Beyond Fossil Fuels: Revolutionizing Transportation for a Sustainable World

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Abstract

India's passenger and freight transport demand in 2020 stood at 3.44 trillion passenger-km and 1.3 trillion tonne-km, requiring over 4700 petajoules of energy during the year. This is projected to almost quadruple by 2050 in the business-as-usual scenario. The growth will largely be driven by increasing economic growth, increasing income levels, and increasing urbanization. A five-pronged approach is being suggested to reduce the energy demand from the transport sector: enhancing energy efficiency, accelerating the use of clean fuels, shifting to cleaner modes of transport, optimal utilization of available capacity, and transport demand management. Several ongoing projects can be leveraged towards effecting a transition to cleaner modes. The Indian Railways is building dedicated freight corridors across the country. Similarly, it has plans to build 12 high-speed rail corridors. The dedicated freight corridors can be leveraged to bring in effect a shift from road freight to rail freight, especially by ensuring last mile road connectivity. The high-speed rail systems should be leveraged to shift from short haul flights to high-speed rail. Coming to urban transport systems, public transport and non-motorized modes of travel, like walking and cycling, are the cleaner modes of transport. A national level apex entity needs to be established to coordinate transport policies and plans across all modes. Each city of over one million people should set up a coordinating agency in the form of a Unified Metropolitan Transport Authority (UMTA). A significant reduction in emissions is certainly possible, but it needs concerted action and a coordinated approach.

Keywords: Transport demand, Five-pronged approach, Freight corridors, Transport policies, UMTA

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Background

India's passenger and freight transport demand in 2020 stood at 3.44 trillion passenger-km and 1.3 trillion tonne-km, requiring over 4700 petajoules of energy during the year (see Table 1). This is projected to almost quadruple by 2050 in the business-as-usual scenario. The growth will largely be driven the following three factors:

1. Increasing economic growth, since India aims to become a $10 trillion (Sharma, 2023) economy by then
2. Increasing income levels of the people enabling many of them to start using motor vehicles and travel more frequently
3. Increasing urbanization, which requires more frequent travel and longer distances, necessitating the use of motorized vehicles.

All of these are positive trends for any developing country and the growth should not be constrained. However, constraints of energy availability and commitments on climate change will require policies to explore how the growth can be accommodated but with a reduced demand for transport and, consequently a lower requirement of energy. This paper suggests policy interventions that will help achieve this enable the growing transport demand to be met with lower energy needs. In some cases, it has also suggested options that may not necessarily reduce the travel demand or energy requirement, but helps a shift towards cleaner forms of energy, and hence it has been retained.

At the outset, it highlights the current challenges in the transport sector and thereafter proposes a five-pronged approach to reducing the transport demand and consequent energy requirements. It goes on to highlight the respective roles that different stakeholders will have to play towards achieving the desired reductions. It specifically focuses on the urban transport and inter-city freight transport sectors as these are likely to see the highest growth.

Table 1: Estimated transport demand, energy use and emissions for 2020

Mode	Passenger/Freight Demand	Energy Demand (petajoules/year)	CO_2 Emissions (million metric tonnes/year)	CO_2 per year *
Road Transport				
Passenger (trillion PKM/year)	2.94	2036	150	51
Freight (trillion freight tonne-km/year)	0.65	2280	153	235
Railways				
Passenger	0.47	58	3	6
Freight	0.34	79	4	11
Aviation				
Passenger	0.04	130	9	225
Freight	0.0002	4	0.3	1500
Shipping				
Passenger	NA	15	1	-
Freight	0.31	118	9	29
Total				
Passenger	3.44	2238	162	47
Freight	1.30	2480	166	127

**CO_2 per year/trillion passenger km for passenger and CO_2 per year/trillion tonne-km for freight*
Source: Author's own computation based on estimates of a steady increase in per capita intercity and intra-city travel demand for passengers, estimated due to increase in economic activity and improved access to transport infrastructure. The calculations are based on data from India Energy Security Scenarios IESS 2047.

As may be seen from the above, the transport sector energy requirement is 4718 petajoules. This will nearly quadruple by 2050 in the business-as-usual scenario. The table also shows that on a passenger - km and tonne-km basis, rail and marine systems are much more energy efficient and cleaner than road and airline systems.

Challenges with the Current Transportation Systems

The transport sector in India is currently facing several challenges. Some of the most important ones are highlighted in the following sections.

Rapid motorization

India has seen a very rapid growth in the number of registered motor vehicles since the middle 1980s and an even steeper growth since the economic liberalization in 1991. The entry of a large number of foreign car and motorcycle manufacturers has spurred interest in personal motor vehicle use, in a market that was otherwise stuck with outdated technologies. Figure 1 shows the growth in the number of registered motor vehicles since 1951.

The surge has resulted in a growth of per-capita car ownership which went up from 8.9 per 1000 people in 2006–07 to 22 per 1000 people in 2016–17 (MoRTH, GoI, 2017). By international standards this is still very low and indicates every possibility of even further growth if things were to continue as usual.

Apart from this rapid growth in the total number of motor vehicles, there has also been a sea change in the profile of motor vehicles on the roads. Two-wheelers now dominate the motor vehicle fleet as shown in Figure 2.

This figure also shows that the share of public buses has fallen from 11% in 1951 to less than 1% now, demonstrating reduced importance of public transport systems in the country. More strikingly, during 1981 to 2019, while the country's total population grew by 90% but the number of registered motor vehicles grew by 5511%.

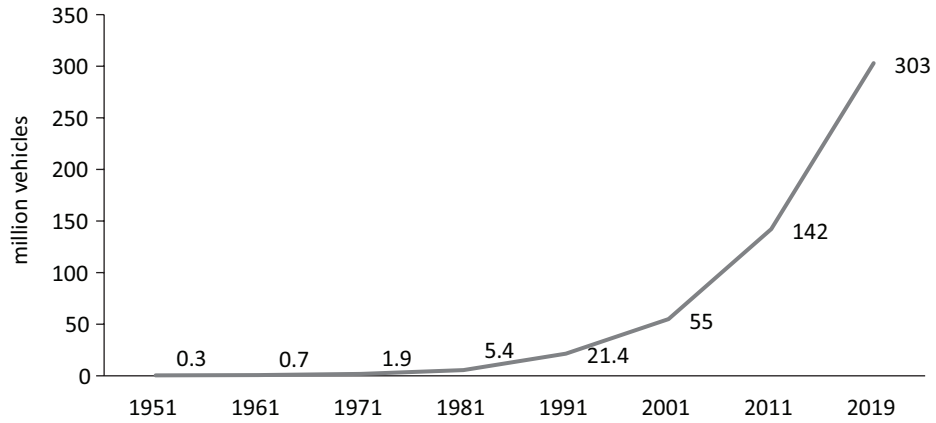

Figure 1 Growth of registered motor vehicles (million vehicles)

Source: Road Transport Statistics, MoRTH, various years

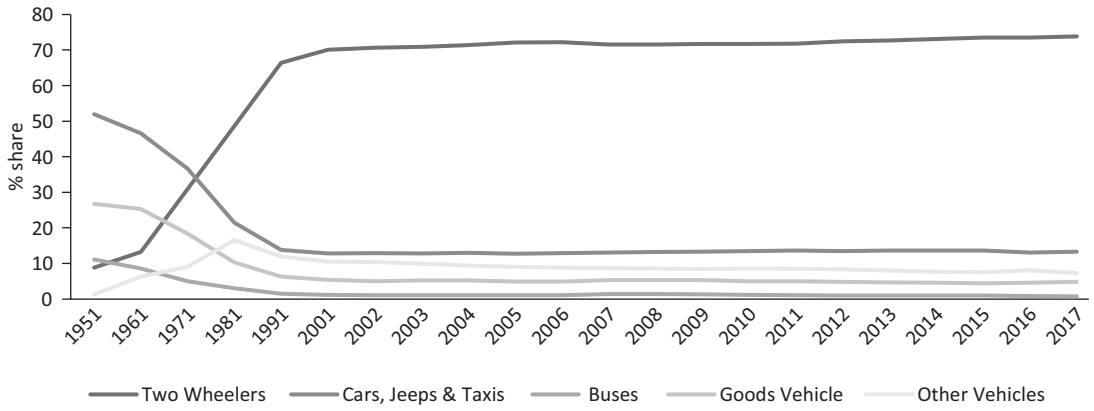

Figure 2 Year-on-year growth of different types of vehicles

Source: MoRTH, Government of India from https://morth.nic.in/

Poor public transport systems

Part of the reason for the steep growth in personal motor vehicles has been the poor and inadequate public transport system, especially in India's growing cities. India has only 1.3 buses for every 1,000 people (NITI Aayog, Rocky Mountain Institute & Observer Research Foundation, 2018), much lower than other developing countries such as Brazil (4.74 per 1,000) and South Africa (6.38 per 1,000).

Public bus systems especially in urban areas are largely operated by publicly-owned state transport undertakings (STUs). Their services have been incurring heavy losses, to quite an extent due to their inefficient and high-cost operations. The result has been an inability to augment their fleet with the growing demand, thereby nudging people to move away from them. Besides, many of the cities, especially those with 0.5 million people or less have no structured public bus system and rely on informal paratransit services like tempos and minibuses to meet the travel needs of those who cannot afford a personal motor vehicle.

Most services, wherever they do exist, have been focused on providing affordable services for the poor. Quality of service, or premium services, have not been a priority. As a result, efforts at attracting personal motor vehicles back to public buses has not been successful.

Recommendation

The National Urban Transport Policy of 2006 strongly recommends the promotion of public transport, but it does not parallelly suggest any measures to discourage the use or ownership, of personal motor vehicles. The time has come to bring in policies that will discourage the use of personal motor vehicles. Policies like high taxes on the purchase of a personal motor vehicle, and high usage charges, as have been imposed in cities like Singapore, Seoul and London, need to be considered.

Further, the current bus systems have been put in place with affordability in mind as the objective was to offer a mode of travel to those who could not afford a personal motor vehicle. Affordability was important for them. However, today when we are looking for personal motor vehicle owners to also shift to public transport, the key determinant will not be affordability but quality. Accordingly, it will be essential to adopt policies that permit premium bus services to be available in all cities to attract personal motor vehicle users. These services will help reduce the energy demand by drawing personal motor vehicle users towards shared modes. These

services may not need a public subsidy but will help reduce energy needs.

Dominance of road transport

As seen from Table 1, 91.5% of the energy demand from the transport sector is for road transport. The same table shows that 85.5% of the passenger transport demand and 50% of the freight transport demand is from the road sector. Only a meagre 17.5% of freight traffic is transported by the railways. In fact, the share of road freight is higher than in major economies like the United States and China where it is between 45–50% (NITI Aayog, 2021). Surprisingly, this is so, despite road freight being the more expensive mode. The main reason for this is its ability to provide door-to-door service and the lack of mechanisms that enable better integration between rail and marine systems with road systems. Besides, the railways give higher priority to passenger traffic, thereby adversely impacting the reliability of their freight movements.

Decreasing reliance on coal for power generation is likely to create excess capacity in rail systems for freight movement. Besides, dedicated freight corridors will add rail freight capacity. Therefore, bringing about a shift to rail freight will be imperative not just to reduce energy demand but to ensure that the large investments in rail capacity do not prove infructuous.

Coming to urban areas, road transport continues to dominate. A few cities have built metro rail systems but their prohibitive cost (over ₹300 crore per km for elevated systems and ₹500 crore per km for underground systems) coupled with the high carrying capacity that justifies them, has meant that only a few cities have been able to build them. Even in the cities where metro rail systems have been built, ridership levels are very low in the absence of last-mile connectivity and poor integration with other modes of travel.

Coming to long-haul passenger services, airline traffic has grown by leaps and bounds, with a significant share of the erstwhile rail traffic having moved to air. The entry of low-cost airlines has made air travel eminently affordable. Besides, with increasing income levels and a highly competitive airlines market, many prefer air to rail for long trips.

Recommendation

Given the above, the recommendations are to:

i. Aggressively promote better integration of rail with road systems to enable good last mile connectivity and thereby, a pronounced shift in road freight to rail freight.

ii. Undertake comprehensive planning for metro rail systems to enable better integration with land use and road systems to enable greater usage of these high cost systems.

iii. Discourage short haul flights and persuade a shift to rail systems for distances up to 300–350 km and as high-speed rail corridors get built up these can be extended up to 600–650 km.

Inefficient trucking industry

Medium and heavy-duty freight trucks contribute to 40%of vehicular energy requirement. Furthermore, trucks in India run an average of 300 km per day in comparison to the global average of 500-800 km per day, with empty running rates of 40% (Errampalli et al. 2020). The trucking industry is dominated by many those who own small fleets. With high level of competition, they operate on very small profit margins and do not have the financial muscle to replace old and polluting vehicles. Often, these are poorly maintained with the result that they are even unsafe.

Recommendation

Stringent truck maintenance standards, strong enforcement of these standards, and incentives to nudge a better organized corporate trucking industry will go a long way in making this industry more efficient. Besides, advancements in electric vehicle and charging technologies are

making it increasingly possible to shift from ICE trucks to electric trucks. Financial incentives are necessary to nudge this shift till a time the entire eco-system for such vehicles attains maturity.

Inadequate attention to Inland Water Transport

Despite there being 111 national waterways, with a length of over 20,000 km, inland waterways have clearly been a neglected mode of transport. The Inland Waterways Authority of India (IWAI) had been set up in 1985 to create the required infrastructure to make the national waterways navigable. However, inadequate efforts at encouraging this sector have meant that there are few operators and it has a miniscule share in the freight movement. Being one of the cleanest modes of transport, it can take on a larger burden in moving freight traffic. Lack of last mile connectivity and relatively slower speeds make them unattractive, but for many non-perishables, the low cost of this mode can make it very attractive.

Several initiatives have been taken up recently to scale up the use of Inland Water Transport (IWT). 111 river stretches covering a length of 4332 km have been declared as national waterways under the National Waterways Act of 2016. This allows the Central Government to take responsibility for development of these stretches for greater use as transportation facilities. However, there are 14,500 km of navigable waterways in the country leaving plenty of opportunity to take advantage of these as sustainable transport systems.

Like in the case of IWT, coastal shipping is also not carrying an adequate share of freight traffic and needs to be scaled up.

Recommendation

An aggressive push to scale up IWT and coastal shipping is needed by making investments in the needed fixed infrastructure and the vehicles. Innovative PPP models where the public partner invests in the fixed infrastructure and the private sector does so in the vehicles can be a winner. Cargo from public agencies like the FCI, and others can seed the demand, especially on identified routes such as to the northeast and along coastal routes can be good starting points. Enhancing IWT to the N-E may need persuasive negotiations with Bangladesh that will present both the countries with a win-win situation.

Institutional fragmentation

India is perhaps the only country in the world where even at the national level, policies relating to transportation are dealt with through five different ministries – Ministry of Road Transport and Highways, Ministry of Railways, Ministry of Ports & Shipping, Ministry of Civil Aviation and Ministry of Housing & Urban Affairs. There is no institutional mechanism for meaningful coordination amongst these ministries, with their result that each is developing its own policies and plans. All of this translates into even greater fragmentation at the local level. In particular, if we look at cities, there are multiple agencies involved with transport, with very little coordination between them.

The national urban transport policy, which was adopted in 2006, with an approval of the national cabinet, has recommended the setting up of Unified Metropolitan Transport Authorities in all the large cities. While several of them have notified these authorities, with Kerala even having passed legislation for a Kochi Metropolitan Transport Authority, none of them have really started effective operations. In the absence of this, urban transport systems are also highly fragmented thereby hindering the possibility of integrated and multimodal systems coming up in the cities. This results in a greater preference for road-based systems, especially the personal motor vehicle, which is the only way of ensuring good last mile connectivity.

Recommendation

A national level apex entity needs to be created to coordinate transport policies and plans across

all modes. This could either be in the form of a Cabinet Committee on Transport or better still, have one Ministry of Transport and mode specific departments, or mode specific technical agencies, reporting to the Ministry.

In each city of over one million people, there should be a coordinating agency in the form of a Unified Metropolitan Transport Authority (UMTA).

Reducing Transport and Consequent Energy Demand—A Five-Pronged Approach

A five-pronged ground approach is being suggested to reduce the energy demand from the transport sector. These are highlighted in the sections that follow:

Enhancing energy efficiency

Primarily the objective is to reduce the amount of energy consumed per vehicle kilometre of travel. In other words, the idea is to meet the transport demand but with a lower consumption of energy in doing so.

Several initiatives in this direction are already on. The series of initiatives for tightening emission standards, though undertaken primarily for reducing air pollution, are also supporting the reduction in the amount of fuel consumed. These initiatives need to be made more stringent by setting tighter standards and requiring the use of lighter vehicles which are more aerodynamic. The outdated designs for trucks and buses need to be transformed into more aerodynamic designs that would save fuel. This is particularly important for long distance road freight vehicles. Thinking in terms of smart vehicle designs would help reduce energy consumed in the road freight sector.

Accelerating the use of clean fuels

While a shift to cleaner fuels like electricity or hydrogen, by itself, will not reduce the transport demand, it is not very clear whether it helps reduce the energy demand, in terms of joules. Yet a section on clean fuels has been added as it supports reducing emissions both from a climate perspective and from a local air pollution perspective.

The National Electric Mobility Mission Plan (NEMMP) aims to promote hybrid and electric vehicles over IC Engine vehicles. The Faster Adoption and Manufacture of Electric Vehicles (FAME) program offers financial incentives for the purchase of EVs and for setting up charging facilities. A recent initiative for aggregating the demand for electric buses and shifting them towards private operations has shown immense promise for a large-scale shift to cleaner fuels for buses. This initiative needs to be scaled up manifold.

There have been discussions around several clean fuels. While electric vehicles have dominated the discussion, there are options in bio-fuels, hydrogen, CNG, etc. There are also discussions around pure electric vehicles and hybrid vehicles. At this stage, as these technologies are evolving, it would be most appropriate to allow a level playing field to all of them and let the market determine what the Indian consumer prefers. In the interim, it would be prudent to ensure a level playing field by not having a tax structure that tilts the scales in favour of one or the other. A degree of uniformity in the tax and incentive structures would be the right approach forward.

While developed countries have been concentrating on shifting a large share of vehicle fleet to electric, in India our focus should be on shifting a large share of vehicle miles to electric.

The adoption of electric vehicles is the key to India's transition to sustainable transportation and achieving its Net Zero goals. To increase EV adoption, low cost incentives such as free or discounted parking, toll fee waivers, supported by local municipal policies can further reduce operational costs and attract consumers.

Savings in emissions accrue on use and not on the number of vehicles themselves. Therefore,

the types of vehicles that need attention are public buses, urban freight vehicles, taxis, and autorickshaws. All of them typically have a more intensive use across the day.

An important barrier to scaling up the transition to electric vehicles is the low energy density of batteries. A fully charged battery can power a car to travel only around 200–300 km, depending on the type of vehicle and size of the battery, before it needs charging again. Charging itself needs several hours ranging from 2 to 8 hours, depending on the type of battery. Hence, it will be necessary to continue research on battery technologies to develop models that have a higher energy density to suit the needs of long-distance travel. New technologies that emerge in this regard would make it possible for long distance trucking, and possibly even shipping services move to electric traction. Battery swapping is emerging as a good option and is yet another alternative to encourage and support.

Addressing infrastructure gaps is also critical in increasing EV adoption. Mandatory EV charging points in new and existing developments along with battery swapping services for two wheelers can ease range anxiety and also improve convenience, especially in urban areas. Additionally, market driven solutions like battery leasing, EV rentals and subscription services can decrease the upfront ownership costs, making EVs more accessible. Collaborations with ride hailing platforms can further help in reducing emissions by establishing EV fleets. Public education campaigns that highlight the benefits of EVs will also drive consumer awareness and behavioral change. Green hydrogen is another potentially clean fuel, especially for the transport segments where electrification may be difficult. A major challenge in the process of adaption of green hydrogen is its storage and transportation as it is full of risks. Despite this, long distance trucking, shipping and aviation could someday move towards green hydrogen as an alternative. Investments in R&D for lowering the cost of green hydrogen as well as making its storage and transport safe would go a long way in enabling the transport sector to move towards net zero.

Coming to rail transport, the Indian Railways has already been working on moving from diesel traction to 100% electric traction and hopes to achieve this feat in the next few years.

Shifting to cleaner modes of transport

It is well known that air transport and road transport emit far more greenhouse gases compared to rail and waterway transport. This is largely due to the reduced friction between a steel wheel and a steel track on rail compared to the friction between a rubber tyre and a bituminous surface in the case of road transport. As a rough example, for carrying 1000 tonne-km of load, a truck would consume 30 litres of diesel as against about 4 litres by a locomotive. It would, therefore, be logical that a larger share of passenger and freight transport moves towards either rail or marine systems. Similarly, aviation uses a lot more fuel than rail (approximately 14,000 litres per hour of flying as against 400 litres per hour by train). It would therefore be logical to shift as much of air travel to rail as possible.

Unfortunately, these shifts have been difficult mainly because each of these modes is managed through separate ministries. This position is unique in India as most other countries have a single ministry for transport, even if there are separated technical bodies under that ministry. Such a structure allows better coordination across modes, especially at the policy and planning levels.

Several ongoing projects can be leveraged towards effecting a transition to cleaner modes. The Indian Railways is building dedicated freight corridors across the country. Plans are to build 6 corridors covering a length of 8359 km (PIB, April 2022). Similarly, it has plans to build 12 high-speed rail corridors covering a length of 7856 kms (PIB, February 2022). The dedicated freight corridors can be leveraged to effect a shift

from road freight to rail freight, especially by ensuring last mile road connectivity. The high-speed rail systems should be leveraged to effect a shift from short haul flights to high speed rail, by either higher taxation or limiting permits for short haul flights.

This kind of a transition will not happen organically. It will need policy leadership and some proactive measures such as limiting the number permits given for short haul flights and ensuring that the Indian Railways ties up with the trucking industry for last mile service, to offer shippers a single window for door-to-door service. The Gati Shakti platform and the National Logistics Policy 2020 are promising initiatives that could facilitate this transition and need to be accelerated.

Coming to urban transport systems, public transport and non-motorized modes of travel, like walking and cycling, are the cleaner modes of transport, as evident from the simple back of the envelope calculations given in Table 2.

As may be seen from the table above, on a per person basis, public bus systems emit less pollutants than personal cars and motorbikes. Walking and cycling are, of course, non-polluting as they do not consume any kind of fossil fuel. It is necessary to bring about a greater shift from personal motor vehicles towards these modes. This is, in fact, the prime objective of the national urban transport policy adopted in 2006.

Table 2: Fuel consumed per person–km with different types of vehicles

Vehicle type	Fuel consumed per 100 kms (litres)	Persons per vehicle	Fuel consumed per person km (litres)
Personal car	8	2	0.04
Motor bike	2	1	0.02
Bus	22	40	0.0055
Bicycle/walking	0	1	0

Recommendations

The earlier recommendations relating to having an apex entity to plan for transport in an integrated manner would apply here as well. The policy direction should clearly be towards increasing the share of rail and marine systems and reducing the share of road and aviation.

Promoting non-motorized transport (NMT) is important for reducing traffic, improving air quality, and making cities more accessible. Indian cities should focus on building infrastructure that connects walking and cycling to public transport, making it easier for people to use different types of transport. Policies like creating pedestrian-friendly streets, setting up car-free zones, and expanding bike-sharing programs can encourage more people to walk or cycle. Awareness campaigns, offering rewards for cycling to work or school, and organizing community car-free events can also help people shift to more sustainable travel. By investing in safe and well-connected infrastructure for walking and cycling, cities can achieve climate goals and create cleaner, healthier, and more inclusive urban spaces.

The National Urban Transport Policy of 2006 makes a strong recommendation for increased share of public transport and non-motorized modes of transport, like walking and cycling. While investments in public transport have gone up, similar emphasis on non-motorized modes needs to be scaled up.

Optimal utilization of available capacity

Optimizing the use of available capacity has two dimensions. First, transport demand by nature has peaks and off peaks. However, transport capacity is available throughout the year. Therefore, off peak periods entail low-capacity utilization.

Secondly, transport vehicles often move around without their full capacity being used up. Many personal cars have a single occupant

despite having a capacity to seat four people. Buses can seat around 40 people but often have fewer passengers. This kind of unused capacity is wasteful as the fuel for carrying this additional load has already been consumed. It is therefore important to ensure that all available capacity is fully used to minimize fuel wastage in meeting the complete travel demand.

Coming to long distance freight movements, a similar problem is seen, as freight movements tend to be skewed in one direction and the reverse movement often involves empty haulage. This is also a waste of available capacity.

Capacity utilization could go up if suitable platforms are created for better information exchange and a certain amount of dynamic pricing which allows lower prices based on marginal costs rather than levying a fixed price. This can be done both for passenger as well as freight traffic. For airline travel, this is already in place as most airlines have a system of dynamic pricing depending on the number of seats available on a flight.

Recommendation

The emerging innovations that use technology to enable sharing of available capacity need to be given strong emphasis by modifying legislation that may restrain them. Car-pooling and aggregator systems need to be promoted and not restrained. Aggregator systems should also be encouraged for small-sized buses as a kind of premium bus service.

Transport demand management

As seen earlier, rapid urbanization coupled with growing income levels are expected to increase passenger transport demand, especially in urban areas. However, effective methods of demand management can be deployed to reduce this growth, as demonstrated by initiatives in several countries.

Passenger travel demand is a function of:

i. The number of people travelling

ii. The average number of trips made by each person daily

iii. The average length of their trips

iv. The average number of people per vehicle

While it may not be possible, or even desirable to reduce the number of people travelling, the average number of trips made by each person daily can be reduced through measures like:

- Policies relating to working from home
- Reducing the number of working days, especially the number of days requiring working from the office
- Online shopping and e-commerce

The average trip length can be reduced by adopting planning principles that encourage compact cities and discourage sprawl. Similarly, mixed used planning will also help reduce the average length of trips.

The number of persons per vehicle needs to be increased so that the transport demand can be met with fewer vehicles. This is possible by encouraging public transport and also other shared modes of travel like car-pooling. Measures that discourage the use of personal motor vehicles like high parking fees, high taxes on personal motor vehicle ownership, high fuel taxes and congestion pricing are initiatives that many cities have adopted to nudge a shift to shared modes of travel.

Respective Roles

Attaining net zero in transport will require major changes in the way transport systems are managed. Multiple stakeholders will have to play an important and transformative role. These will include the government, independent regulators, private operators, financial institutions, think tanks and academia, civil society, and the market in general. The following sections highlight the

role that each of these stakeholders will have to play, and the changes they will have to make in their current policies and practices.

Government

Reforming urban and sub-urban public transport entities

Most states have a government owned state transport undertaking (STU) that operates both intra-city and inter-city public bus services. Intra-city services are much more complex and loss making compared to inter-city services and therefore suffer considerable neglect. However, the growing congestion and air pollution in cities made them extremely important. As a result, several states such as Karnataka, Tamil Nadu, Maharashtra, Madhya Pradesh and Gujarat have created separate entities only for operating city bus services in their major cities. But in all these cases, it is still a state-owned undertaking that is operating the services.

The arrangement of government-led operation was put in place at a time when many cities were faced with the situation of many small bus owners provided low quality services. Competition on the streets made them unsafe and the high degree of competition forced them to operate on small profit margins. The services were of poor quality and capacities did not expand to meet the growing demand. It is for this reason that the government had to take over these services in many cities around the world. The objective was that a government agency would be able to provide better services, in all parts of the city, and at an affordable price, even covering non profitable routes. Unfortunately, publicly operated services have proved to be extremely expensive, largely due to the inherent inefficiency of public agencies to operate such services. They have also lacked customer focus and not been innovative enough to align services with changing demand patterns. They incurred huge losses and needed high levels of financial support from the government. This was a huge drain on the public budget, compelling many cities to look at alternative delivery models.

New models for providing bus services have since emerged, wherein a government entity decides on the routes, schedules and fares but contracts a private party to operate services. London has been a pioneer, and many others have followed suit. Commonly known as the gross cost contracting model, this requires a private operator to procure the buses and operate services in accordance with the schedules given by a public agency. The private operator incurs all operational expenses and is compensated on the basis of the km operated. The per-km compensation is pre-decided through a competitive bidding process. The public agency collects the fares and uses it to compensate the private operator.

On some routes the fares collected may be higher than the amount paid by way of compensation whereas in others it may be the reverse. On an overall basis, however, adopting such a model result has seen a significant reduction in the overall outgo from the public budget, largely due to the operational efficiency of the private sector.

This fact is now widely known. Yet, STUs in India, as in several other countries, have been hesitant to undertake the needed reforms, primarily apprehending a political backlash from the large complement of drivers and mechanics who would be rendered surplus. It has however become increasingly important that this reform be carried out and ways of either redeploying the surplus staff or offering them a generous voluntary retirement package be undertaken. This would not only lead to a reduced outgo from the public budget, but also give cities a vastly improved bus service, that may be more effective in attracting personal motor vehicles users. This would help reduce emissions from the transport sector.

Private operators are also hesitant to respond to invitations for operating city bus services, primarily for two reasons. First is the lack of

capacity to operate city bus services as they have not had the opportunity to do so over the last few decades. Second is the apprehension of delayed payment of compensation, or even non-payment of the same.

Recommendations

Given the above, governments must look at reforming public bus services in two ways:

- Becoming regulators and facilitators of these services rather than operators of the same. This will require building the capability to procure, contract and monitor rather than operate services.
- Becoming owners and providers of the fixed infrastructure like depots.
- Use of the private sector beyond operating urban public transport.

Establishing independent regulators for price determination wherever a fair interface is needed between private operators and public agencies.

Additionally, Transit-Oriented Development (TOD) should be integrated as a key recommendation. TOD in India focuses on promoting high-density, mixed-use development around transit hubs like metro, bus, or rail stations to reduce reliance on private vehicles and improve public transport efficiency. This involves creating pedestrian and non-motorized transport (NMT) infrastructure, including wide sidewalks, cycling lanes, and safe pedestrian crossings, to encourage walking and cycling. Successful examples, such as Ahmedabad's BRTS and Delhi's metro-centric TOD policies, demonstrate how TOD can integrate public transit with sustainable transport options through public transit incentives, parking restrictions, zoning adjustments, and eco-friendly last-mile connectivity like electric rickshaws and public bicycle-sharing programs.

Use of the private sector in other areas

Government must also look at a greater involvement of the private sector in many other segments of the transport ecosystem. The government has already given up all its stakes in airline operations. Some of the bigger airports have entered into PPP arrangements and more are planned. It must look at similar roles for the private sector in railway systems and in managing ports and shipping services. A similar role is easily possible even in IWT systems, where publicly-owned entities continue to dominate today. Greater involvement of the private sector can lead to significant efficiencies in operations and reduced fuel consumption.

Fuel efficient trucks

As noted earlier, a large share of the intercity freight traffic is carried by trucks. Unfortunately, the trucking industry in the country comprises a large number of small truck owners who, due to intense competition, function on very thin profit margins. The result is that old trucks are generally not replaced and even their maintenance is inadequate. They tend to become highly polluting and even unsafe otherwise. It is therefore necessary for the government to formulate clear and stringent policies requiring a modernization of the trucking industry, if necessary, by offering financial incentives for fleet renewal and replacement. When coupled with stringent and well enforced regulations, the change to more efficient trucks will be possible.

Facilitating multi-modalism

On another front, government must also emphasise multi-modalism, both in urban passenger transport and inter-city freight transport. This will have to be done by creating multimodal transfer/logistics hubs where easy transfers are possible between modes, especially between road and rail as well as between ships and road. Similarly, for urban passenger

transport it will be important to create lead entities that can effectively coordinate between different segments of the transport ecosystem.

The Gati Shakti platform is an excellent tool to facilitate this. However, this platform is good to coordinate project delivery. A similar platform will be needed to coordinate operations as well.

Pricing, taxation, incentives and subsidies

Effecting a shift to cleaner modes or cleaner technologies will require the desired modes and technologies to be more economical and more convenient. Taxation policies of a government must reflect a strong interest in reducing the demand for energy by levying deterrent taxes on modes of travel that use more energy and lower taxes on more efficient modes of travel. Therefore, personal motor vehicle use must be taxed high and public transport system must be taxed lower, or not taxed at all. Even within public transport, cleaner technologies must be taxed lower than more polluting technologies like diesel buses. Overall, there must be a proper gradation of taxes to encourage a move towards less energy intensive modes of travel. In the initial years, say till 2026, it may be necessary to use the additional taxes to subsidize cleaner modes wherever they are unable to compete with the traditional technologies, or use these proceeds to invest in the supporting systems needed. An example will be charging facilities for electric vehicles or R&D for better battery technologies.

Periodic review of policies, regulations and laws

It would also be important for the government to review various laws, regulations, rules and policies at a certain periodicity to ensure that they are better aligned with the changing needs and demands of the day. Technologies are changing rapidly, and new paradigms are emerging across the world. All of these are working towards more efficient transportation of people and goods as also towards cleaner transport. Unless our policies and laws are reviewed periodically, we run the risk of being stuck in outdated systems which would be to our disadvantage. Ideally these reviews should take place at 3–5 year intervals. It is also important to ensure that exhaustive data is collected regularly to monitor progress and make changes to our policies and laws based on what the data tells us.

As an example, our Motor Vehicles Act is outdated in many respects and needs to be comprehensively reviewed. The emergence of electric mobility, the usefulness of app-based aggregators, the need for vehicle pooling systems, etc., are essential today. However, the motor vehicles act does not seem to recognise this and, in fact penalizes them. Yet another example is the national urban transport policy which was adopted in 2006. It has served the needs of that time very ably but with the new technologies and systems that have emerged for urban travel this policy needs to be reviewed and updated.

Markets

If the government were to transform its role from being a regulator and a facilitator of public bus services instead of being an operator, the market must respond by building up its own capacity to be efficient operators and appropriately respond to invitations for operations. Currently the private sector does not have the requisite capacity, largely because it has not had the opportunity to operate city services over the last several decades. Yet, such services are going to be a big opportunity and where considerable demand for good quality bus services would emerge. It would also be a way of significantly reducing emissions from the urban transport sector.

Markets must also build up capability to manage a lot of the fixed infrastructure facilities that may become available to them such as airports, bus depots, bus terminals and other fixed infrastructure. Opportunities will also

emerge for the private sector in port operations, multimodal logistics hubs and possibly in IWT systems.

This will also require the private operators to build up capability in credible financial analysis so that financial institutions are able to trust them for making their lending decisions.

Regulators

Currently, there are no independent regulators in the transportation sector. Yet, there are suggestions for a greater involvement of the private sector in the operation of public transport systems. For this to happen in a fair manner, it will be necessary to set up independent regulators. Such regulators must make a special effort at nudging a shift in demand towards off peak periods by pricing public transport systems higher during the peak and lower during off peak.

Several cities around the world have adopted the concept of differential pricing between peak and off-peak periods for public transport and also parking charges to nudge better utilization of available capacity. Similarly, cities have adopted principles that allow easier movement of vehicles that are occupied by two or more persons as against those with only one passenger. Parking fees in areas well served by public transport can be an effective nudge in favour of public transport as would congestion charges for entry into central city areas in personal vehicles.

Regulators must deploy this thinking into the tariff determination process.

Financial system

If private operators were to enter into operating public transport systems, especially those using clean technologies, the financial system must develop innovative instruments to finance them. These instruments must recognize the risk of new technologies and add innovative insurance instruments that would de-risk non-payment or delayed payment, of dues by public agencies.

In a recent example, financial institution had expressed hesitation in financing potential private operators of electric buses due to concerns about timely payment of dues by the STUs. Innovative escrow mechanisms and insurance systems would be needed to provide greater assurance that the operators would be able to pay back their debts.

There are concerns that the use of private operators for public transport systems may lead to job losses as they would be more efficient and would bring in new technologies. However, there is an immense amount of unmet demand for public transport which the private sector would be well placed to serve. For example, there is a need for premium services and services that can meet special needs like travel to airports and railway stations as well as employment hubs in a city. The private sector will help expand services and may create more jobs.

Civil society

Think tanks and academic institutions have a critical role to play in furthering the move towards net zero in the transport sector. They need to undertake the necessary analysis to suggest the right pathways for government policies. They need to hand-hold implementation of these policies at the ground level and finally they need to contribute towards building the right capacities and awareness so that appropriate policies are understood and supported by the people at large. They would also have a critical role in pointing out gaps and suggesting changes that may be needed. They would serve a useful purpose as friends, philosophers and guides of the public system rather than being adversaries.

Overcoming Barriers

There are several barriers to implementing these suggestions. These barriers need to be clearly understood and worked around.

First, and foremost, is the institutional fragmentation as highlighted earlier. This does not permit integrated policy and planning.

Coordinated action across different modes becomes extremely difficult when policies and plans are developed independently across multiple ministries. Getting around this will require either the creation of a single ministry of transport which takes responsibility for policies and planning, with separate agencies, working under them, to take responsibility for technical issues only. In the Indian context, an alternative would be to create a high-level transportation policy and planning unit either in the cabinet secretariat or in the NITI Aayog where all transport related policies and plans are formulated in an integrated manner, funds for implementation of these policies and plans should be allocated to this unit, who should then sub-allocate for different modes of transport. Similarly, for city transport systems, a Unified Metropolitan Transport Authority (UMTA) should be set up and made effective in all cities with over a million people.

The second barrier is the lack of professionalism in most of the transportation sectors especially at high levels. People join the Indian Railways or STUs without any professional academic background in transportation. They come from a variety of academic backgrounds but learn on the job. While this may serve our basic purpose, it does not give the needed professionalism that is necessary in the country today. The setting up of Gati Shakti Vishwavidyalaya to help prepare professionals in the country is a step in the right direction. IIT Roorkee has set up a Centre for Transportation (CTrans) with precisely this objective. Other institutions must also be encouraged to set up professional transportation programmes that go beyond purely technical and engineering aspects, to cover a wider gamut of disciplines such as economics, social, political, behavioural, sociological, and environmental dimensions.

A third barrier is the lack of reliable data. While railway systems, being centrally managed, have a good collection of protocols, these are sorely lacking for road transport systems, which are the most polluting. This is largely due to very decentralized operations and the absence of a single data management entity. It is extremely difficult to get reliable data on the movement of trucks, the origin and destination of different commodities and passengers moved by road, and the movement patterns of people in cities.

In the absence of such data, it becomes very difficult to understand the current demands in the market and the kind of policies that could help move towards reduced emissions. Therefore, intensive work on developing protocols for data collection and management will be necessary. The government may like to set up a special task force to come up with ideas on this and also, mechanisms for implementing them.

Summary of Recommendations and Way Forward

In conclusion, the transport sector is a significant contributor to GHG emissions in India and its share in the total emissions will grow with urbanization, increasing incomes and the overall economic growth of the country. A highly skewed share of road transport and the rapidly growing share of aviation will be major concerns in moving towards net zero in the transport sector. A five-pronged approach covering stringent fuel efficiency standards, use of clean technologies, a shift towards cleaner modes of transport and a more optimal utilization of available capacity should be the one that the country should adopt. Given below is a summary of the recommendations contained in this paper towards reducing the growth in transport demand and consequently, the energy demand:

1. A national level apex entity that needs to be established to coordinate transport policies and plans across all modes, even if implementation remains the responsibility of mode specific ministries or agencies.
2. Each city of over one million people, should set up a coordinating agency in the form of a Unified Metropolitan Transport Authority (UMTA).
3. The National Urban Transport Policy of 2006 strongly recommends the promotion of public transport, but it does not parallelly suggest any measures to discourage the use or ownership of personal motor vehicles. The time has come to put in policies that will emphasize demand management measures such as working from home, reducing the number of days requiring staff to go to office, scaling up e-commerce, adopting measures that discourage the ownership and use of personal motor vehicles.
4. Aggressively promote better integration of rail with road systems to enable good last mile connectivity and thereby, a pronounced shift in road freight to rail freight.
5. Discourage short haul flights and persuade a shift to rail systems for distances of 300–350 km and as high-speed rail corridors get built up these can be extended to 600–650 km.
6. Undertake comprehensive planning of metro rail systems to enable better integration with land use and road systems to ensure improved usage of these high-cost systems.
7. Improve public city bus systems by leveraging the operational efficiency of the private sector, even if public entities determine the level of service needed. Introduce premium bus services that will be attractive enough for personal motor vehicle users to consider a shift to them.
8. An aggressive push to scale up IWT and coastal shipping using innovative PPP models where the public partner invests in the fixed infrastructure and the private sector operates cargo and passenger services.
9. Aggressive push towards adoption of electric vehicles, with a focus on shifting vehicle-miles more than shifting the number of vehicles.
10. Keep up the efforts on developing green hydrogen as a potential clean fuel for transport systems.
11. Modify legislation as may be needed to scale up technology-based initiatives than encourage car-pooling and vehicle sharing.
12. Establishing independent regulators for price determination wherever a fair interface is needed between private operators and public agencies.
13. Formulate clear policies requiring modernization of the trucking industry, if necessary, by offering financial incentives for fleet renewal and replacement. Introducing smart freight vehicles and systems to reduce emissions and empty haulage.

In doing so, some of the major barriers it would face would be the institutional fragmentation, the lack of reliable and comprehensive data as also the lack of professional manpower in the transport sector. It would have to significantly improve the quality of its public transport systems in order to attract private motor vehicle users. For these the current governance mechanisms operating public transport will need to be reformed with a greater involvement of the private sector in operating city bus services.

At the national level, a mechanism for integrated policy making and planning for transport across all modes must be put in place. At the city level, UMTAs need to be set up in all the large cities for integrated policies and planning as well as coordinated operations. Academic programmes that would ensure professional manpower and mechanisms for reliable database management will also be needed.

Review of outdated laws, regulations, rules and policies will be necessary to make sure that the current philosophy adopted is in line with the demands of the market and the latest technologies currently available. A major effort at moving from road and aviation to rail-based modes will be essential, and certainly possible. IWT needs to get far more attention than it is getting today.

A significant reduction in emissions is certainly possible, but it needs concerted action and a coordinated approach.

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