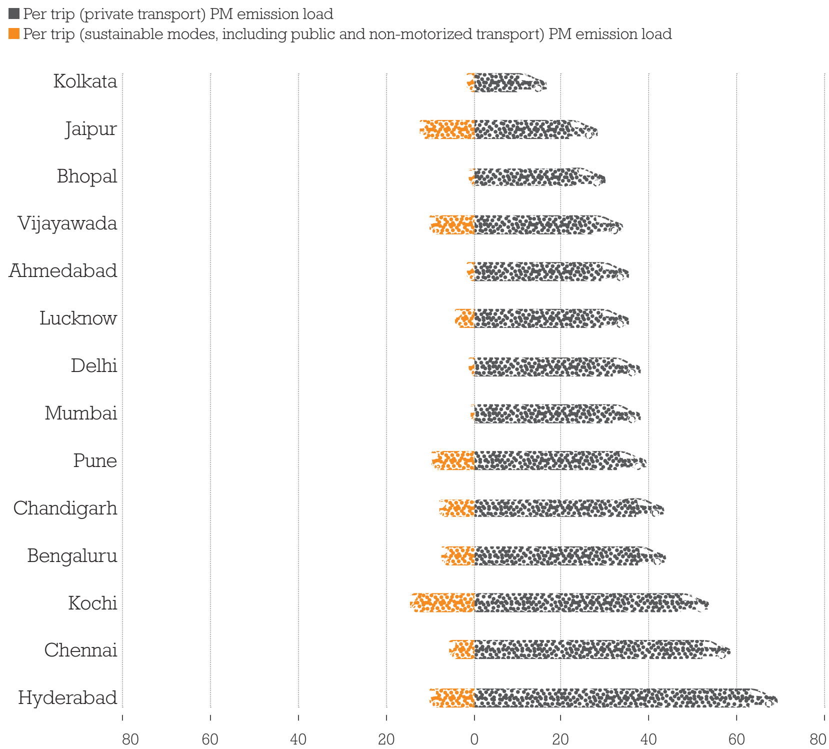
Source: CSE analysis

Graph 6: CO_2 emission load from urban commuting in the 14 cities (tonnes per day)



Source: CSE analysis

Graph 7: Particulate emission load per trip from private and public modes of transport (g per year)



Source: CSE analysis

THE ANALYSIS

WHAT HAS BEEN ANALYZED?

This is a simple exercise of estimating two things: (a) the quantum of toxic emissions of particulate matter (PM), nitrogen oxides (NOx) and heat-trapping carbon dioxide (CO_2) and (b) energy consumption—from only urban commuting practices in the 14 cities. This involves reviewing and assessing the available data on how people commute in these cities. This does not involve freight movement in the cities.

The critical parameters that have been considered to understand the difference across cities include level of motorization, volume of travel demand based on population, share of different modes of transport in meeting travel demand (public transport, walking and cycling, and personal vehicles), average distances in cities, average length of daily travel trips, and the quality of vehicle technologies and transport fuels. This also reflects on the differences in level and type of action and also the legacy advantages that some of the cities enjoy because of sensible urban planning adopted at the early stages of their growth.

Based on the results of this analysis, the 14 cities have been ranked to see which ones pollute the most and which ones are the biggest energy guzzlers. This also translates into information on how people travelling by different modes are responsible for fuel guzzling and emissions in their respective cities. It is imperative that policy decisions as well as personal choices undergo a change—only then would we notice the difference.

An analysis of this kind is not easy in India, as the Central and state governments do not have established protocols to survey and create databases on commuting practices in cities. The only data that is maintained is that of vehicle registration—which is not always corrected or updated on the basis of obsolescence, retirement and phase-out. Often, the numbers are cumulative and inflated. Data on critical commuting parameters in terms of usage of different modes of transport, the distances people travel, trends in trip generation among others are not tracked regularly by regulatory agencies. The 2011 Census is the only document that offers some insights about work trips in cities.

If better data and estimates do exist for some cities, it will only serve to improve or demote the ranking of cities considered here, without changing the broader policy message

Most data, therefore, is typically available in transport studies (such as Comprehensive Mobility Plans) which are usually conducted for any city only once in 10 years. There is huge variability in this data in terms of detail and granularity; neither is it available for the same years. At times, data has to be mined from the detailed project reports for metro and other infrastructure projects or other city-level studies. In the absence of robust methods for reasonably projecting these data points, studies by C-STEP, Bengaluru and the Institute of Urban Transport, Delhi are references where projections have been carried out for various travel parameters. The growth factors have also been calculated by them and used for this analysis to get a baseline for 2017. Such an analysis has limitations in terms of approximations (where taken), as well as the projections that were necessary to be carried out.

Clearly, the results are indicative rather than absolute. If better data and estimates—which this study has not managed to access—do exist for some cities, it will only serve to either improve or demote the rankings of the cities considered here. The broader policy message will remain unchanged.

THE CONTEXT OF THE RANKINGS

What are the imperatives and emerging challenges at the national, state and city levels that make this spotlight on fuel guzzling and emissions from only urban commuting practices so important?

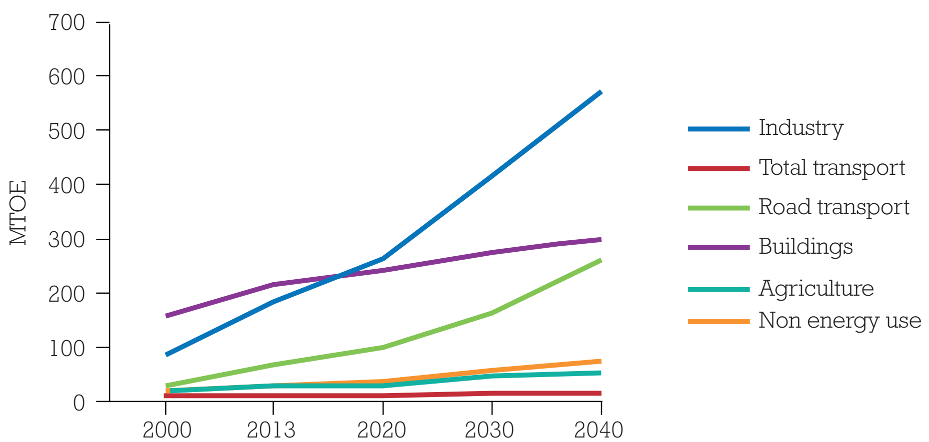
Threat to energy security

More than 40 per cent of oil and its products in India go into the running of vehicles. In fact, fuel guzzling in the transportation sector can seriously upset the country's energy security and undermine the vision of energy independence that the Government of India has set. It can also endanger the co-benefits of reducing toxic emissions and public health risks, as well as the climate change risks as underscored in the National Climate Change Plan. If fuel guzzling in the transportation sector continues unabated, it can wipe out the gains of fuel savings from all other measures (*see Graph 8: Trends in primary oil consumption in India—present (2000–13) and projected (2013–40)*).

India imports about 80 per cent of its crude oil, but has not made any serious efforts to prepare a fuel-saving roadmap for all modes of transport (including road, non-road, railways and aviation). The country's oil import bill is already close to 7 per cent of its GDP. Imports have made India vulnerable to oil price shocks. The growth rate in energy consumption is the highest for the transport sector (*see Graph 9: Growth rate in energy consumption in different sectors (CAGR 2000–13)*). More worrisome is the fact that till 2040, the transport sector in India will continue to record the highest growth rate in energy consumption—as much as 7 per cent—followed by industry at 6.4 per cent and the building sector at 2.4 per cent.

Graph 8: Trends in primary oil consumption in India—present (2000–13) and projected (2013–40)

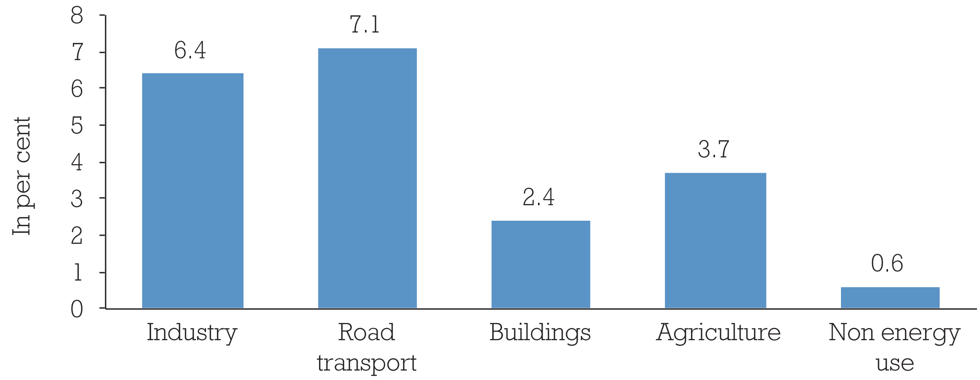
Over 40 per cent of oil and oil products in India go into running of vehicles



Source: India Energy Outlook - World Energy Outlook Special Report, 2015
https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf

Graph 9: Growth rate in energy consumption in different sectors (CAGR 2000–13)

Transport sector is the highest, and will continue to top the chart till 2040

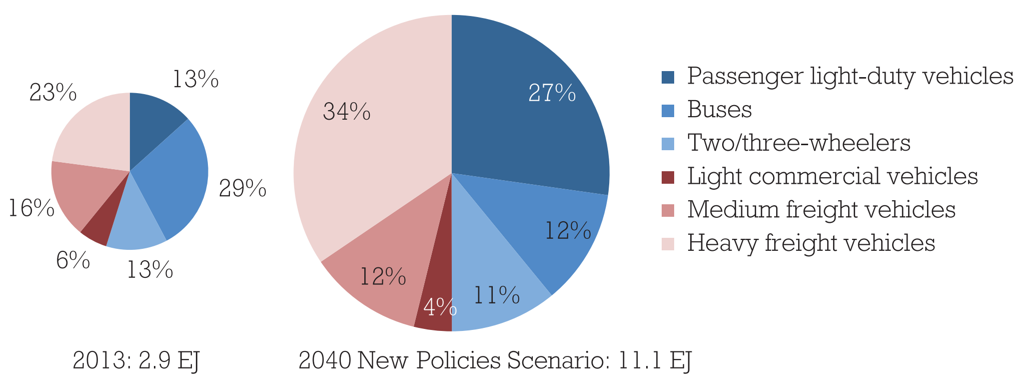


Source: India Energy Outlook - World Energy Outlook Special Report, 2015
https://www.iea.org/publications/freepublications/publication/IndiaEnergyOutlook_WEO2015.pdf

The energy demand within the transport sector will be driven by the demand from the light-duty segment (largely, personal vehicles) and heavy-duty trucks. In 2013, light-duty vehicles used up 13 per cent of the overall energy consumption by the transport sector; by 2040, their share will increase to 27 per cent. Share of heavy-duty trucks will increase from 23 per cent in 2013 to 34 per cent in 2040. While increased use by heavy-duty trucks is a reflection of a growing economy and dependency on roadways-based freight, the increase in car share is primarily due to growing automobile dependence in cities (*see Graph 10: Energy use by different transportation modes (2013 and 2040)*).

Graph 10: Energy use by different transportation modes (2013 and 2040)

Personal vehicles and heavy duty trucks drive the consumption



Source: http://www.iea.org/publications/freepublications/publication/IndiaEnergyEfficiencyOutlook_20161215_Final.pdf

Transport—key contributor to CO_2 emissions

All the carbon in the fuel that is burnt gets emitted as the heat-trapping global warming gas—carbon dioxide (CO_2). Though CO_2 emissions from the transport sector are relatively lower than that from the manufacturing and residential sectors, it is among the fastest growing sources in the country. According to the estimates of the first *Biennial Update Report* that contains the national greenhouse gas (GHG) inventory for India for the year 2010, submitted by the Union Ministry of Environment, Forests and Climate Change (MoEF&CC) to the United Nations Framework Convention on Climate Change (UNFCCC), the road transport sector in India is responsible for 10 per cent of total CO_2 emissions from all sectors.[1] But at the level of the city, the scenario can be entirely different. In Delhi, for instance, the transport sector is responsible for close to half of all CO_2 emissions.[2]

Other studies point out that among all oil-consuming sectors, CO_2 emissions from transport are increasing at the fastest rate. The MoEF&CC's report indicates that the growth of vehicles is much higher in metropolitan cities than in the smaller ones: the metropolitan cities account for about one-third of the total vehicles in India. The report adds that these trends indicate that the growth rate of vehicles is likely remain high as the cities continue to grow.[3] Although public transport still meets a large share of commuting demand in key metro cities, that share is at risk of getting eroded due to the high motorization rate. Consequently, CO_2 emissions will increase with more fuel-guzzling.

Explosive motorization

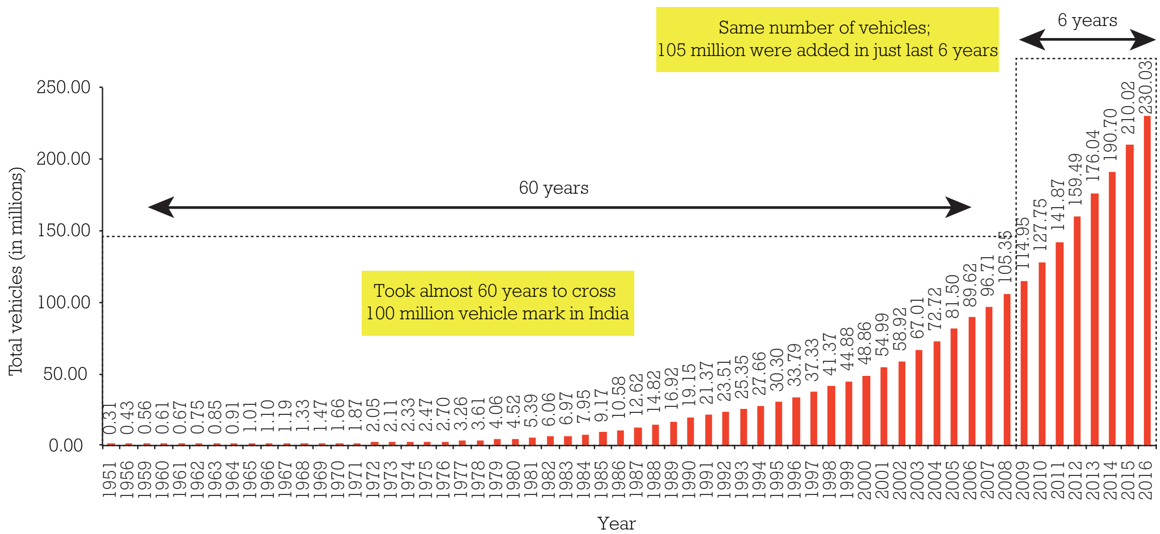
It is a no-brainer that the explosive motorization that India is faced with today, is fanning energy-guzzling and pollution. The speed at which motorization is growing is evident from the fact that initially, it took 60 years (1951 to 2008) for India to cross the mark of 105 million registered vehicles. But thereafter, the same number was added in a mere six years (2009–15)!

The number of vehicles in India has increased 700 time—from 0.3 million in 1951 to 210 million in 2015. The number of cars registered in India between 1951 and 2005 stands at 10.3 million. Almost twice that number of cars were registered in just 10 years—20 million from 2006 to 2015. The number of two-wheelers registered in India from 1951 to 2004 was 51.9 million. Almost twice the same number of two-wheelers were registered in 10 years (2005–15)—102 million. In these 10 years, the growth in the cars and two-wheelers segments has been 10.5 per cent and 10.3 per cent, respectively (*see Graphs 11–13: Trends in vehicle registrations in India (1951-2015)*). If cars and two-wheelers are combined, the personal motorization rate in India would exceed that of many advanced countries.

There is a wide variation in motorization trends across cities. While the overall and absolute numbers of vehicles are much lower in the metropolitan cities compared to the mega cities, motorization per thousand people can be higher in smaller cities than even in the big metros.[4] This is largely because an organized public transport system is not available on an adequate scale in these cities to absorb the shift from traditional non-motorized transport and para-transit. The impact of motorization in the next rung metropolitan cities is, thus, equally devastating.

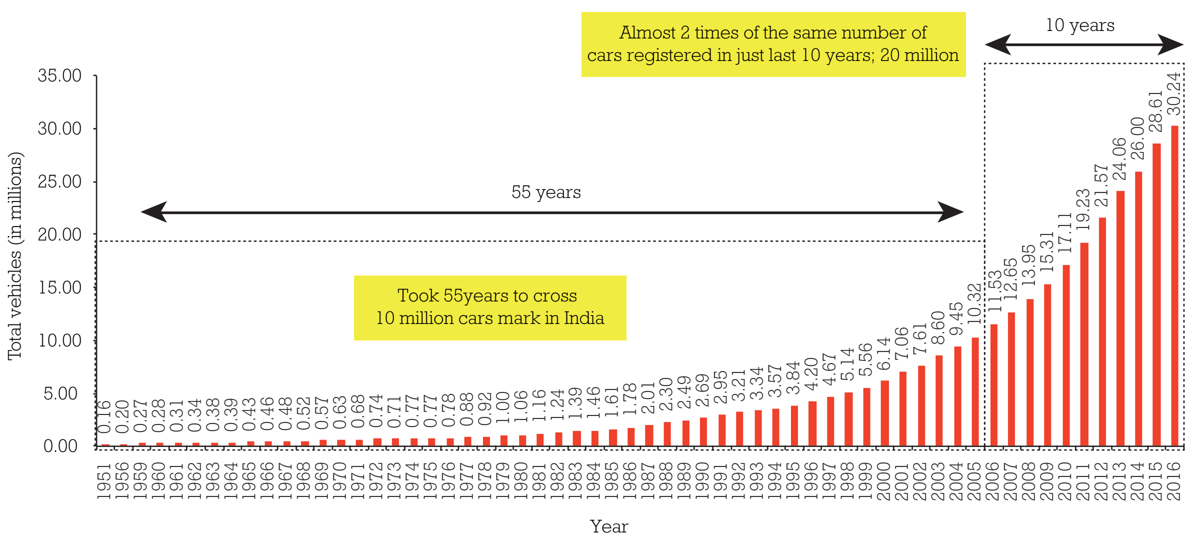
Graph 11: Trends in vehicle registrations in India (1951–2015)

Total vehicle registrations—the number has increased 700 times



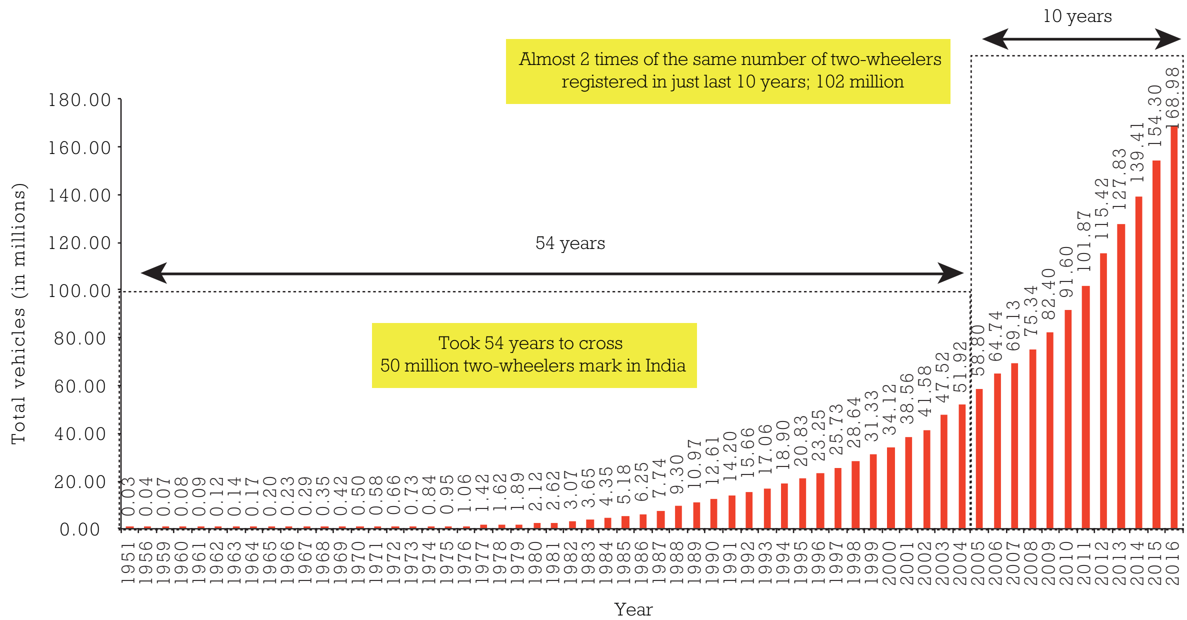
Graph 12: Trends in vehicle registrations in India (1951–2015)

Total number of cars registered—over 10 million was the number in this period



Graph 13: Trends in vehicle registrations in India (1951–2015)

Total number of two-wheelers registered—a 10.3 per cent growth was witnessed



Source for all three graphs: 2016, Road Transport Yearbook, MoRTH

Eroding share of public transport ridership

It is ironical that while urban commuting has such a profound impact on energy guzzling and pollution, there is no mechanism at the Central government level to regularly track the changes in modal share of different modes of transport nationally and in cities. Therefore, it is also not possible to assess if the national and state policies on urban transport are making any impact on protecting the ridership of sustainable modes and catalyzing a shift from unsustainable modes like personal transport.

There is limited academic research that gives us an idea of some indicative trends. For instance, one older estimate by the Indian Institute of Technology, Kanpur has projected that the overall share of public transport will decline significantly in the years to come, while that of personal vehicles will increase.[5] According to this study, in 2000–01, India's road-based passenger mobility catered to 3,079 billion passenger km (BPKm)—of this, buses accounted for 2,330 BPKm, two-wheelers 364 BPKm, cars 283 BPKm and autorickshaws 102 BPKm—this means buses alone catered to 75.7 per cent of the road-based passenger transport modal share.

The mobility projections in the IIT study point to a massive decline in the share of public transport, which will have serious implications on CO_2 emissions, energy intensity and pollution. The share of public transport is projected to decrease from 75.7 per cent in 2000–01 to 44.7 per cent in 2030–31, whereas the aggregate share of private and para-transit modes is projected to increase from 24.3 per cent to 55.3 per cent during the same period. In this business as usual scenario, the energy intensity (mega joules per passenger-km), will increase from 0.31 in 2000–01 to 0.47 in 2030–31.

Estimations of the modal share of different modes of transport—share of daily travel trips carried by different modes of transport—are rare and far between. Even though this is the most important parameter for assessing the state of urban transport, it has not received the policy attention that it requires for planning of urban transport. Most estimates available for different cities in various mobility plans and other sources are for the time frame of 2010–12—but these are indicative of the relative position.

This declining trend is clear at the city level. Delhi, for instance, shows drastic reduction in modal share of bus transport from 60 per cent in 2000 to 40 per cent in 2008, with a further subsequent decline. Even though several cities—including Delhi, Pune and Kolkata—have set a target of increasing public transport ridership to 80–90 per cent by 2020, there is no proper action plan for achieving this target.

From 2000–01 to 2030–31, the ridership share of public transport in Indian cities is projected to decrease from almost four-fifths to about two-fifths

Yet, studies emphasize on the importance of increasing the share of public transport, walking and non-motorized transport. A research by the International Energy Agency has estimated a 100 per cent difference in oil use in a future scenario dominated by high quality bus systems as opposed to personal vehicles in Delhi. Likewise, an Asian Development Bank study of 2005 has projected that Bengaluru can save 21 per cent of fuel consumption if it increases its share of public transport from the current 62 per cent to 80 per cent. Clearly, cities cannot afford to trade off car restraint policies for car-centric growth.

Tax policies are equally distorted—public transport is made to bear a disproportionately high tax burden that increases the cost of travel for all. Available data for state- or city-level taxation bears out this challenge where the annual road tax on a bus is higher than the one-time road tax a car pays in any given year. Lack of integration of public transport systems, poor last mile connectivity, and adverse economics erode public transport ridership. In most cities the minimum bus fare cannot compete with the per kilometer operational cost of a two-wheeler, which is a lot cheaper. Frequent interchanges from one mode to another during one journey add up to make the journey costly. Therefore, as public transport services become deficient and expensive, it leads to a steady migration to personal vehicles. This locks in enormous pollution and fuel guzzling.

Not designed for sustainable modes

Most cities in India have the advantage of compact urban designs that have helped reduce travel distances. Estimates from IIT Delhi show that more than half of all travel trips in most cities are below 5 km average due to compactness of the cities. But this advantage is rapidly eroding as cities are sprawling and adopting the gated community approach. At the same time, road networks and designs are changing dramatically around vehicles to enable seamless movement at high speed, which impedes pedestrian movement and public transport access—a disproportionate share of right-of-way is being taken up by the carriageway and its continuous widening, and crossings and signals are being removed for seamless movement of vehicles. Sprawl is increasing distances and overall vehicle miles travelled. All new towns and expansions are low density, and based on segregated land use. If urban infrastructure continues to change in this manner it will lock in enormous pollution that cannot be easily undone—something that several megacities are already experiencing.

Worsening urban air quality

Air pollution is a national crisis; it ranks among the top killers in the country. The annual air quality data submitted by the MoEF&CC to the Parliament shows that the percentage of cities in India with a critical level of PM_{10} (more than 1.5 times the standard) has increased from 60 per cent in 2007 to 88 per cent in 2016. There has been a drastic fall in the number of cities complying with the standard—from 13 per cent in 2007 to 2 per cent in 2016. There is no city in the 'low pollution' or 'good' categories (50 per cent below the standard).

Today, smaller cities are more polluted than the megacities. As air quality monitoring expands, it is showing that cities are also in the grip of a multi-pollutant crisis—along with particulate pollution, the levels of NOx and ozone are rising as well. This has increased the public health risk manifold. The State of Global Air 2018 report released by the US-based Health Effects Institute says that as many as 1,090,400 premature deaths had occurred due to air pollution related diseases in 2017. This not only makes air pollution the top killer in the country, but also makes India occupy the dubious second rank in the world in terms of premature deaths recorded.

As many as 1,090,400 premature deaths occurred due to air pollution related diseases in 2017, according to the US-based Health Effects Institute

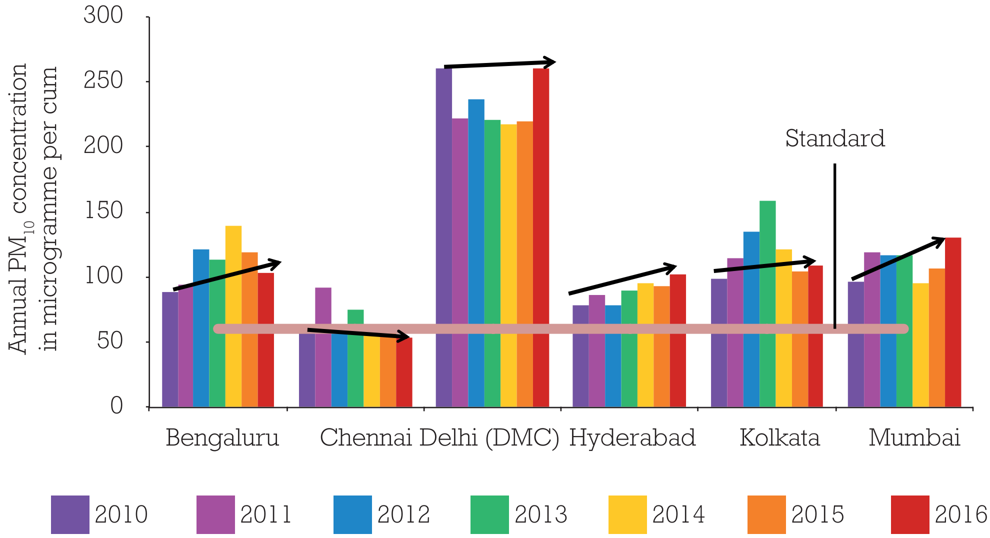
The 14 cities under the scanner show a mixed trend in air pollution (*see Graphs 14–17: Air quality trends*). The pollutants of concern are particulate matter and nitrogen oxides—all cities point to violation of the national ambient air quality standards for particulate matter, while several others show a rising trend in NOx. However, it is important to note that local climatic conditions can influence the peak pollution build-up across different ecological zones. Northern Indian cities like Delhi and Lucknow have significantly higher pollution levels than cities in southern and western India. Northern India is land-locked and traps pollution, especially during winter, due to inversion conditions. Southern and western cities of Chennai and Mumbai have the advantage of the sea breeze. Climatic conditions in the more inland southern cities such as Hyderabad and Bengaluru do not aid in trapping of pollution.

But the relatively lower pollution levels in these cities should not breed complacency. Though the ambient levels are low, the actual exposure in close proximity to the source of pollution—especially vehicular traffic—remains high. Moreover, as the global burden of disease estimates show, longer term exposure to even lower levels of ambient pollution that we largely observe in southern cities, have significant effect on health. Most of the health effects occur at much lower levels than we observe in northern India and this has been demonstrated in cases of ischemic heart disease and cancers.

In view of these national challenges, the key cities of India have been brought under the scanner for a deeper insight into their commuting practices and their links with emissions and energy consumption.

Graph 14: Air quality trends

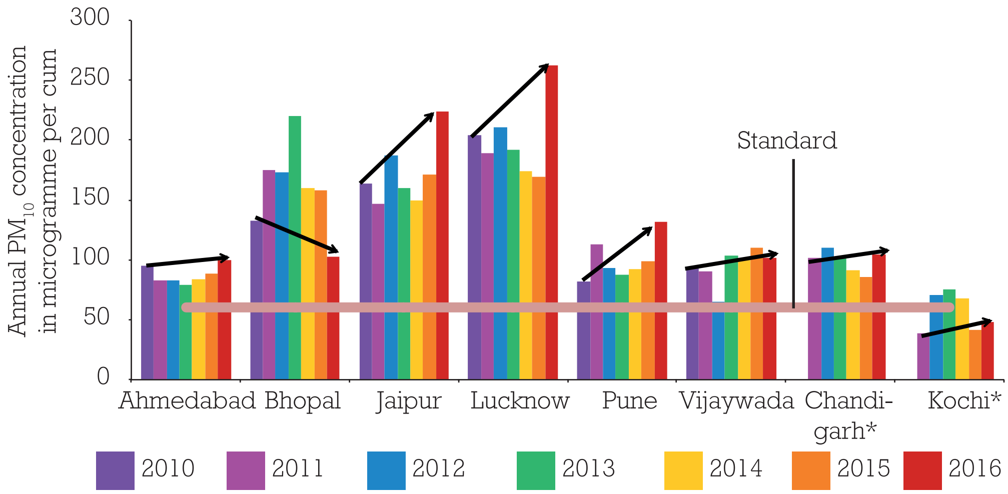
PM^{10} concentration in six mega cities—way above the standard



Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities

Graph 15: Air quality trends

PM_{10} concentration in metropolitan cities

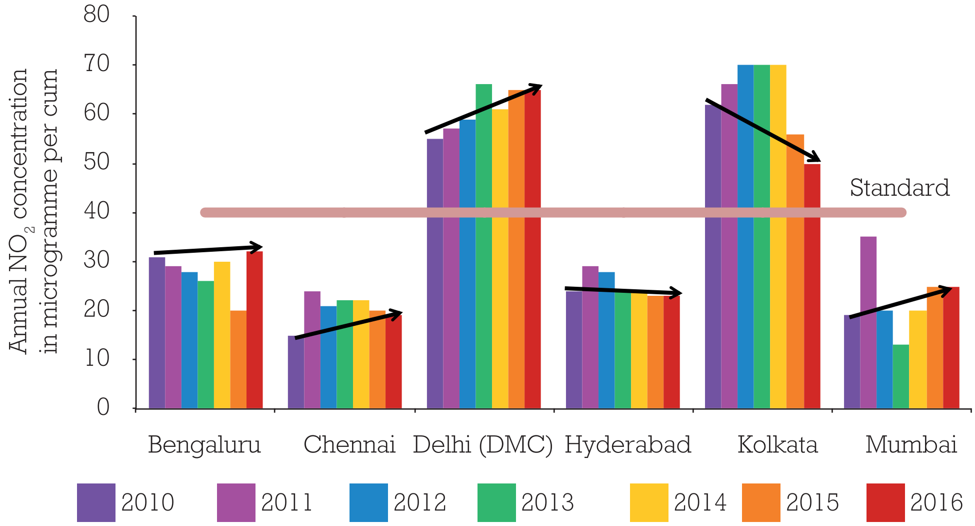


*Data available since 2011

Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities and CPCB the ENVIS centre

Graph 16: Air quality trends

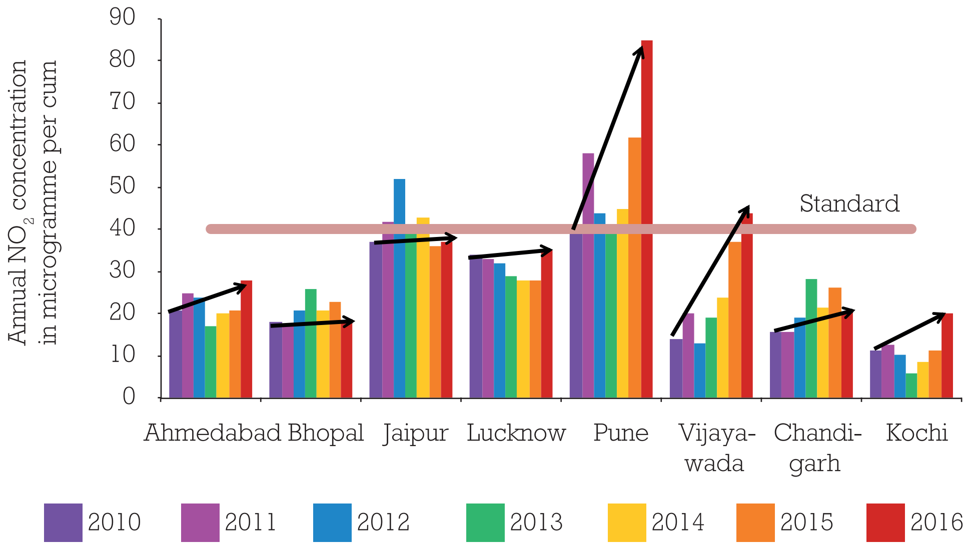
NO_2 concentration in six mega cities



Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities

Graph 17: Air quality trends

NO_2 concentration in six metropolitan cities



Source: Computed by CSE from CPCB air quality data submitted to Rajya Sabha for 44 cities and the CPCB ENVIS centre

COMMUTING PRACTICES

What are the factors that influence commuting practices across cities? Any public policy initiative on urban transport needs to factor in several elements in urban commuting that determine the level of emissions and fuel guzzling in cities. The key factors that have a strong bearing include the volume of travel; modes of travel; distances covered; fuel quality; vehicle technologies; and the fuels in use.

In the absence of an official mechanism to track this data on a regular basis in cities, fragmented data available from government sources like vehicle registration data, limited set of research by few research agencies etc. have been pieced together to get an indicative trend. This points to wide divergence among cities.

TRIP GENERATION IN CITIES

For mobility experts, the primary travel indicator is how many trips each person is expected to undertake that adds upto the total volume of travel in the city

PCTR: 1

Per capita travel trip rate (PCTR) indicates number of travel trips generated per person per day. These might be on foot, in a personal vehicle like a two-wheeler or a car, through public transport like a bus or train, or a combination of the different modes of travel

PCTR: 4

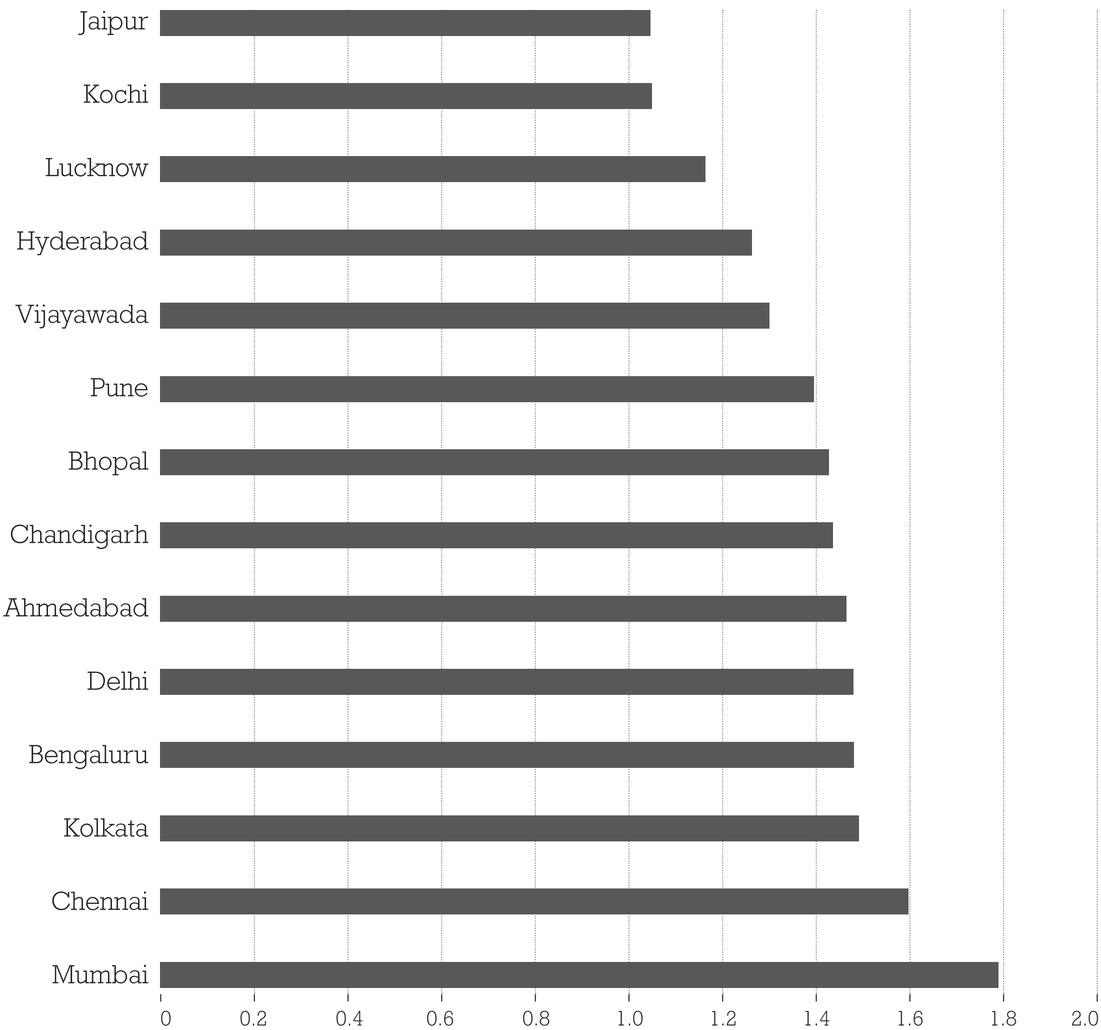
PCTR: 3

PCTR takes into account daily intra-city, city to outside city, and outside city to city trips. This is largely influenced by the city's economic situation, workforce participation rate and gender ratio in the workforce, amongst other factors

PCTR: 4

Depending on the travel mode, higher the PCTR, higher emissions levels in a city. Personal vehicles increase emissions and require greater space, whicle public transport needs less fuel and space, and emits less as well

Graph 18: PCTR in 14 Indian cities in 2017



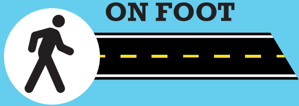
Note: *For Hyderabad, the trip rate is for Greater Hyderabad Municipal Corporation area which was constituted in 2007 and thus exhibits a non-uniform level of urban development within its boundary, possibly leading to a rather lower trip rate.
Source: Base figures from multiple transport studies; projections using factors given in "Review of Urban Transport" prepared by CSTEP and IUT

The population size in cities has enormous impact on the volume of trip generation—more people in cities with higher PCTR will lead to more travel demand. Among the 14 cities under the scanner, all the megacities with very high population are at the top with high PCTR: Mumbai is in the lead, followed by Chennai, Kolkata and Delhi. Among the next rung of cities, Bhopal, Pune, Vijayawada, Lucknow, Kochi and Jaipur are placed in that order. Bigger and more populated cities will have to, therefore, account for this while providing for sustainable modes of transport

AVERAGE LENGTH OF TRAVEL TRIPS IN CITIES

It is standard practice to estimate the average trip length that a person undertakes daily. This is determined and influenced by urban form, land use and density patterns, and city size

ON FOOT

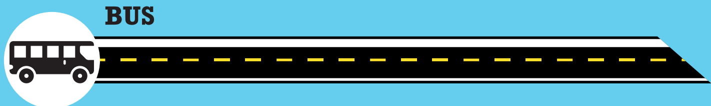


On foot trips in cities are typically the shortest. In any case, they are the cleanest trips in terms of emissions, zero consumption of fuel, and occupy the smallest road space

TWO-WHEELER

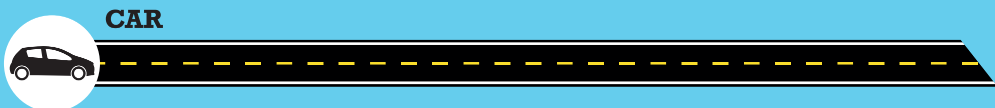
Two-wheeler trips, on an average, are longer than on foot trips. There are two patterns of two-wheeler trips. On the one hand, they are used as short-distance trips which are inconvenient to make on foot. On the other hand, they are used to make longer distance trips by certain economic sections of the society

BUS



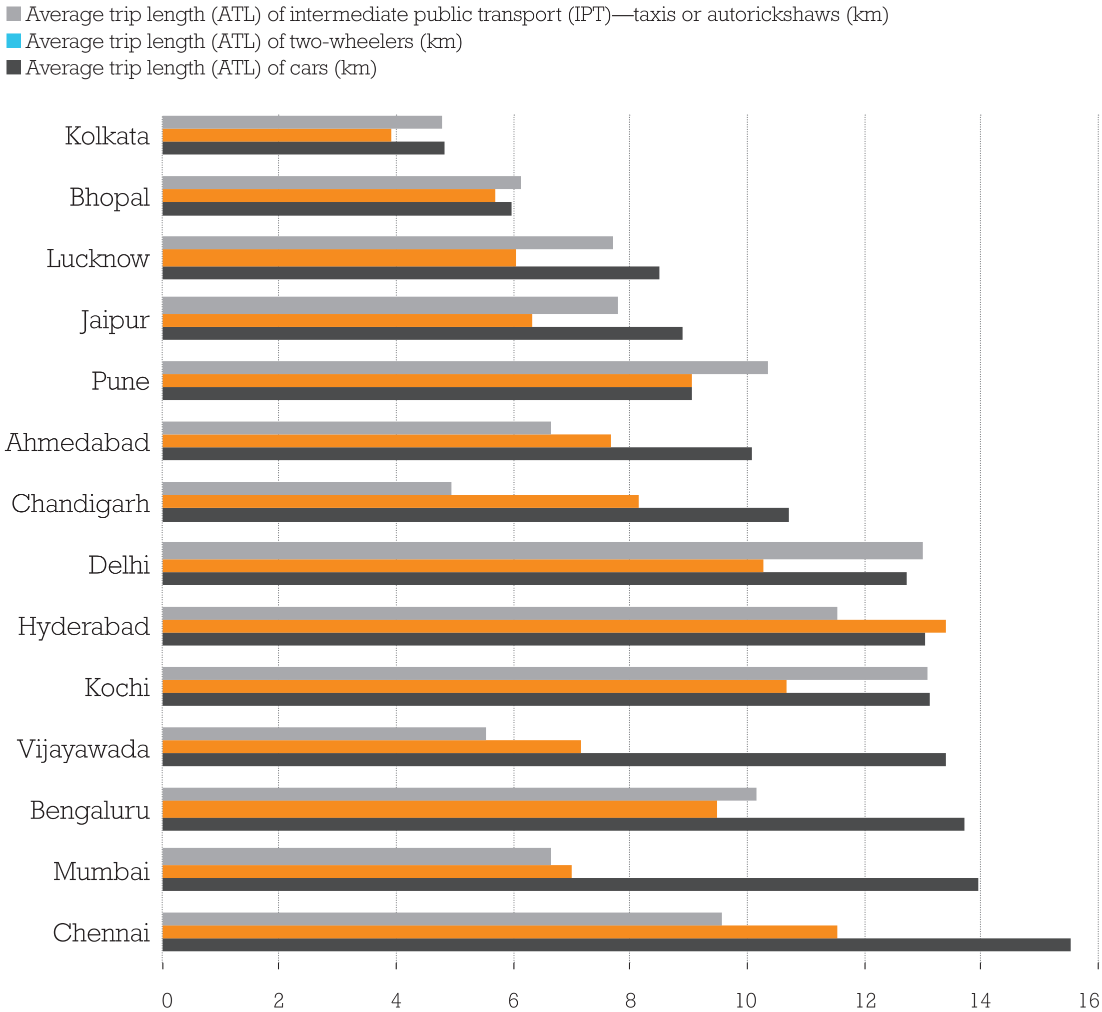
Bus trips and trips made through other modes of public transport are typically longer than two-wheeler trips. A city with a well-developed network of public transport modes usually consumes less fuel, and has cleaner air and less traffic logjams

CAR



Car trips are, in a typical scenario, the longest trips. People in cars are more likely to be amenable to travelling longer distances due to the comfort level accorded by car travel

Graph 19: Average trip length of cars, two-wheelers and taxis or autorickshaws in the 14 cities in 2017

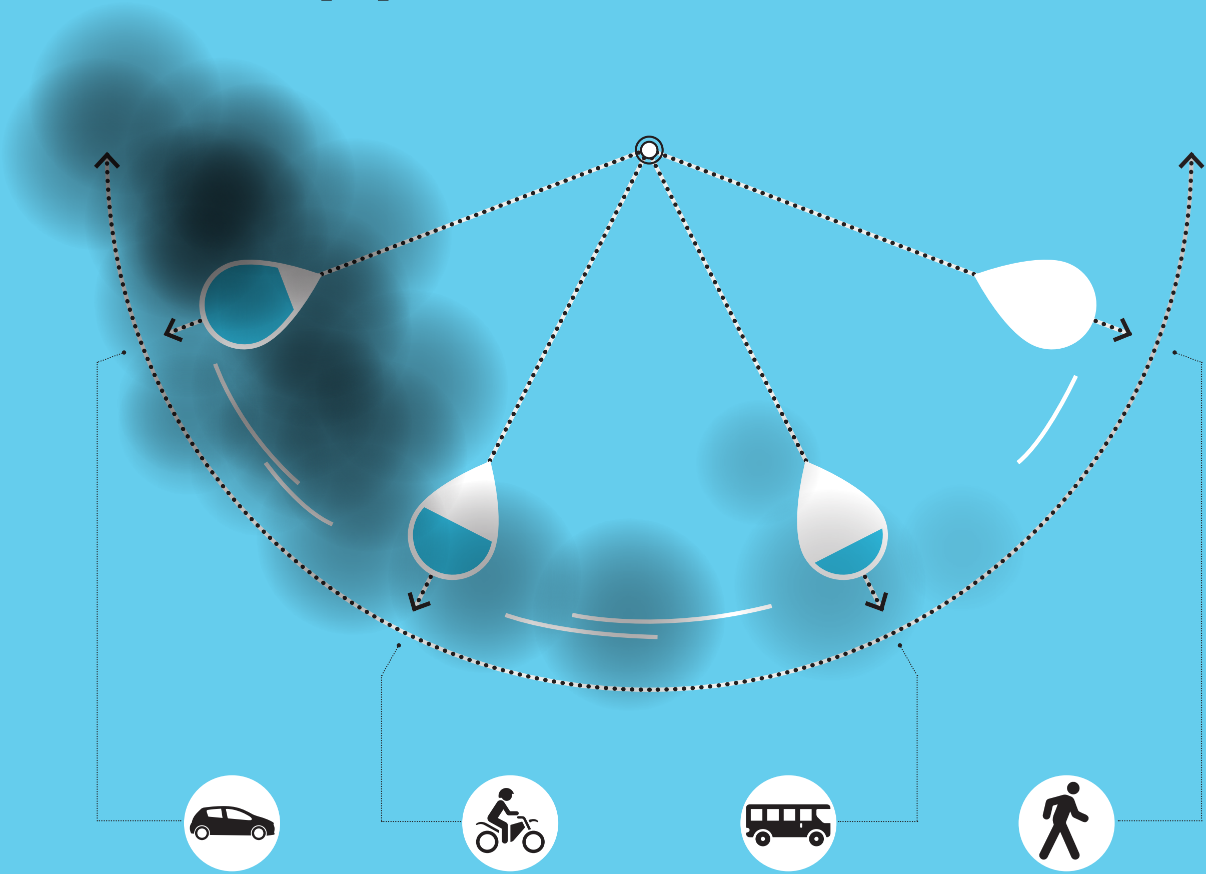


Source: Base figures from multiple transport studies; projections using factors given in "Review of Urban Transport" prepared by CSTEP and IUT

Available data shows that among the big cities, Mumbai, Chennai, Delhi and Hyderabad have high average trip lengths. But some of the next rung metropolitan cities including Kochi and Vijayawada are also on the higher side because these operate largely as twin cities (e.g. Kochi–Ernakulam). From a public policy point of view, it is noteworthy that Kolkata, despite being a megacity, has the smallest average trip length among the 14 cities. This is a reflection of a good practice of keeping the urban design compact with mixed land-use and high street density

HOW PEOPLE TRAVEL—SHARE OF TRAVEL MODES IN MEETING TRAVEL DEMAND

The biggest influence on emissions and fuel guzzling comes from the choices people make about travel modes



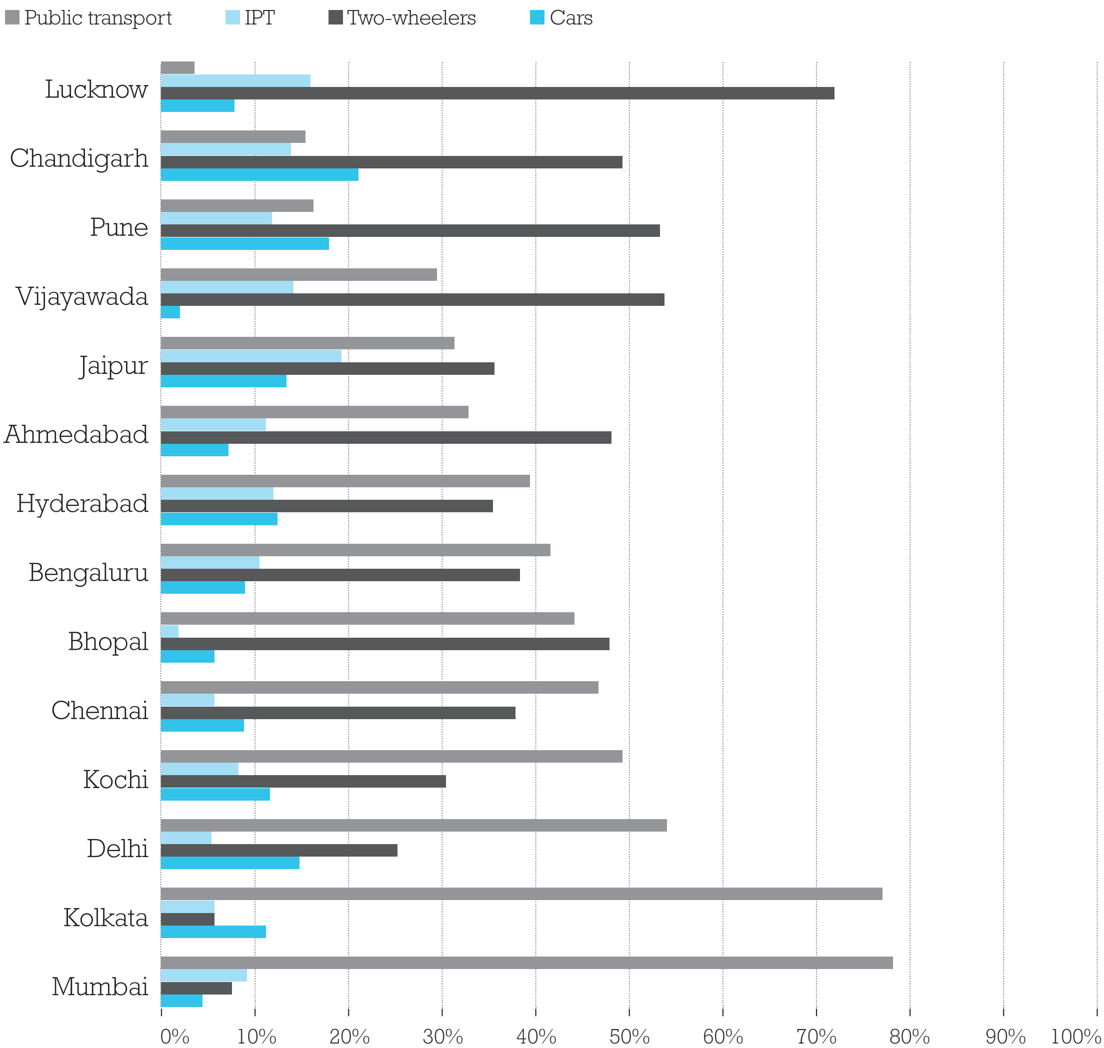
Cars: They are the most polluting mode of transport. They guzzle the most fuel, emit the highest quantities of dangerous pollutants and occupy the largest road space

Two-wheelers: They are very fuel and space efficient, but their sheer numbers on Indian roads are staggering, which means that their pollution impact is also huge

Buses and other modes of public transport: Do consume quantities of fuel and emit pollutants, but they carry a large number of people, improving their overall per capita statistics

On foot and bicycling: Nothing beats the old one-two of walking and cycling. Zero emissions, zero fuel consumption, a low road-space occupancy, and a high-five for being the best mode of transport

Graph 20: Share of different modes of transport in motorized trips in the 14 cities in 2017



Source: Base figures from multiple transport studies

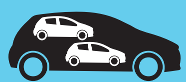
Among mega cities, the highest personal vehicle dependence for work trips is noted in Hyderabad, Bengaluru, Chennai and Delhi, with Mumbai and Kolkata bucking the trend. But the share of personal vehicle usage is substantially higher in next rung metropolitan cities. It is close to 80 per cent in Chandigarh, followed by Lucknow, Ahmedabad and Jaipur at 70, 65 and 60 per cent respectively. These smaller cities were traditionally dependent on non-motorized transport and paratransit, but are now seeing a rapid shift towards personal vehicles as they lack formal organized public transport systems to absorb the dynamics of increased urbanization

HOW PEOPLE TRAVEL—THE MATHEMATICS OF MODES OF TRAVEL

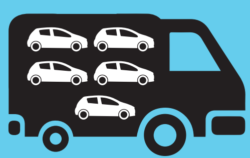
The relationship between modal share and emissions is in part linked to the occupancy levels of different modes. Let's do some maths

FUEL CONSUMPTION

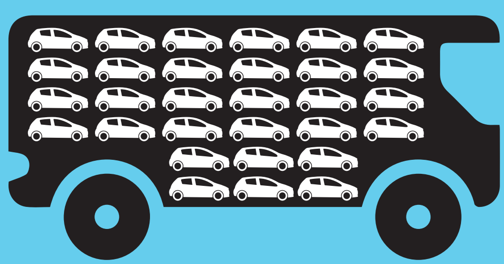
On a average, a car carries 1.5 to two persons



This means that if two people car-pool, the consumption of fuel as well as emissions will be halved



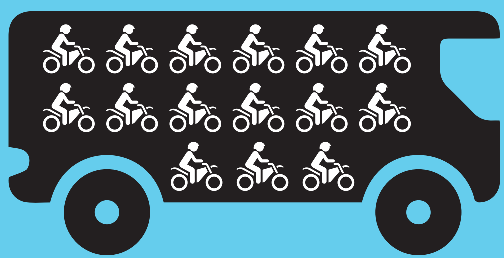
Para-transit modes of transport carry about five persons, which means fuel consumption and emission of air pollutants may be reduced to a third



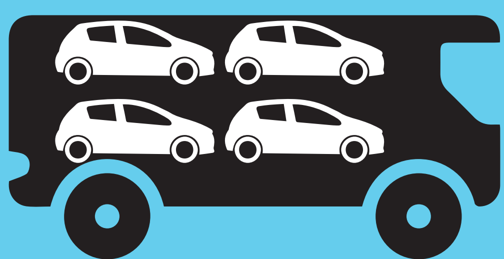
On an average, a bus carries between 40–60 passengers. This is equal to what 30 cars carry. A bus emits about 4–6 times what a car does. Thus, fuel consumption and air pollution is reduced to 1/6th when users of 30 cars take a bus

ROAD SPACE OCCUPIED

Two-wheelers carry even less, an average of one to 1.2 persons

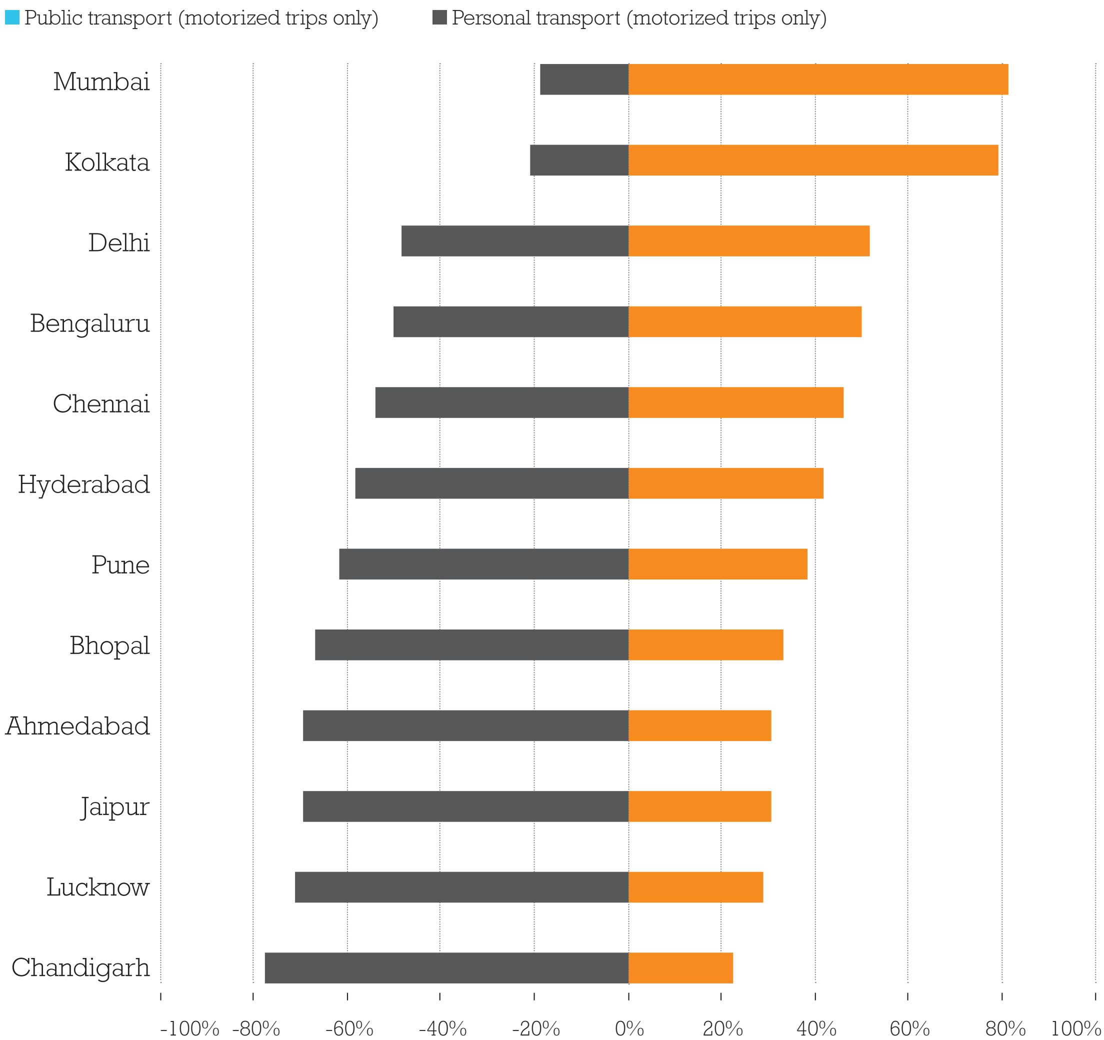


In terms of space, 15 two-wheelers require the amount equivalent to what a single bus requires. However, a single bus carries approximately three times the number of people 15 two-wheelers carry, thus reducing the road space occupied to a third



Four cars occupy space which a single bus occupies. But, a single bus carries approximately eight times the number of people four cars carry, thus bringing the road space occupied to 1/8th

Graph 21: Share of public and private transport in motorized trips in the 14 cities in 2017



Source: Base figures from multiple transport studies; projections using factors given in "Review of Urban Transport" prepared by CSTEP and IUT

Mumbai and Kolkata have the highest share of public transport trips followed by Delhi and Chennai. In this group of mega cities, Bengaluru is at the lower level, in terms of share of public transport trips. In fact, cities that have a better organized and formal public transport system have higher public transport modal share. The interesting trend is that even though the next rung metropolitan cities have higher share of walk and cycle trips, their share of personal vehicle trips is sometimes higher than even that of the bigger cities due to lack of a formal public transport system in these cities

AVERAGE KILOMETERS TRAVELLED BY DIFFERENT MODES

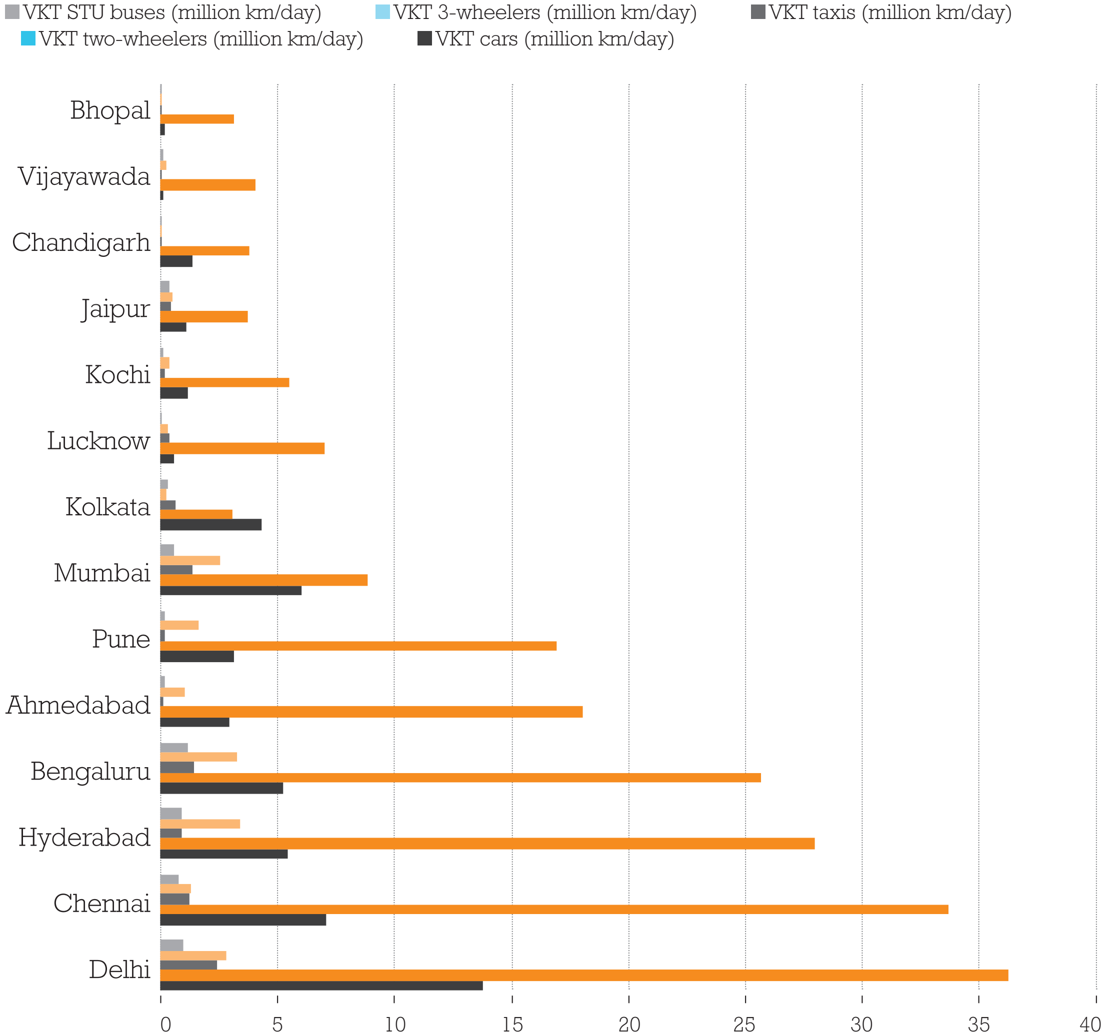
It is not enough to know the number of vehicles or the average trip length in cities. It is also important to assess the average number of kilometers vehicles run in a city. It is this operational phase that has the most profound impact on actual emissions and fuel guzzling

BUSES
A combination of lesser absolute numbers, small number of daily trips and median trip lengths ensures that buses and other forms of public transport travel less in total, on an average

CARS
The number of cars in a city is higher and (ever increasing), their average trip lengths are the long, and they make a few rounds every day, increasing their daily average kilometres travelled

TWO-WHEELERS
Two-wheelers, two-wheelers everywhere. Sneaking through the tiny spaces between other vehicles. They make frequent trips, albeit shorter ones. Yet their total average daily kilometres travelled is the highest

Graph 22: Average distance travelled by different modes of transport in the 14 cities in 2017



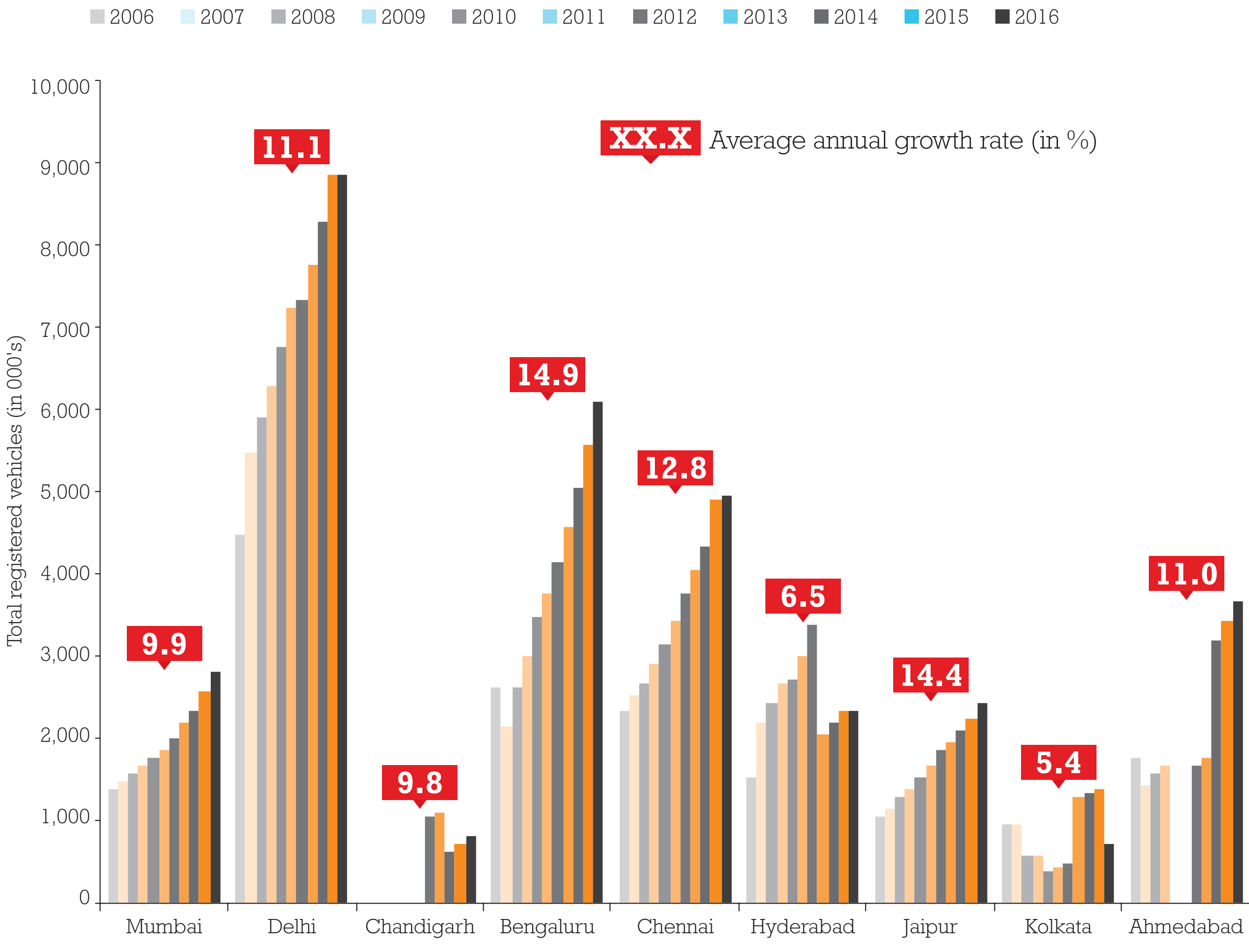
VKT: Vehicular kilometres travelled
Source: CSE analysis

Personal vehicles dominate the daily distance travelled in all the cities. Two-wheelers travel the maximum, particularly in Delhi, Chennai, Hyderabad and Bengaluru. But, Kolkata and Mumbai, despite being megacities, have lowest share of personal vehicles compared to other megacities, in terms of total kilometres travelled. Even though the overall distance travelled by vehicles is comparatively much lower in the next rung metropolitan cities than megacities, personal vehicles dominate in these cities as well

LEVELS OF MOTORIZATION IN DIFFERENT CITIES

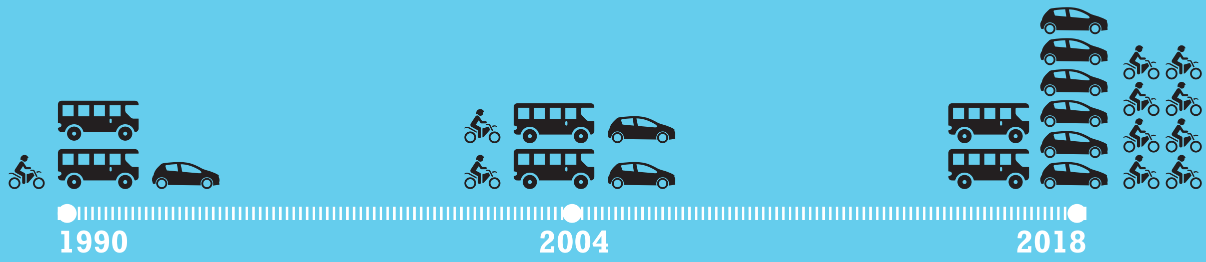
The rate of growth of vehicle numbers in a city is a key indicator of forthcoming challenges. In some cities, they worsen situations, in other cities, they will create a new set of problems

Graph 23: Trend in total registered vehicles and average annual growth rate in the 14 cities (2006–16)

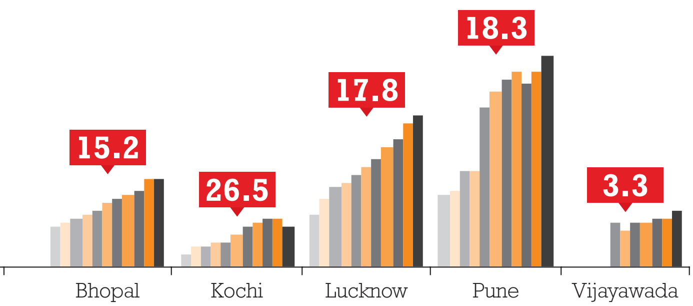


Source: MoRTH statistics

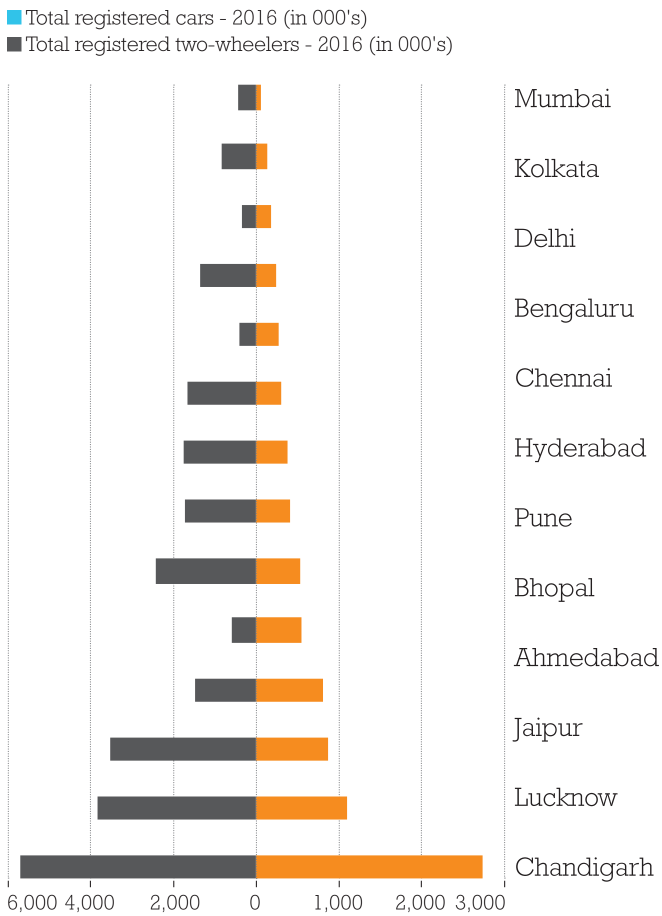
In megacities, where the absolute number of registered vehicles is already large, the average annual growth rate is in 2006–16 has varied from close to 15 per cent in Bengaluru to 11 per cent in Delhi, 9.9 per cent in Mumbai, 12.8 per cent in Chennai and 6.5 per cent in Hyderabad. Among them Kolkata has recorded lowest growth rate of 5.4 per cent



The number of vehicles on the roads of Indian cities has been rapidly increasing. Most of the new vehicles are cars and two-wheelers



Graph 24: Total registered cars and two-wheelers in the cities under study in 2016



Source: MoRTH Statistics

It is, however, stunning that some of the other metropolitan cities that have comparatively smaller number of registered vehicles, have recorded considerably high average annual growth rates. This is as high as 10 per cent in Chandigarh, 18 per cent in Pune, 15 per cent in Bhopal, and 14 per cent in Jaipur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THE CONSEQUENCES

Who guzzles and pollutes more? The 14 cities under study are ranked based on energy consumption, and load of particulate matter, nitrogen oxide and carbon dioxide emissions from urban commuting. The total load of emissions bears out the sheer impact of volume of travel. On the other hand, per trip emissions indicates the difference between different modes of travel.

Many factors converge to determine the difference in travel related pollution load and energy consumption in a city. This complex matrix of factors include extent of urban sprawl, average travel distances, share of public transport, walking and cycling trips, restrain on personal vehicle usage or emissions management. But this also underscores the importance of public policy in deciding urban form and design, scale up of integrated public transport systems supported by efficient last mile connectivity, safe access for all, and efforts to reduce on-road emissions. This will determine whether a city's urban commuting paradigm and its emissions and energy impacts will improve or worsen with time.

The rankings are, therefore, not final statements on the cities' urban commuting practices. Instead, they indicate the choices that the cities should make to promote sustainable commuting practices and set examples for others to learn by emulating the best practices and avoiding the worst practices.

PARTICULATE LOAD FROM URBAN COMMUTING

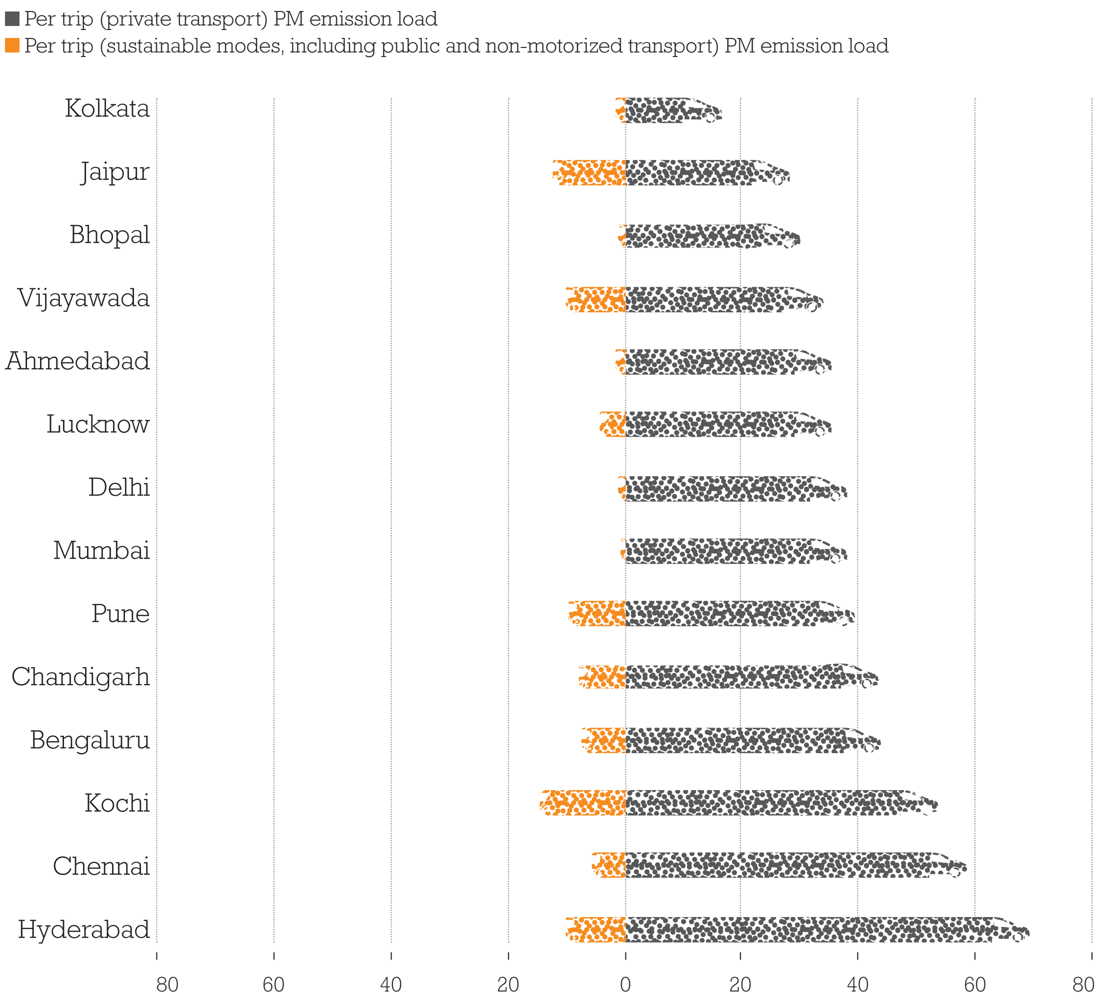
PM_{10}
PM_{10} refers to atmospheric particulate matter (PM) with a diameter of less than 10 µm. These particles can get deep into the lungs and cause respiratory problems such as asthma, chronic bronchitis, heart diseases and cancer. The permissible daily and annual concentration in the atmosphere of PM_{10} is 100 and 60 µg/m^3 respectively

$PM_{2.5}$
Atmospheric particulate matter with width of less than 2.5 µm is referred to as $PM_{2.5}$. These particles are so small that they can penetrate deep into the lungs, and get into the bloodstream. Short-term health impacts include irritation in the eyes, nose and throat, coughing, sneezing and shortness of breath. Prolonged exposure to $PM_{2.5}$ can cause permanent respiratory problems such as asthma, chronic bronchitis, heart diseases and cancer. The permissible daily and annual concentration in the atmosphere of $PM_{2.5}$ is 60 and 40 µg/m^3 respectively

Graph 25: Total particulate emission load from urban commuting in the 14 cities (kg per day)

Source: CSE analysis

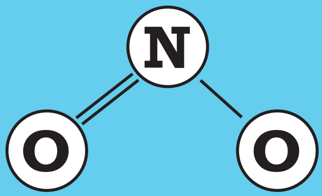
Graph 26: Particulate emission load per trip from private and public modes of transport (in g per year)



Source: CSE analysis

Particulate load from urban commuting in Bhopal is 11 times lower than Delhi. It is also crystal clear that every time we make a trip by personal transport—cars and two-wheelers, we contribute two to five times more emissions as opposed to making a trip by public transport. Pollution load for particulate matter per travel trip per year from personal vehicles is significantly higher than the public transport trips across cities

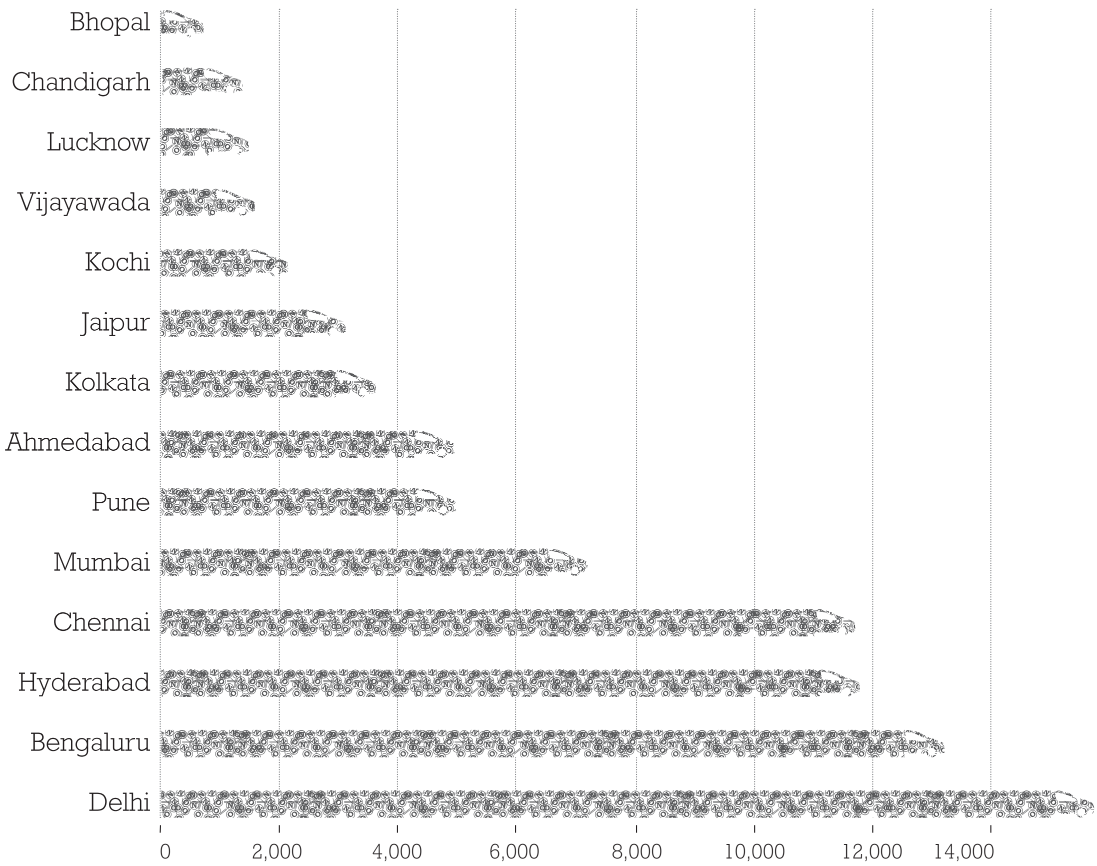
NITROGEN OXIDE LOAD FROM URBAN COMMUTING



NO_2

Nitrogen dioxide (NO_2) is one of a group of highly reactive gases known as oxides of nitrogen or nitrogen oxides (NO_x). Breathing air with a high concentration of NO_2 can irritate airways in the human respiratory system. Exposure over short periods can aggravate respiratory diseases, particularly asthma, leading to respiratory symptoms (such as coughing, wheezing or difficulty breathing), and may even lead to hospitalization. Longer exposures to elevated concentrations of NO_2 may contribute to the development of asthma and potentially increase susceptibility to respiratory infections. The prescribed permissible daily and annual concentration in the atmosphere of NO_2 is 80 and 40 µg/m^3 respectively

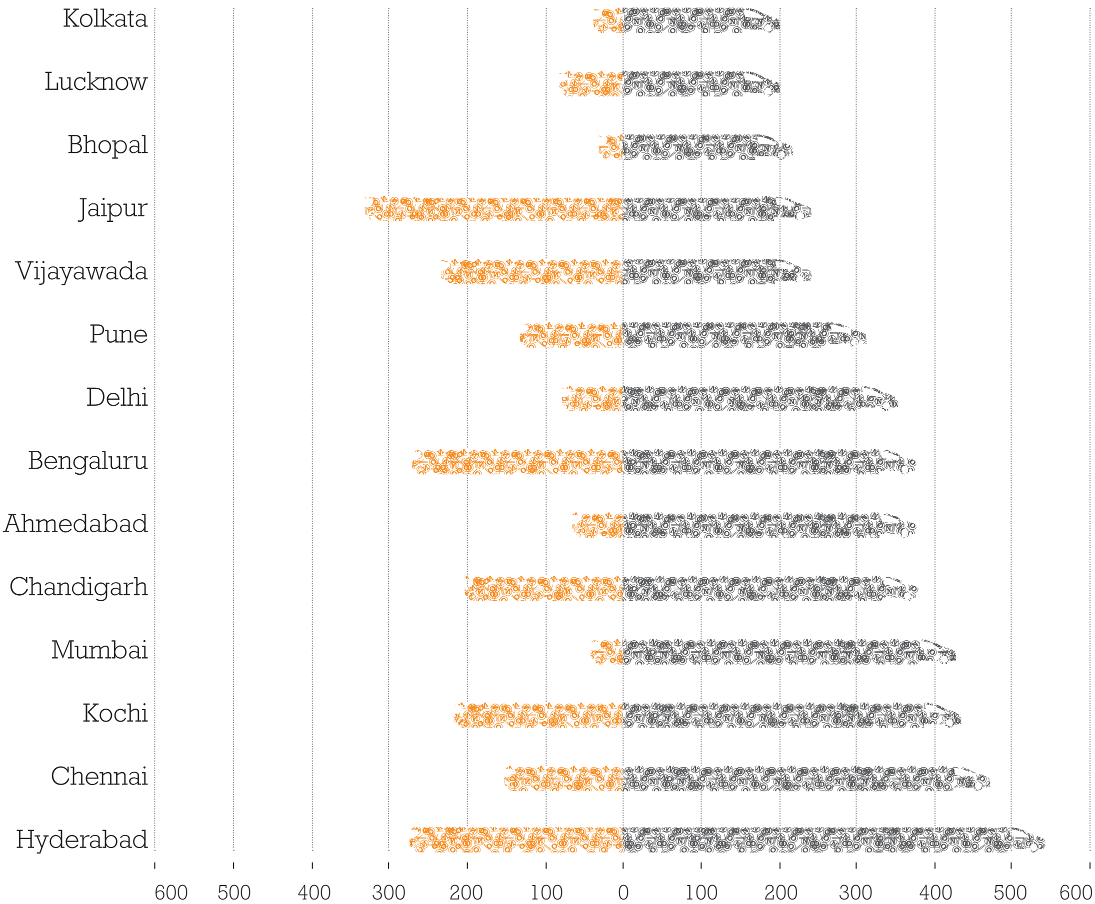
Graph 27: Total NO_2 emission load from urban commuting in the 14 cities (kg per day)



Source: CSE analysis

Graph 28: Nitrogen oxide emission load per trip from private and public modes of transport (in g per year)

■ Per trip (private transport) NO_x emission load
■ Per trip (sustainable modes, including public and non-motorized transport) NO_x emission load



Source: CSE analysis

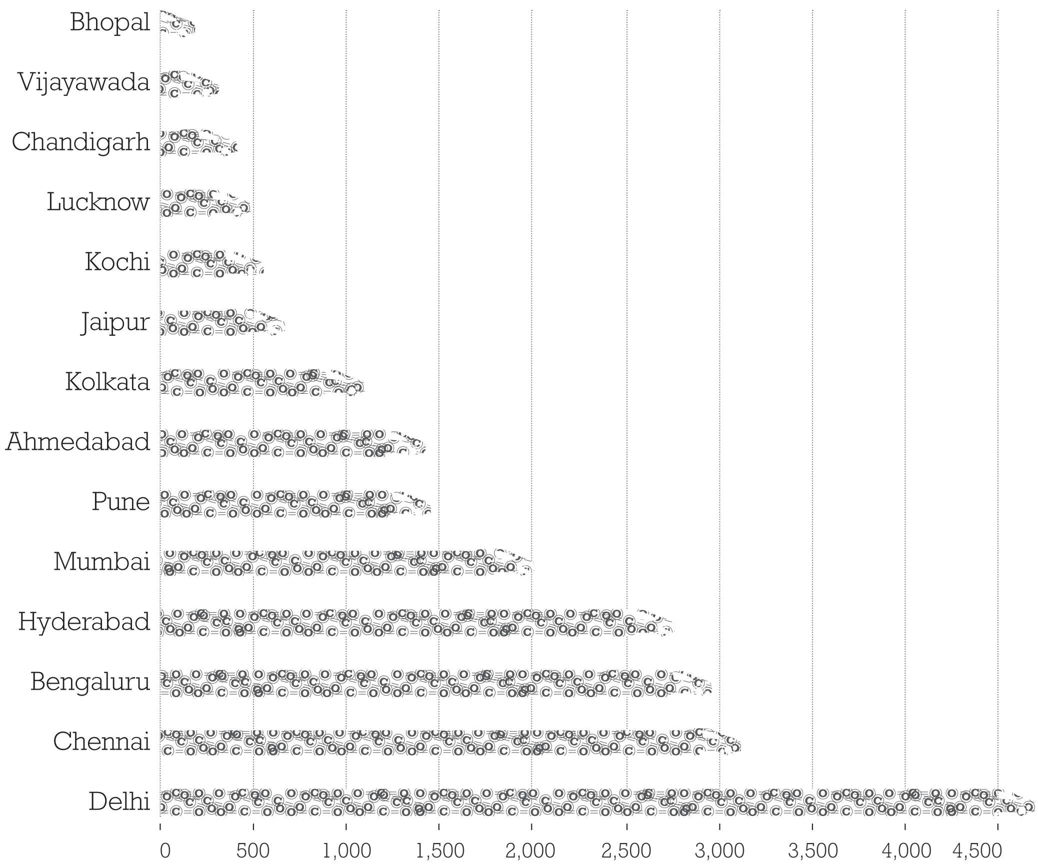
The cumulative effect of pollution load of NO_x for all travel trips is enormous. This underscores individual responsibility. It also indicates that in cities with a rising volume of travel if personal vehicle trips are substituted with public transport trips, transport-related emissions and energy consumption can decline substantially

HEAT TRAPPING GASES INCREASE CLIMATE RISK IN CITIES

CO_2

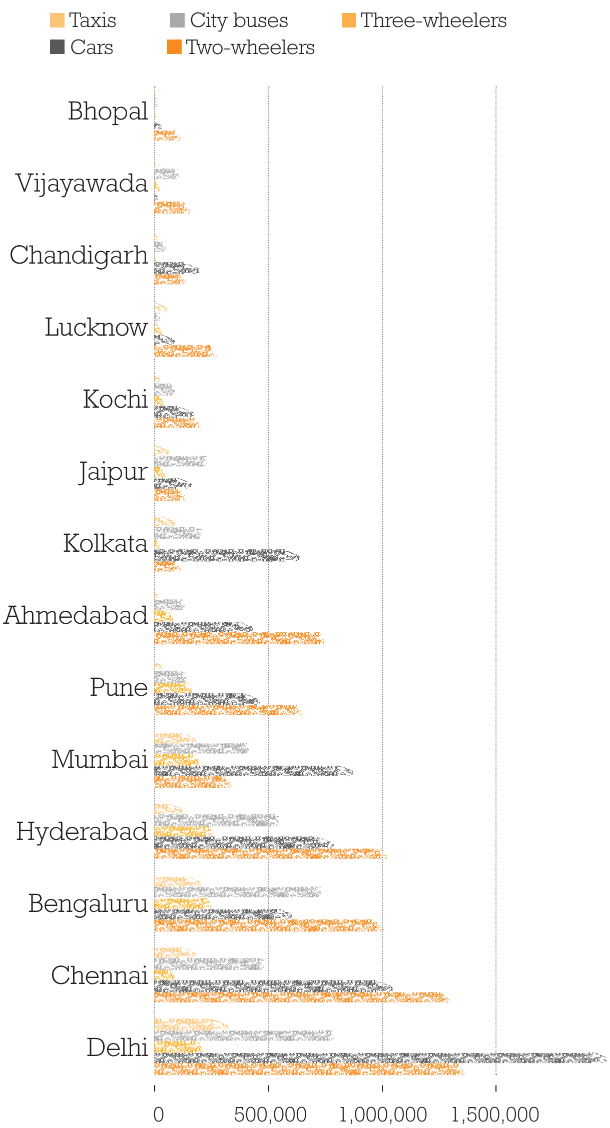
Carbon dioxide (CO_2) is the primary heat-trapping greenhouse gas linked to climate change, having far reaching consequences in terms of extreme weather events, adverse health impacts and environmental damage

Graph 29: CO_2 emission load from urban commuting in the 14 cities (in tonnes per day)



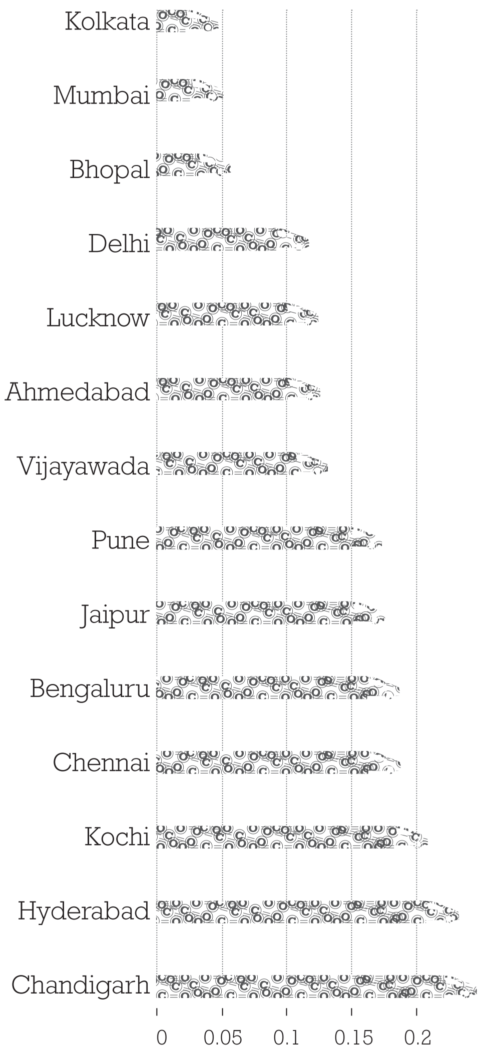
Source: CSE analysis

Graph 30: CO_2 emission load from different modes of transport in the 14 cities (kg per day)



Source: CSE analysis

Graph 31: Per trip CO_2 emission load in the cities under study (kg per day)

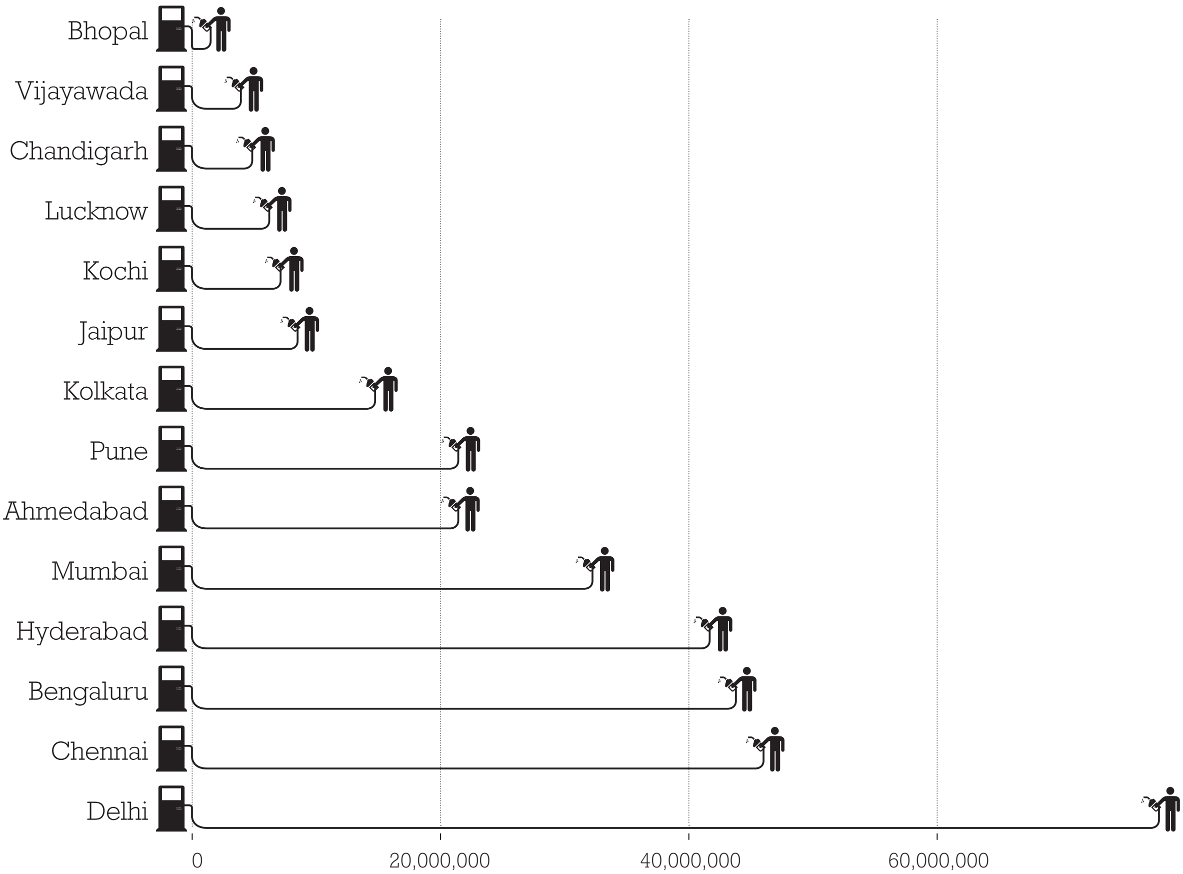


Carbon in the fuel that we burn while commuting gets emitted as heat trapping CO_2. Vehicles in megacities of Delhi, Chennai, Bengaluru and Hyderabad (in that order) emit the most CO_2. The worrying factor is that emissions in Pune and Ahmedabad are higher than even Kolkata and Mumbai, which perform best among the big cities—testament to better public transport in these two megacities

ENERGY GUZZLING FOR URBAN COMMUTING IN THE 14 CITIES

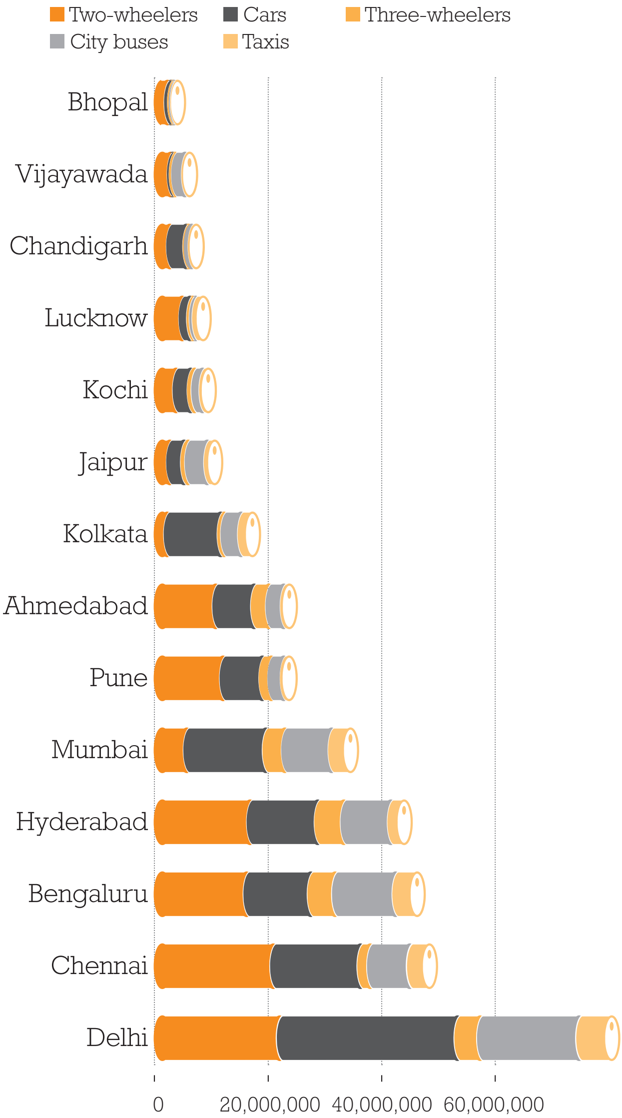
ENERGY CONSUMPTION
The consumption by transport sector in cities has a two-fold impact. On the one hand, it usually means consumption of precious fossil fuels and on the other hand, more consumption usually means more pollution load on the air sheds within cities

Graph 32: Energy consumption for urban commuting in the 14 cities (in MJoules per day)



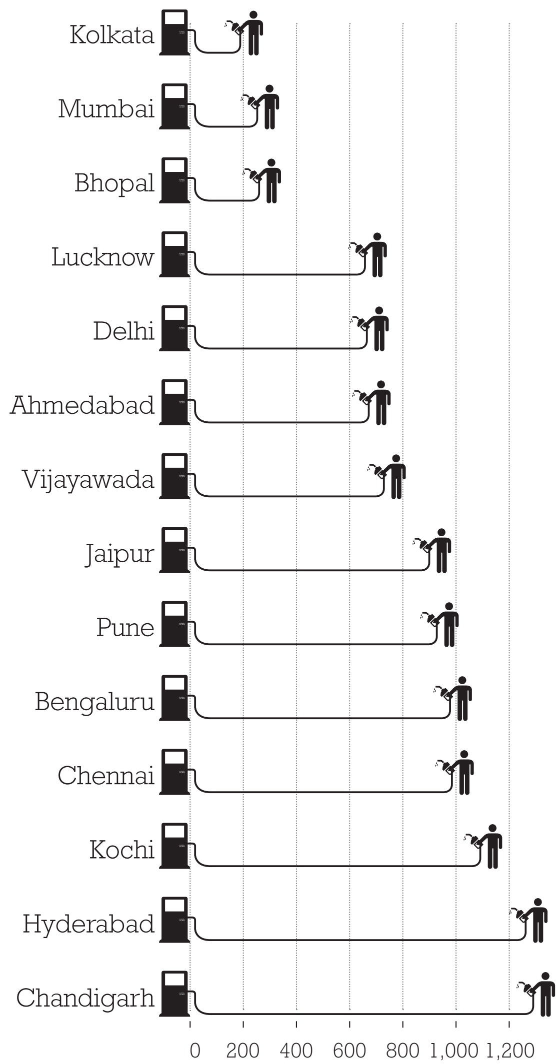
Source: CSE analysis

Graph 33: Mode-wise distribution of energy consumption in the 14 cities (in MJoules per day)



Source: CSE analysis

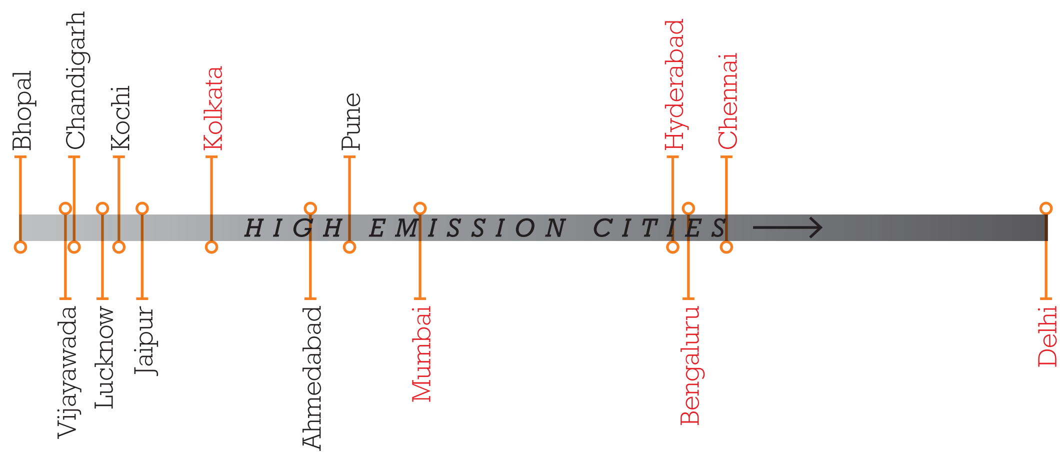
Graph 34: Per trip energy consumption in the cities under study (in MJoules per year)



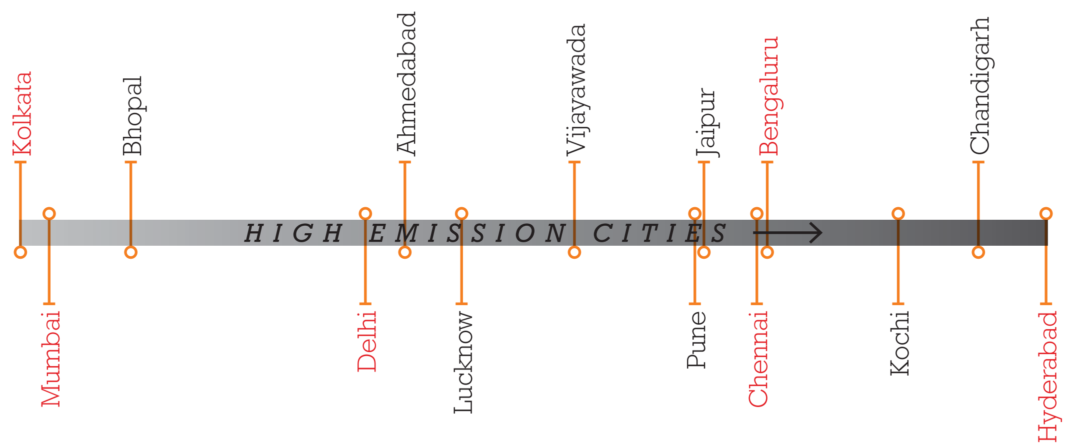
Car and two-wheeler users are guzzling maximum fuel in any given city. Public transport buses, and para-transit, including taxis and three-wheelers use comparatively less fuel per capita than personal modes. With growing automobile dependence energy consumption will continue to increase for urban commuting threatening energy security of the cities and the country as whole

COMPREHENSIVE RANKING OF THE CITIES (ALL MODES)

Graph 35: Based on overall emissions and energy consumption



Graph 36: Based on per travel trip emissions and energy consumption



Source: CSE analysis

EAR TO THE GROUND

The numbers speak for what is right and what may have gone wrong in these cities. It is now clear that the difference in the baseline of emissions and energy consumption for urban commuting in cities is a reflection of the difference in the level of motorization, volume, modes and distance of travel, and quality of vehicular technology and fuel used in travelling. But these differences are not a matter of chance. These results have been shaped by policy action and legacy of advantages or disadvantages from actions in the past. We are seeing a cumulative effect today. But each of these cities has a story to tell and a lesson to share. Putting ears to the ground to learn and drawing lessons to frame future roadmaps is essential.

The two sets of rankings—one based on total emissions and fuel consumption and the other based on per trip emissions, give us different insights into what is going on in our cities.

INSIGHTS FROM RANKINGS BASED ON TOTAL EMISSIONS AND FUEL GUZZLING

Bhopal is at the top

Among the 14 cities, emissions and fuel guzzling from urban commuting is lowest in Bhopal. The overall ranking of the 14 cities based on total emissions load from urban commuting shows that the top cities with lowest emissions across all categories are Bhopal, Chandigarh and Vijayawada. These three cities are the lowest populated of the 14 cities, which accounts for their low overall travel demand, and lower volume of travel and emissions. Adding to this are certain characteristics of each city that have helped them score high to be in the top positions.

Kolkata outperforms all megacities

Kolkata provides the resounding message that despite population growth and rising travel demand, it is possible to contain motorization with a well established public transport culture, compact city design, high street density and restricted availability of land for roads and parking. This is exactly the model that Japanese cities and Hong Kong are following. Therefore, it is not an acceptable argument, made in the other megacities, that with growth in motorization and automobile dependence untamed motorization is inevitable and infrastructure needs to respond to that.

Policy action and legacy of advantages or disadvantages from actions in the past are responsible for the present situation in the cities. We are seeing a cumulative effect today. But each of these cities has a story to tell and a lesson to share. Putting ears to the ground to learn and draw lessons to frame future roadmaps is essential

Mumbai, with the highest per capita GDP, has a lower rate of motorization compared to other megacities, proving that income levels are not the only reason for deciding automobile dependence. Other policy decision on scaling up of sustainable modes and urban forms play a very important role

Despite having similar population profiles, Mumbai and Kolkata rank much better than Delhi

Among the six megacities, Mumbai has fared second best after Kolkata whereas Delhi has performed the worst. If anyone tries to argue that lower level of motorization in Kolkata is also the result of comparatively lower level of per capita GDP, then it may be noted that Mumbai, with the highest per capita GDP among the six megacities has a lower rate of motorization than other key megacities. Therefore, income levels are not the only reason for deciding automobile dependence. Other policy decision on scaling up of sustainable modes and urban forms play a very important role.

Metropolitan cities rank better than megacities

When it comes to total emissions and fuel consumption, nearly all the megacities plummet to the bottom of the rankings as worst polluters and guzzlers. The sheer volume of travel and motorization is much higher in these cities than the next rung of metropolitan cities, and weighs them down. Comparatively, smaller metros are at the top as best performers.

Bhopal has a very high modal share of non-motorized transport—as much as 47 per cent—and a well-established city bus system that accounts for 23 per cent of the modal share of public transport. Across all modes, it also has the lowest average trip length among the cities, thus bringing down the overall degree of motorized travel that occurs in the city.

Chandigarh, on the other hand, though more dependent on personal vehicles, is still ranked better in total emissions load from urban commuting because it is small in size and has short average trip lengths across all modes.

Lucknow, despite having a higher population and lower modal share for public transport than Jaipur and Kochi, fares marginally better than them; this is largely because of a very high modal share of non-motorized transport compared to Jaipur and Kochi. Moreover, Lucknow has lower average trip length compared to the other two cities, in particular Kochi, where trip lengths are typically higher due to its status as a twin city (Kochi–Ernakulam). Lucknow has also made a transition to CNG, which reduces its particulate matter emissions substantially and has kept the overall emissions load from urban commuting comparatively lower.

Delhi leads other megacities in plunge to the bottom

Toxic emissions of particulate matter and nitrogen oxides as well as energy guzzling and heat trapping CO_2 emissions are highest from urban commuting in Delhi. Mumbai fares much better, even though the two cities have comparable populations. This difference is clear in Mumbai's heavy reliance on public transport, a major part of which is the less polluting suburban rail system. Delhi, on the other hand, has seen a boom in private vehicular ownership and usage. There has been systemic neglect of its city bus system, and no cohesive attempt to develop integrated systems with the metro rail. As a result, the positive effects of the metro and the CNG programme are lost. Between, Chennai, Hyderabad and Bengaluru, Chennai is marginally worse off due to its higher per capita trip rate and higher trip length.

INSIGHTS FROM THE RANKINGS BASED ON PER TRIP EMISSIONS AND FUEL GUZZLING

Transport emissions occur during travel trips and the quantum of emissions is influenced by demand for travel. Each trip, if it is by a motorized mode, causes both toxic and carbon emissions while consuming energy. Therefore, looking at per trip emissions gives us a better idea about how sustainably people travel in a city, and how much they affect their ambient as well as the larger environment every time they take a trip.

This is important as one can find that certain small cities may have overall lower emissions, but a very unsustainable pattern of travel underwritten by high emissions per trip. For example, a trip of 10 km taken by a person adds 0.01 g of PM if the ride is on a bus, but 0.08 g (eight times) if it is in a car, 0.1 g (10 times) if it is on a two-wheeler and 0.46 g (46 times) if it is in an auto-rickshaw. This has serious implications because as cities grow, their unsustainable travel patterns, if not corrected in time, can turn them into big toxic chambers and climate rogues.

The ranking based on per trip emissions and fuel consumption show Kolkata and Mumbai are the best. But Chandigarh and Hyderabad are the worst. This essentially conveys the significance of looking at per trip emissions. Kolkata and Mumbai, which are in the middle of the spectrum in terms of total emissions, and the best among the megacities, are the best in terms of per trip emissions among all 14 cities. This indicates that their travel patterns, underwritten by a high modal share of public transport and non-motorized transport with low trip lengths, is helping mitigate their overall emission levels that is caused by their huge overall population.

On the other hand, a city like Chandigarh, which is a top performing city in terms of low total emissions because of comparatively lower total volume of travel and vehicles, is one of the worst performing in terms of trip emissions. Indeed, Bhopal seems to be on a good track, being at the good end of the spectrum both in terms of overall emissions as well as per trip emissions.

Attention also needs to be paid to travel patterns of smaller cities. As they grow, their unsustainable travel patterns, if not corrected in time, can turn them into big toxic chambers and climate rogues

Essentially, every time a trip is made in Chandigarh, where per capita car ownership is the highest, it is likely to have a much worse impact on the environment than in the megacities of Kolkata and Mumbai, which have the best public transport systems and modal shares in the country. This is worrisome, as Chandigarh is already a tri-city with Chandigarh–Panchkula–Mohali, forming a large urban agglomeration where the travel patterns are likely to be similar to Chandigarh. In such a scenario, the tri-city area may become an extremely polluted place in the years to come if corrective steps are not taken in time. On the other hand, while cities like Kolkata and Mumbai can take respite in the fact that any further population growth is not likely to affect their overall emissions levels significantly in the near future; this may change if steps are not taken to ensure this advantage is not lost in the future.

Hyderabad, on the other hand, presents a concerning picture in terms of being in the higher end of the spectrum of total emissions, while also being the worst city in terms of per trip emissions. What this means is that given the growth trajectory and economic position of the city, it could become a highly polluted city in time. While the city has had a good bus system traditionally, it hasn't kept pace with the city's growth pattern in terms of fleet size and, therefore, the volumes of passengers it carries. The metro system, which has become operational recently and will expand in the near future, will help mitigate this situation, but only marginally. If the bus system does not correspond to the growing travel demand, the demand will invariably move to two-wheelers, which are contributing the highest portion of emissions in most cities, including Hyderabad.

In the middle of the spectrum are a host of metropolitan cities bounded by the megacities of Delhi, Bengaluru and Chennai at either end. While Delhi is in the better part of the spectrum, indicating the effectiveness of its initiatives such as CNG programme and metro rail development over the years, cities like Chennai and Bengaluru are in worse shape. Given their growth trajectory, the pollution levels from urban commuting may become worse in the times to come if corrective and preventive measures are not taken, as travel demand will keep increasing. Given their high per trip emission rate, their transport related emissions will also increase significantly. Cities such as Ahmedabad, Lucknow, Vijayawada, Pune and Jaipur are at an inflection point. Their per trip emissions are in the middle of the spectrum, and depending on what direction their mobility policies take over the next years and decades, their pollution levels may increase or decrease drastically. They have the time to take corrective measures now and avoid the fate of the megacities, as growth and rise in travel demand will be inevitable for all these cities with time.

WINNING BASELINE OF KOLKATA AND MUMBAI

Advantage of a public transport spine

Both Kolkata and Mumbai have grown with a unique advantage of a public transport spine well integrated with the existing land use patterns. This has ensured high usage of sustainable modes and comparatively lower dependence on personal vehicles. In Mumbai the share of public transport trips in overall motorized trips is as high as 78 per cent and in Kolkata it is 77 per cent. Cities around the world facing the challenge of improving sustainable modes of transport to combat pollution and heat-trapping green house gas emissions can take inspiration from the example of these two cities.

Kolkata has a very diverse public transport system that includes metro, bus, tram, suburban rail, taxi and auto services, and a well-utilized water transport system. Such a diverse system can cater to a wide variety of income classes and users, and affords many levels of fares.

On the other hand, Mumbai's public transport spine in the form of a suburban rail system is capable of moving more than eight million persons per day. This is the highest among all rail-based systems in cities under study. The suburban rail itself meets 52 per cent of the travel demand in the city. The public transport system of Mumbai, including the suburban rail system, buses and metro, is so efficient that only 13 per cent of the travel demand is required to be met by personal vehicles.

There is very little policy recognition of the strength of this baseline that represents global best practices. This strength can be easily undermined if the quality of public transport and its accessibility are allowed to deteriorate. It is a fact that despite crushed capacity and often poor quality of transport, ridership has remained high because a lion's share of it is captive ridership. A majority of the population cannot yet afford to shift to personal modes of transport. The challenge in these cities (and others as well) is to reform and modernize public transport to make it attractive for all, including the rich. Policy measures will have to be crafted to ensure that there is no erosion of public transport ridership.

ANNANYA DAS/CSE

Kolkata has a unique combination of a compact city design and a most diverse public transport system

Action begins

Steps are being taken to reform public transport in these cities. Kolkata is aiming for a bus fleet renewal and improved utilization by West Bengal State Transport Corporation. State-run bus corporations are being reformed. Three public bus corporations (Calcutta State Transport Corporation, Calcutta Tramways Company and West Bengal Surface Transport Corporation) have been merged to form the West Bengal Transport Corporation in 2016 with the objective of streamlining all services and unifying operations. Electronic ticket vending machine- (ETVM) based fare collection system was introduced in buses in 2012. Smartcard-based ticketing system has also been introduced in city buses. The Pathadisha app has been launched to let passengers track buses and know their timings. A grievance redressal system was put in place for bus users through a Whatsapp number in 2017. While the city has been served for decades by a north–south line, an east–west metro line is under construction with operations planned to begin by 2019.

Kolkata has also taken the lead in linking public transport with electric mobility. Already, the tram and metro are moving large number of trips together without any tailpipe emissions. To this will be added 40 new electric buses. This is a win–win strategy for low pollution and carbon neutral mobility. Restricted night-time parking in small lanes and limited parking infrastructure has also helped to restrain vehicle ownership.

In Mumbai, several positive steps have been taken over the last few years. In bus services, the notable step forward is that the city has started to run 25 air-conditioned electric hybrid buses. It is also in the process of adding 60 more buses with a 60 per cent cost subsidy. Bus ridership, however, is poor—without getting priority, buses have become low-speed vehicles on congested streets, affecting frequency and lowering ridership per bus per day. A route rationalization process for city bus services is being undertaken to stop the losses. The fleet is also proposed to be expanded from 3,500 buses to 3,758, including 200 AC buses. Brihanmumbai Electric Supply and Transport, the city bus operator, is also looking at fare reforms. Forty more buses are proposed to be purchased under the Faster Adoption and Manufacturing of Hybrid and Electric Vehicles scheme. Out of a total planned network of 174 km, 11.4 km of metro rail became operational in 2014. The city has seen largely unsuccessful attempts at bike-sharing schemes, such as the "cycle chalao" scheme launched in 2011 to encourage more people to use bicycles for commuting.

Even though the number of person trips is said to be quite stagnant in the last 10 years, a substantial shift from buses to private transport has worsened traffic congestion. Without a clear policy focus, Mumbai stands to lose its baseline strength because, according to studies, public transport ridership is expected to reduce from 63 per cent to 52 per cent on the north–south corridor in Western Mumbai by 2022–23. This decline will happen despite the augmentation of the public transport systems. For instance, the capacity of the Western Railway and metro rail is expected to increase by 63 per cent on the north–south corridor in Western Mumbai by 2022. There is, however, very high usage of para-transit.

If all motorized and non-motorized trips are combined, walk trips in Mumbai constitute 52 per cent of the total trips. This is logical, as with high share of public transport ridership, pedestrian movement is expected to be high. All public transport trips end and begin as walk trips. Besides investing in sky walks that are sub-optimally used and are also not appropriate for safe and convenient access, very little has happened to revamp pedestrian infrastructure in the city.

GETTYIMAGES

Mumbai's public transport spine in the form of a suburban rail system is capable of moving more than eight million persons per day

Kolkata is known for its public transport culture but its public transport systems are under enormous pressure and require radical improvement in service quality. Its zero emissions tram network, instead of being modernized, has been curtailed significantly.

Kolkata and Mumbai will have to leverage their advantage and need to set quantifiable and verifiable targets of effective modal shift within a stipulated timeline and build public transport options at a much bigger scale to meet commuting challenges and reduce pollution and energy consumption in the urban mobility sector.

Advantage of compact urban form of Kolkata

The biggest advantage of Kolkata is its unique combination of compact city design with very high street density and availability of most diverse modes of public transport systems and restricted availability of parking spaces compared to the other cities. This makes the city very accessible, reduces dependence on personal modes of transport, and encourages more walking. The compactness of the city has allowed at least 60 per cent of its travel to be below 3–4 km. When served with a vast network of streets and lanes, this facilitates walking and easy access to public transport.

This strength if not protected can be undermined. With Kolkata Metropolitan Area expanding significantly in the eastern direction with the development of the New Town, private vehicular dependence may increase in time as the population decides to settle in these suburban locations. If this expansion is not integrated with a robust public transport network and strategy with last mile connectivity, the current advantage of the city will be lost.

ACTION IN MEGACITIES—TOO LITTLE TOO LATE

Even though megacities have attracted maximum investment and attention over time, most of them have not been able to make urban commuting sustainable. These cities have the highest vehicle stock and automobile dependence. They are continuously losing their share of public transport and non-motorized transport. These cities have more organized formal public transport systems but given the trip volumes and average trip length a massive scaling up is needed to shift sizeable number of trips to sustainable modes.

DELHI—SCALE OF MOBILITY ACTION LIMITED AND INADEQUATE

Among the 14 cities, Delhi ranks the worst in emissions and fuel guzzling from urban commuting. Even though the share of public transport trips in the overall motorized trips is a little over half—54 per cent—the 22 per cent modal share of cars and two-wheelers is still staggering as trip volumes are huge. Although Delhi has scaled up metro transport considerably—a total of 288 km of operational metro system, it has not been supported by scaling up of any other public transport system, including buses. Bus numbers have dwindled to less than 5,500 buses, their ridership is also declining rapidly over time. Several routes have been curtailed; as a result a large part of the city is public transport-deficit. All bus

VIKAS CHOUDHARY/CSE

Among the 14 cities, Delhi ranks the worst in emissions and fuel guzzling from urban commuting

plans are in the anvil without any improvement on the ground. If more buses are not added right away, Delhi will not have any buses left by 2022.

Delhi has, instead, invested heavily in road building and widening—using up 23 per cent of the geographical area and committing another 10 per cent equivalent of urbanized land to parking of vehicles. With one-third of Delhi devoted to facilitating vehicles, Delhi has locked in enormous carbon, fuel guzzling and pollution in its transport infrastructure. Undoing this will require aggressive scaling up of infrastructure for sustainable modes and restraints on personal vehicle usage.

Several state government proposals to do so are on the anvil but without any clarity about timelines for implementation. There is a proposal for expanding the bus fleet by 2,000 CNG buses and adding another 1,000 fully electric buses. The transport department is expected to support the induction of 905 electric feeder vehicles by Delhi Metro Rail Corporation (DMRC). The Common Mobility Card scheme has been implemented by issuing cards that can be used in both the metro system as well as the bus system. DMRC has registered a subsidiary company called Last Mile Services Limited, under which it plans to organize all forms of last mile connectivity to and from metro stations, starting with 427 AC mini-buses. But these are all plans. No new sizeable non-motorized infrastructure has been created after the Commonwealth Games of 2008 in Delhi.

Even the Delhi Decongestion Plan of the Central government has remained a non-starter. There is a silver lining now as a Supreme Court directed time-bound Comprehensive Action Plan has been notified under the Environment Protection Act that provides for massive scaling up of public transport infrastructure, and integration of and improvement in public transport services along with improvement in walking and cycling infrastructure. This also requires restraint policies on parking and taxation, among other measures.

BENGALURU—BUS OR BUST

Even though Bengaluru is known for some progressive reforms in the bus sector, its share of public transport ridership in overall motorized trips is 42 per cent—much less than that of several other megacities like Kolkata, Mumbai and Delhi.

Several measures have been taken in Bengaluru. In the bus sector, Bangalore Metropolitan Transport Corporation (BMTC) has adopted innovative financing in which land assets are leveraged to generate revenue and cushion costs. It has also adopted vehicle tracking and monitoring of bus services, segmented bus services according to income groups, and improved application of ITS. BMTC has even recorded increase in bus ridership. To increase uptake of airport-destined buses, automated check-in kiosks have been introduced in the Vayu Vajra buses, through which one can check-in and print boarding passes while on board. 150 hi-tech UBS-2 compliant buses are being inducted by BMTC. These buses will feature mobile and laptop charging points at every row of seats, an emergency switch for passengers near the middle door, a panic button near the driver's seat, provisions for wheelchairs to enter and exit from middle door, two cameras to ensure safety and an intelligent transport system to provide information about the bus, route and place to the passengers. BMTC has introduced feeder service in the east–west corridor of Namma Metro with 23 Volvo and 16 ordinary buses. Fare has been rationalized to attract more commuters with fare reduced for the stage upto 4 km and increased for the stage up to 6 km. BMTC is also installing on-board

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The city government, along with Bangalore City Connect Foundation, has initiated implementation of street design to improve walkability

entertainment systems along with free Wi-Fi in 200 buses. The Corporation is in the process of inducting 40 electric buses as well.

Directorate of Urban Land Transport (DULT) had invited private bicycle operators for the operation of public bicycle sharing in the city. It has identified 345 docking stations in two zones of the Central Business District and has recommended that 6,000 bicycles be introduced under the first phase, covering 28 sq km. The city government, along with Bangalore City Connect Foundation, has initiated implementation of street design to improve walkability in some parts of the city. DULT has also promoted cycling initiatives. The city has carried out parking pricing reforms to some extent and implemented parking information systems.

The scale and scope of this action is still very small and partial and is not designed to effect major modal shift to sustainable modes in the next five years. The parallel development in the city is at war with the goals of sustainability. Road design and usage are changing rapidly in terms of road widening, grade separators, signal free and one-way corridors etc. to promote more vehicle usage. The scale of change needed for integrated public transport systems, quality of walking access, organized para-transit and parking and taxation restraints on personal vehicle usage has not been planned for.

CHENNAI—WALKING THE TALK


AVIKAL SOMVANSHI/CSE

Chennai has redesigned over 50 km of "complete streets", which include a walking and cycling network

At 47 per cent, the share of public transport trips in the overall motorized trips in Chennai is a little better than Bengaluru, but it is still less than half. Chennai has started to take action and is moving forward. It was the first city in India to adopt a Non-motorized Transport (NMT) Policy in 2004 that aims to arrest the decline of walking and cycling by creating a safe and pleasant network of footpaths, bicycle tracks and greenways. The policy targets to achieve 40 per cent modal share for pedestrians and cyclist by 2018. The policy mandates that a minimum of 60 per cent of the Greater Chennai Corporation's transport budget is allocated to construct and maintain walking and cycling infrastructure. The Policy has inspired cities from Chandigarh to Nairobi to adopt a similar policy. The adoption of the Policy, along with other initiatives such as the Car Free Sunday, that demonstrates the Corporation's commitment to creating safe streets for all users, was recognized with the 2015 Sustainia Award, presented by the Danish think tank, Sustainia.

Since the adoption of the policy, the city has implemented over 50 km of "complete streets"—with wide, continuous footpaths, safe pedestrian crossings, designated on-street parking, organized vending, and properly-scaled carriageway. Since 2017, the city has planned and redesigned double the street length (100 km) to create a city-wide walking and cycling network. With a strong focus on moving people rather than vehicles, the city has also proposed a Dockless Public Bicycle Sharing System of 5,000 cycles, and a Parking Management system for 12,000 parking spaces on all major roads.

Chennai is known for an efficient of bus service that carries high passenger volumes. The city has undertaken renewal of the bus fleet. It has taken up 71 bus route roads to rebuild walking infrastructure. It has even resized motorized roads to reduce the carriageway width to maintain the desired width of footpaths. Chennai has also attempted to reform its para-transit. This includes GPS installation linked to metering in autorickshaws, converting them to LPG-run, installing panic buttons etc.

HYDERABAD—STRUGGLING TO REDUCE PRIVATE TRANSPORT

The share of public transport trips in the overall motorized trips in Hyderabad is lowest among all the six megacities—only 40 per cent. Denizens of this city are among the five worst emitters and guzzlers from urban commuting. The city is growing and sprawling rapidly without commensurate expansion in sustainable modes of transport that can effectively lead to massive shift of trips from personal vehicles to public transport and walking.

However, several steps are being taken to make public transport attractive. Greater Hyderabad Municipal Corporation is planning to build 826 bus shelters across the city with modern facilities like free Wi-Fi, public toilets, anytime water kiosks, FM radio, comfortable seating, electronic streaming of bus timings and routes. GPS-based vehicle tracking equipment is being installed in all city buses. Other technology-enabled fare collection systems are also being introduced in the city bus system. Forty electric buses will be inducted and operated in the city, replacing the existing Pushpak buses that cater to airport passengers from the IT district of the city. "Only women" shuttle buses for the IT corridor have been introduced in Hyderabad. A metro system, of which 30 km is operational, is under construction for a total of 72 km, creating a high-density commuter service corridor served by 63 metro stations. The Hyderabad Bicycling Club (HBC), Hyderabad Metro Rail (HMR) and UNHABITAT have made a tripartite Memorandum of Understanding (MOU) to provide last-mile connectivity for metro rail passengers. But given the magnitude of emissions and guzzling from urban commuting, massive scaling up of intervention is needed.

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GHMC is planning to build 826 bus shelters across the city with modern facilities like free Wi-Fi, public toilets, anytime water kiosks and FM radio

DIRECTION OF CHANGE IN METROPOLITAN CITIES

The next rung of metropolitan cities with comparatively lower population and vehicle stock has their own another set of challenges. If not addressed at the early stages of growth, they can compound the pollution crisis and worsen energy security.

Lower share of public transport trips—non-motorized travel at risk of being eroded

The worrying trend among these rapidly growing metropolitan cities is the very low share of public transport trips in the motorized trips. The worst reported share is a mere 4 per cent in Lucknow, followed by 16 per cent in Chandigarh, and 17 per cent in Pune. Relatively higher share is evident in Vijayawada with 30 per cent, Ahmedabad with 33 per cent, and Jaipur with 31 per cent. These are worse off than even the megacities as they do not have adequate formal public transport systems. Only Bhopal and Kochi have a better share—44 per cent and 49 per cent respectively.

Traditionally, these cities have been dependent on local para-transit (autorickshaws, shuttle services and cycle rickshaws) and walking and cycling. While these systems have deteriorated in quality and urban infrastructure is changing rapidly, motorized travel is increasing. In the absence of a well-organized and locally appropriate and attractive public transport system, there is a massive shift from non-motorized transport to personal transport including cars and two-wheelers. If interventions are not made right away, vehicle density and ownership in the cities can surpass mega cities and undo benefits of action.

Experiences and ground realities vary across cities.

BHOPAL—BICYCLES AND BUSES

Among the 14 cities, Bhopal emits the lowest and guzzles the least fuel during urban commuting. One of the biggest advantages of Bhopal is the very high share of walking and cycling—as much as 47 per cent of all trips. Bhopal has also invested in improving public transport system and operates 225 buses under a public–private partnership system across 12 routes which carries around 1.25 lakh passengers per day. The city has opened a 24 km long BRT corridor in 2013. Under the Smart City programme of the Government of India, Bhopal has initiated a public bicycle-sharing programme. The city initiated a large-

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Bhopal operates 225 buses under a public–private partnership system across 12 routes which carry around 1.25 lakh passengers per day

scale bike-sharing scheme in 2017 with 500 high-end bicycles and 50 stations across the city. The system has had mixed response over time. It has 12 km of dedicated bicycle tracks and bicycles are placed in 50 locations in the city for hiring based on easy payment schemes. These are good signs and can be leveraged for the city to remain low emitting and guzzling even as it grows.

VIJAYAWADA—GOOD BEGINNINGS WILL HAVE GOOD RESULTS

Vijayawada, the new capital city of Andhra Pradesh, is still in its early stages of growth. If it gets its blueprint right, it can avert pollution and guzzling from urban commuting in the future. Action has just about started. There is a proposal for circular train connectivity between Vijayawada, Guntur, Tenali and Mangalagiri (the VGTM metropolitan cities) which form an urban agglomeration and constitute heavy travel demand. The city has been a pioneer in the region in running buses on CNG. This strategy for combining clean fuel with public transport is advantageous. The Vijayawada BRTS has started operation on one 15 km long route in 2012. Along with 27,296 autorickshaws, 49 "she autos" ply in the city—this was a gender safety and women empowerment initiative launched by the Government of Andhra Pradesh in 2015. A 3 km elevated air-conditioned walkway connecting the Kanakadurga temple with bus stands and railway stations has been proposed. At this stage, a quarter of the city's daily trips are walking and cycling trips. This needs to be strengthened.


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Vijayawada has been a pioneer in the region in running buses on CNG

CHANDIGARH—TOO MANY CARS

Chandigarh ranks third on total emissions and guzzling due to low volumes of travel and lower distances covered, as well as comparatively lower vehicle stock. But it is at near bottom in the ranking for per trip emissions. This brings out very high usage and dependence on personal vehicles for all trips. Even the ownership of cars per 1,000 people is among the highest in the country. Cities like this will have to be extremely careful about enabling massive scaling up of sustainable modes.

Several measures have been initiated and proposed. The city has adopted an intelligent transport system to promote public transportation in 2017, that includes installation of GPS devices in buses, which would help track each of the vehicles in operation across the city. A 24 x 7 Central Control Station (CCS) would be monitoring the movement of buses and provide real-time information on bus arrival and departure times to commuters on their mobile phones and through the internet. The city finalized and adopted a transport policy which encourages mass rapid transit system (MRTS), stage carriage operation in the Union Territory and on inter-state routes, pricing of the public transport services and replacement of old autorickshaws etc. To make Chandigarh friendly for cyclists, the Union Territory's engineering department has been paying special attention to the development of specific tracks. The department has developed 56 km of bicycle tracks with a target of 90 km. Sector 17, the CBD of the city, is a fully pedestrianized area.


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In Chandigarh the ownership of cars per 1,000 people is among the highest in the country

Chandigarh administration has reversed some of its decisions and reduced the speed limit to align with other cities, allocated space for eco-cabs, and introduced traffic calming measures to reduce accidents. This is important in a city that has otherwise been following a pro-car approach.

KOCHI—INTEGRATING METRO WITH WATER TRANSPORT

Kochi, a rapidly growing city, has its own imperatives. It's a twin city, which increases average travel distances. Its public transport share is close to half—49 per cent. But evidence shows its overall non-motorized transport is quite low at 15 per cent. In recent years, Kochi has focused on developing its public transport spine. The city has a metro system with 18 km operational routes out of a total 54 km planned to be developed. The Kochi metro is one of the few metro projects in the world to be integrated with a water transport system. The metro system is being used to revitalize the city. Kochi is reviving its ferry service as part of a multi-modal integration strategy. The city is operating eight electric buses on a trial basis. Every month, one day is assigned the Kochi Public Transport Day, as part of a people-driven campaign to spread awareness on the available modes of public transport and deploy them wisely for the benefit of all. The day has a different theme assigned for each month. The city has prepared a non-motorized transport Master Plan (including public bicycle sharing scheme).


AVIKAL SOMVANSHI/CSE

Kochi metro is one of the few metro projects in the world to be integrated with a water transport system

JAIPUR—METRO RAIL, BUT WITHOUT INTEGRATED SERVICES?

In Jaipur, the public transport share is 33 per cent and that of non-motorized transport is 31 per cent. Two-thirds of all trips are still sustainable. But given the current growth in a city whose population is expected to triple by 2031, if current efforts at deploying sustainable systems are not scaled up and integrated, it can lead to serious emissions problem.

Jaipur has implemented a metro rail system but without a strategy to increase its ridership. It is also not supported by scaling up of bus transport with reliable and integrated services. Some stretches of roads have been redone to improve walkability. Considerable work has happened in Jaipur on improving walking access to Jauhari Bazaar etc. Under the Smart City project, Jaipur is planning to introduce Smart Passenger Information System for the city bus system. Modern bus depots, integration of intelligent transport systems, and management information systems are being introduced under the World Bank Global Environment Facility (GEF) Programme for efficient and sustainable city bus services. Two public bike sharing systems are being introduced under the Smart City Scheme to promote non-motorized transport. One scheme will include 20 cycle stands placed in different locations to motivate people to use bicycles. The second project is a dock-less concept being implemented with Zoom car in the walled city where 300 bicycles would be available in 30 locations. Forty electric buses are proposed to be introduced in the city.

Considerable work has happened in Jaipur on improving walking access to Jauhari Bazaar

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LUCKNOW—INCREASING THE "TEMPO"

Lucknow is fourth in the rankings on total emissions and energy guzzling. This has unique advantages and disadvantages. At one level, the city's public transport modal share is very low, a mere 4 per cent, but its share of non-motorized transport is as high as 47 per cent. Also, a large part of its public transport bus ridership and para-transit are running on CNG, which has provided it immense emissions benefits. This has helped to improve the overall rank of this city among metropolitan cities.

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Lucknow has organized a shared-tempo system consisting of 2,575 tempos that operate on about 37 routes

Lucknow has taken steps to restore footpaths for vibrant public spaces. It has rejuvenated some of its public spaces. A notable effort is the conservation and redevelopment of the historic marketplace of Hazratganj. It has organized a shared-tempo system consisting of 2,575 tempos that operate on about 37 routes. The transport department has created a system in which permits are issued according to routes. It operates like a bus service with fixed routes and fixed stations. It also operates flexibly. Lucknow metro was launched in 2017 with 8.5 km currently operational. 35 km of dedicated bicycle track was constructed in 2015, which is being demolished now as it is deemed not proper in terms of design and functionality.

PUNE—AT THE CROSSROADS, ACT NOW

Pune started with the disadvantage of low public transport ridership at 17 per cent. Its share of non-motorized transport is, however, 33 per cent and has not been nurtured well. With burgeoning volume of travel this has increased emissions and energy guzzling and has brought the city to a mid-level in the rankings.

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Burgeoning volume of travel has increased emissions and energy guzzling and brought this city to a mid-level in the rankings

Several steps are being taken now, but only if they gather momentum and achieve scale can they make a difference. A total of around 30 km of BRT system is currently operational in the city, out of a total of 112 km planned. The system, however, remains far from an ideal BRT system. The city is served by a city bus system run by PMPML formed in 2007 that operates 2,045 buses across 371 routes carrying around

17,074 persons per day. Around 1,200 bicycles were deployed under a bike-sharing scheme in 2017. The city has formulated street design guidelines under the label of "complete streets" and has embarked upon implementation of converting 100 km of arterial roads into "complete streets' with adequate space for pedestrians and cyclists.

AHMEDABAD— SCALE UP ACTION TO STOP SLIDE

Ahmedabad is ranked lowest among the metropolitan cities but better than megacities. Ahmedabad is a unique example that has reported improvement in modal share for public transport over the last decade. Currently, the share is reported to be 33 per cent. The share of non-motorized transport is also 46 per cent. But overall growth in travel and motorization is driving the emissions and energy consumption up.

Ahmedabad has experienced substantial improvement in its bus system. With expansion of conventional bus system and bus rapid transit system it had succeeded in improving the public transport modal share substantially. The city has created 97 km of BRTS. It has integrated the routes of AMTS (the city bus system) with the BRT system to make public transport more convenient and useful for the city. The city bus system has undertaken route rationalization and a Common Mobility Card was introduced in 2017 that can be used for other retail uses too. A total of 39 km of Metro is under development to connect Ahmedabad and Gandhinagar as well as all the existing public transport modes of the city. The city is expected to get 50 electric buses under the FAME scheme. Bicycle tracks were introduced alongside the BRT system.

AVIKAL SOMVANSHI/CSE

Ahmedabad is a unique example that has reported improvement in modal share for public transport over the last decade

THE WAY FORWARD

Cities have locked themselves in a difficult race. While some have stayed ahead others have slipped. But both groups are facing the challenge of protecting the current level of usage of sustainable modes, reverse the slide and then surging ahead to decarbonize and minimize toxicity of urban commuting significantly.

While several urban transport policies at the Central and state level have taken on board sustainability principles, and many funding strategies have been designed by the Centre to support some of the mobility initiatives under different programmes, including the Smart City Programme, there is no clear handle on implementation of the strategies at a scale.

Need legal mandate: One of the main concerns is the weakness of the legal framework for mobility action at the Central government level. While Ministry of Urban Transport, Housing and Poverty Alleviation is in charge of framing policy they do not have the laws to back up implementation. This is also because, for the most part, urban transport and mobility are the state's or city's responsibility. Therefore, the funding arm of the Central government is the only lever to ensure change on ground. Funding strategies will have to be designed effectively and cohesively to ensure that all the requisite detail of urban transport transformation, including public transport systems, infrastructure for non-motorized transport, and vehicle restraint measures are co-joined for funding and for co-benefits.

The Central government, however, has the legal authority to set emissions and fuel economy standards to reduce pollution and energy impacts of motorization. These are administered under the Central Motor Vehicles Act of the Ministry of Road Transport and Highways and Energy Conservation Act of the Ministry of Power. Additionally, all air quality-related regulations are governed by the Air Act and the Environment Protection Act of the Ministry of Environment, Forest and Climate Change. This opens up opportunities for creating legally binding mandates for implementation. For instance, the comprehensive clean air action plan the National Capital Region of Delhi has been notified under the Environment Protection Act. This makes its provision on mobility and urban transportation along with its timeline legally binding. This can also be monitored.

State and city governments need time-bound action plans with clear implementation strategies for urban mobility. The advantage that a city government has is the provision of notifying master plans under a state statute, for instance the Delhi Development Act. This makes its provision legally binding. It is, therefore, important that Master Plans of cities are periodically revised to take on board sustainability principles, targets for modal share shifts, transportation strategies and the requisite urban planning strategies and designs.

Set time-bound targets for improving modal share of sustainable modes: Only legal backing is not adequate unless implementation is ensured. Even now, Delhi has set a Master Plan target of achieving 80 per cent public transport ridership by 2020, Pune 80 per cent, Kolkata 90 per cent and so on. But this has not propelled planning and investments to ensure attainment of these target. Thus, city-level plans need a comprehensive approach and monitoring mechanism to ensure all the elements of sustainable transportation are implemented without leakages.

Need sustainability indicators for evaluating emissions, carbon and modal shift impacts of transportation programmes: Bulk of transportation investments in cities is tied to road infrastructure that is designed to expand carriageway capacity for vehicular traffic and enable seamless movement of vehicles at speed. This priority impedes improvement in overall accessibility of the city for public transport users as well as local walking and cycling access that are zero emissions trips, leading to more captive usage of personal vehicles and locking in more carbon and pollution in urban travel and infrastructure that cannot be easily undone and reversed. Monitoring and evaluation of all urban transport interventions based on sustainability indicators will help to offset effects and plug leakages from vehicle-centric transport infrastructure plans.

Integrate urban planning with transportation planning to reduce distances and motorized trip generation: Cities need more deliberate and explicit policies to link urban design and planning of redevelopment as well as new development with compact city design for mixed land use and mixed income development to improve access for all and reduce distances. This should be integrated with the transit lines and transportation nodes to improve access to public transport. These areas need to be developed with improved walking and cycling access, low parking requirements and well planned density. Road design needs to be complete catering to the needs of all road users, including walkers, cyclists, vendors, while also providing for adequate vegetation.

Integrate urban mobility strategies with clean emissions and fuel-efficient vehicle technologies and clean fuels: For effective reduction in toxic and carbon emissions as well as energy impacts, combine aggressive mobility strategies with stringent emissions standards and fuel economy standards. India is leaping ahead to meet Bharat Stage VI emissions standards by 2020. It has also implemented a modicum of fuel economy standards for light-duty vehicles. All cities will benefit from these measures. But much more attention needs to be paid for in-use emissions management. This review has also shown that cities that have taken the extra step of moving to clean fuels like compressed natural gas have been able to improve their rank and offset the adverse impact of declining or very low modal share of public transport. For instance, among the megacities, Delhi has shown improved per trip emissions due to substantial fuel substitution by CNG. Similarly, among other metropolitan cities Lucknow, despite having very low public transport modal share, shows overall lesser total emissions due to the implementation of a CNG programme and also relatively higher share of non-motorized transport use. Thus, sustainable mobility roadmap and technology and fuel quality roadmap need to align.

Make economics of public transport work: A fiscal strategy is needed to mobilize resources and fund the mobility transition as well as to incentivize sustainable modes of transport through differentiated pricing and taxation. All public transport system and integration can become scalable if the total journey cost is affordable to all. Increasing modernization of public transport systems will increase cost of investment. But this cannot translate into increased fares and higher journey cost for people. Ensuring this will demand well planned cross-subsidy policies and fiscal instruments to mobilize resources. On the other hand, vehicle and transport-related taxation need to be reformed to reduce the tax burden on public transport buses, and to rationalize taxes on usage and ownership of personal vehicles. Mobility transition will require explicit demand management measures including better parking policies.

Table 1: Low carbon and low emissions urban commuting needs aggressive roadmap and action plan

Action agenda		Central government	State government
Target for scaling up sustainable modes of transport	Modal share target	Central funding for all types of transportation and mobility projects and road infrastructure projects to be tied to monitorable and verifiable modal shift in favour of public transport	Amend Master Plans to set time bound modal share targets to expand the scale of sustainable modes of transport
Public transport	City bus systems	Push for reforms and expansion of city bus services in cities using funding as leverage	Ensure regular support to transport corporations linked to their performance. Bring state owned and privately managed bus services within integrated framework for compliance and service guarantee
		Ensure technological upgradation of city bus systems through a one-time funding.	
	Metro systems	Use metro funding as a means to revitalize a city and its overall transport system	Ensure other modes of transport as well as policies are well integrated with the metro system. Plan and ensure last-mile connectivity with adequate feeder systems
	Integration	Mandate and ensure integration of all forms of transport in cities	To create systems for integration of diverse public transportation systems, including buses, rail-based (metro, trams etc) transport, and water ways, as the case may be
Vehicle restraint	Parking policy	Tie up parking reforms for demand management with other urban funding programmes	Ensure each city has a parking plan in place aligned with a state-level policy that works as a demand management instrument
	Transit-oriented development (TOD) and urban form	Ensure TOD is made an integral part of any mass transit system and urban planning system which is funded by the Central government	Adopt a policy for TOD and ensure cities with transit lines adhere to it
			Ensure Master Plans for cities adopting compact city approaches to land-use and density design and zoning
	Taxation	Rationalize taxation systems for private and public transport, making private transport costlier than public transport	Ensure additional taxes as necessary in cities to bring down private vehicular usage and use the revenue generated for funding mobility initiatives
	Movement restriction	Promote low emissions zones to bar polluting vehicles from entering city centres or targeted zones	Implement low emissions zones to bar very old polluting vehicles from entering city centres or targeted zones. Implement licence plate restrictions. Regulate truck movement inside cities

Action agenda		Central government	State government
Non-motorized transport	Pedestrian infrastructure	Make 100 per cent pedestrian infrastructure provision a basic target for cities and link funding with achieving that target	Mandate street design guidelines and norms that meet the requirements of all road users as well as environmental safeguards. Ensure pedestrian infrastructure is appropriate
	Cycling infrastructure and systems	Promote non-motorized transport through other urban programmes	Ensure relevant guidelines are in place for scaled up implementation of NMT initiatives from the government or the private sector
Informal Public Transport		Ensure all new metro systems duly integrate IPT modes for last mile connectivity in their design plans	Ensure parking policies adequately take care of IPT modes such as auto rickshaws and taxis
		Adopt regulatory reforms, where necessary and possible, to accommodate the growing role of IPT in urban mobility	Deployment strategy for organization of IPT services and quality control
Electric mobility		Link public transport strategies with electric mobility—prioritize buses, feeders, three-wheelers, delivery fleet etc.	Adopt and implement strategy for deployment of electric vehicles, charging stations and subsidy or incentive policy
Vehicle technology and fuel quality		Implement as scheduled Bharat VI emissions standards in 2020 along with real world emissions monitoring, in-service compliance, recall programme among others. Make clean fuels like natural gas for automotive use in polluted cities	Implement clean fuel programme or fuel substitution programme including natural gas and LPG programme for vehicles
Vehicle inspection maintenance and policy for old vehicles		Upgrade in-use emissions monitoring method for on-road vehicles including integration of on-board diagnostic system, remote sensing method, centralized automated inspection centres etc. Adopt scrappage policy and end-of-life policy	Develop infrastructure for implementation of improved inspection and maintenance programme with strong quality control, remote sensing programmes etc. Implement scrappage policy and end-of-life policy and develop requisite infrastructure

Source: CSE analysis

ANNEXURE

Methodology for estimating pollution load from vehicles

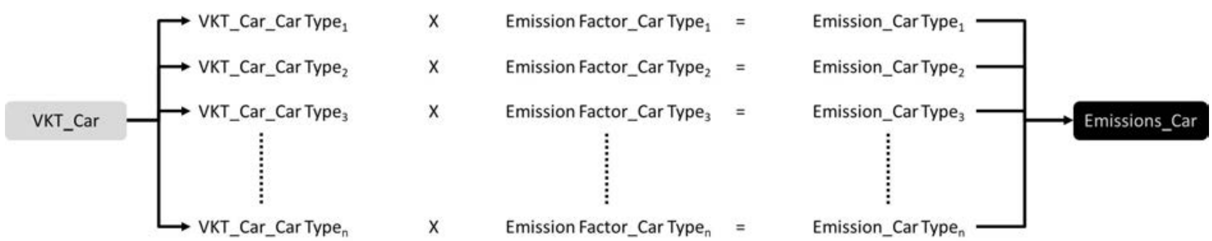
The emission load was calculated for all passenger modes of transport (see *Table: Modes of transport for which emissions load was calculated*). Freight and other commercial modes were not chosen for the analysis due to a deliberate focus on the impact of people's travelling patterns on air pollution, as well as lack of consistent data to suit any available methodology. Private buses that ply in the cities were also excluded due to lack of credible and consistent data, except in the case of Kolkata and Jaipur, where they constitute the dominant section of the city bus system.

The basic formula adopted for calculating emissions for each mode is given as follows using the example of cars:

Table: Modes of transport for which emission load was calculated

S. no.	Mode
1.	Cars
2.	Two-wheelers
3.	City buses (STU only)
4.	Auto rickshaws
5.	Taxis

Source: CSE analysis



Here, the car type refers to variants based on a combination of vintage, fuel and engine technology, whereby each variant has a separate emission factor. The amount of fuel or energy consumed was calculated using a similar coefficient in place of emission factor. For each mode, the total vehicle kilometers travelled (VKT) was calculated and distributed for different variants that together constitute that particular mode of travel. This distribution was, in turn, based on the distribution of variants of a particular mode of travel (such as car) in any particular city.

VKT CALCULATIONS

The prevailing method in emission studies for calculating VKT involves a simple calculation as given follows:

VKT_Car = Total registered vehicles_Cars X Average daily distance travelled_Cars

While this method is nifty and is used in almost all emission load estimation studies, it assumes that all registered vehicles ply within the city. However, this is not true as many vehicles registered in a city often ply in the whole district or even in neighbouring cities. Further, the percentage of vehicles that are registered in a city but not plying in it can vary. Despite this limitation, due to lack of any credible data or method for calculating the percentage of registered vehicles that actually ply within the city, this method is widely used.

For this study, however, an alternative method was used in place of this for all modes except city buses as follows:

$$VKT_{(city,\ mode)} = (Population_{(city)} * PCTR_{(city)} * Modal\ share_{(mode)} * ATL_{(mode)}) / Occupancy_{(mode)}$$

This method essentially utilizes travel data for any city (as is usually given in any transport study such as a Comprehensive Mobility Plan) to arrive at the VKT. It multiplies total trips in the city (which number is obtained by multiplying PCTR by total population) by the modal share of cars, thus giving the total trips by cars in the city. The figure for total trips by cars in a city is then multiplied by the average trip length of passengers using a car in the city. This final figure is then divided by the average occupancy of cars to get the figure for VKT for cars in the city. The latest available city-wise data of all the parameters have been collected and extrapolated to 2017 using annual average growth rates.[6]

This method has been used for cars, two-wheelers and three-wheelers (auto rickshaws) and taxis. Given that the modal share for auto rickshaws and taxis is usually combined in transport studies under the label of IPT (intermediate public transport), the VKT was calculated for IPT as a whole and, thereafter, divided into VKT for auto rickshaws and taxis proportionate to their relative vehicle registration numbers in each city. Subsequently, the VKT calculated was checked for accuracy by running a co-relation with the vehicle registration numbers for each mode. A high degree of correlation was obtained in each case (correlation coefficient in the range of > 0.85), thus validating the methodology for calculation of VKT.

For city buses, a simpler and more accurate method was used to calculate the VKT as follows (using data available from the respective bus agencies):[7]

VKT_buses = Total fleet X fleet utilization X daily vehicle utilization

The emission factors taken were developed by Automotive Research Association of India under the aegis of Central Pollution Control Board. The emission factors are categorized based on engine capacity, vintage, engine type (two-stroke or four-stroke), and fuel use, but the data for vehicle fleet composition is hardly available to match the categories of emission factor. Few studies providing details of vehicle fleet, age distribution and fuel use are available, and the data they provide is limited. Hence, lack of detailed vehicle fleet composition hampers full knowledge about the fleet. Once more detailed data is generated and becomes available in the public domain, CO_2 and fuel consumption estimations will become more robust.

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6. The annual average growth rate of transport parameters (modal share, PCTR and ATL) are analyzed from city category wise baseline data provided in the Report ''Review of Urban Transport'' prepared by CSTEP and IUT. Occupancy data has not been projected. The AAGR of population is taken from UN Population projections.

7. For Kolkata and Jaipur, private bus fleet was also accounted for as they are two cities where the city bus system is largely catered to by the private sector. The fleet size of private buses was estimated based on discussion with private bus operators and experts due to lack of other credible data on the same.

The urban commute—a city dweller's use of vehicles and transportation modes of daily travel—has become one of the most energy- and pollution-intensive activities. Without arresting and reversing the trends in emissions and energy consumption, no city can meet its sustainability targets.

However, there is a wide difference in transport sector emissions and energy consumption across cities. From a public policy stand-point, it is important to recognize that this difference between cities is not a matter of chance, but choice—a result of conscious decision-making and prioritization related to urban road design and transportation planning, with the aim of influencing commuting choices of the masses. This is also important for public conversation as often, public understanding of the relative strengths and weaknesses of cities is sketchy.

Centre for Science and Environment has carried out this quick comparative and diagnostic analysis of key cities in India to check how some cities, which hold sizeable shares of India's urban population, are positioned in this race for clean and low carbon mobility. Who pollutes and guzzles more than other cities? What are the factors responsible for this difference? How can these factors potentially be the basis of disruptive action?

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