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Transporting Masses in Urban India: Policy & Fact Disconnect

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ABSTRACT Current policies on moving masses in Indian cities have failed to address the severity of the problems by neither considering rational alternatives nor optimally managing existing transportation assets and infrastructure. The right rationale requires planners to not only base their decisions on the fundamental considerations of minimising energy, cost, and emission in moving a person over a given distance and using a mix of modes, but also to track and measure these metrics objectively, for enabling the best modal mix that can be offered to the city. This policy rationale remains vague, unmeasured, and unaccountable. A course correction implies moving away from transport technology status-quo and embarking on a definitive search for the best mobility technologies for the city. Moreover, India needs to introspect, open up and adopt more accountable policies. In facilitating mobility for its masses, India can no longer afford to waste energy and cost, nor emit pollutants, at current levels, using status-quo technologies and systems.

INTRODUCTION

The National Transport Development Policy Committee (NTDPC) of the government of India published in February 2014, a policy report establishing the scale of improvements required in the transportation sector in the context of larger goals towards sustainable growth. This report formed the basis for the Twelfth Five Year Plan budget allocations. It highlights the fact that on average, the urban transport sector would require some INR one lakh crore of investments annually for the next 20 years to sustain the growing transportation demand and build the required infrastructure. Out of the total required investments, more than 80 percent is scheduled for facilitating infrastructure for mechanised modes largely using fossil fuel energy, including 50 percent for conventional mass transit systems.

The final report of the NTDPC advocates for a clear approach to the twin issues of constraining the growth of private transport modes, and promoting public ones. It also prescribes a rational and customised policy to considering and selecting competing modes[1]. While recommending a reduction in the number of vehicles on the roads in favour of public transport, however, the policy is quite self-contradictory as it suggests that funds for the transportation infrastructure be raised from, among others, fuel surcharge, insurance cess, and taxation on vehicles purchased—the exact mobility tools that the same policy wishes to contain. It is a puzzle as to how the policy report could envision a roughly 500-percent[2] growth in the absolute number of vehicles on the road within the next 20 years, to finance future urban transport infrastructure—given that the right-of-way on most urban streets today have already succumbed not only to traffic congestion, but also a high degree of encroachment by vehicles utilising public spaces for parking, and thus depriving pedestrians and other zero-carbon modes of mobility channels.

Indeed, various factors are responsible for the problem of moving masses in a city: fixed, non-scalable right-of-way, coupled with the absence of allocation of land for parking in the master plan, and the vanishing mobility channels for the lowest-income sections of society. It is not an understatement to say that the problem has taken on the proportion of a crisis. A fresh, even radical approach has become an imperative to addressing the problems of transporting masses—so far not addressed in NTDPC committee deliberations—especially in the context of the central government's 'Smart Cities' initiative which aims to improve living conditions and achieve higher economic growth in 100 cities across the country.

India's current mass transport technologies together are unable to provide the scale of supply required to cope with the demand, neither is the capacity created being utilised to its fullest. Most analysts agree that the future for mass transport in its current form is bleak, unless a turnaround is achieved through the development of alternative technologies and innovative mobility systems. These alternatives must necessarily offer the best lifecycle value for capital deployed and energy consumed. Such an approach should not only help India fulfil its carbon commitments to the international community, but also assist in the reduction of the country's fuel bill.

Computations[3] show that it is possible to build a high-throughput mobility system that not only releases space on the surface right-of-ways for zero-carbon, low-carbon and shared modes, but also perform with a lifecycle cost, energy and emission efficiency better than the e-cycle, in providing equivalent travel characteristics of airconditioned personalised modes.

The NTDPC report says that given the projected scale of demand on mobility of both passengers and goods, such demand must be supported by a sufficient supply of multi-modal mobility infrastructure that reflects the vision of the government of India with respect to its major policy issues, related to the National Urban Transport Policy (NUTP) and National Action Plan on Climate Change (NAPCC).

Both the NUTP and NAPCC aim to promote energy efficiency as a core component of urban planning with 'well-to-wheel' energy efficiency considerations[4]. The transportation plan and operational 'modal mix' in the city therefore can, and *should* be structured to reflect this concept—where the sum operational energy requirements of different mechanised modes, benchmarked against consumed commuter trips, are defined, measured and targeted.

In this context, this paper makes the following observations on the NTDPC report outcomes:

- Assessments and projections are based on limited and timid considerations without attempting to discuss, explore or extend into the future realm of technique or technologies that could rise up to the occasion and assist in solving the essential capacity challenge efficiently and effectively in urban areas.
- Quantifiable considerations regarding government policy on energy and climate change have not been attended to, while building up the demand projection and supply arguments.
- The fund requirements of approximately INR one lakh crore per annum for the next 20 years for urban transport infrastructure are sought to be fulfilled by way of green surcharge on fuel, taxation on new vehicles and hike in insurance rates, the same mobility machines that the policy advocates to contain. This is circular reasoning and is short of foresight.
- In terms of numbers and broader import, the policy report accepts approximately '1.5X' the

number of current vehicles on city roads with fixed road right-of-way, already exhausted to capacity within the next 20 years, only to be able to finance the urban transport infrastructure. This formula will have a severe impact on congestion in all urban roads.

- In addition to the above problem of moving vehicles, the same policy report also accepts approximately '3.5X' the number of current vehicles as being parked in the city, when it is well-known that new land use for parking simply cannot be carved out from any existing master plan allocations, usually legally sanctioned by a decades-old notification.

THE NATIONAL URBAN TRANSPORT POLICY: LACKING IN OBJECTIVITY

Mass transport capacity creation using any specific mode cannot be done at the cost of energy efficiency, capital optimisation, and emissions minimisation. While the National Urban Transport Policy gives broad guidelines on how mass transportation should be planned and targeted, a few fundamental aspects need to be included as amendments, in the interest of advocating objectivity (which is articulated in the NTDPC vision, but not discussed in detail). These aspects are described in the following sections.

The first consideration is that the energy consumed by transportation systems — collectively and cumulatively — has to be the least for the city. The transportation plan and operational 'modal mix' in the city therefore can, and should be structured to reflect this concept. The 'sum operational energy' and 'sum operational cost' requirements of different mechanised modes in the city should be guided and defined by a multi-modal policy advocating minimisation with respect to consumed commuter trips. This benchmark should be targeted and measured for performance in the choice of modes to be made by the city. A modal split computation in line with this concept is in order and should therefore be established in any master plan review document before any 'measurable' amendments are proposed.

Then there is the aspect of 'seat km' capacity: every mass transit mode has a proportion of 'seat km' capacity that goes to waste daily on account of technological, architectural and operational constraints of transit systems. For a rail-based system like the light rail transit, it could be as high as 82 percent for the Delhi Metro, for instance. This wastage is 67 percent for a private car. This is a huge 'wastage of supply capacity by design', leading to inefficiency in fuel consumption, dependence on imported oil, and higher GHG emissions—all of them avoidable. Capacity creation or augmentation in an urban context thus needs to evaluate any proposed intervention in a city, keeping in perspective both utilisation efficiency and normalised cost of cumulative energy.

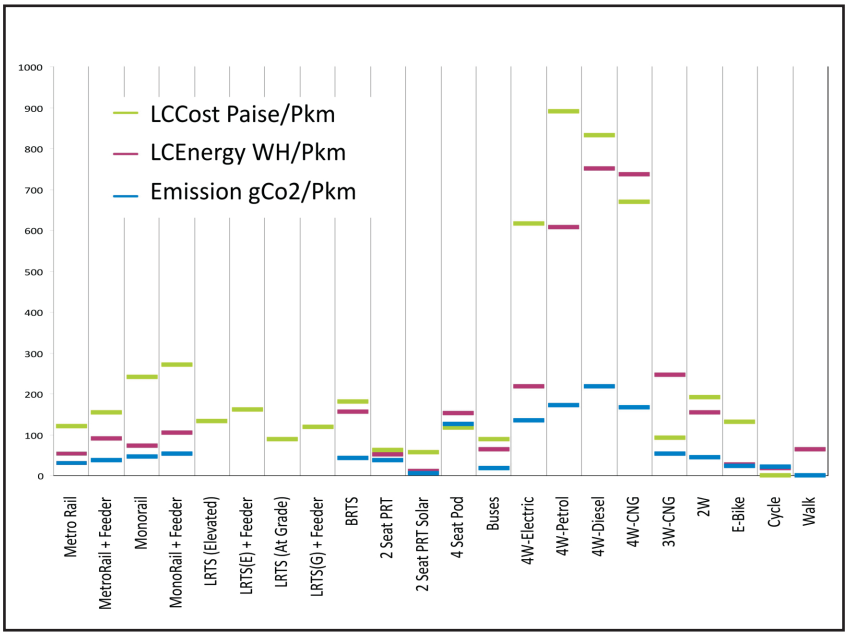
There are huge gains to be made in bringing the above fundamental arguments and analyses into the equation while considering system candidates at the time of the transportation system selection, rationalisation or augmentation process. This has so far not been sufficiently undertaken for any 'comprehensive mobility planning' exercise in India.

MOBILITY MODES AND SYSTEMS SELECTION METHODOLOGY

Mobility systems need to be built with the aim to be optimal from the viewpoints of both capacity and energy consumption, without losing sight of the order of demand and its density. Transportation technologies that have historically been relied upon have been unable to assist transport system planners in finding solutions to the issues of road congestion, severe pollution, and the lack of capacity to transport huge volumes of masses.

The urban transport section of the NTDPC report based its findings regarding various urban transport modes on information sourced through several government agencies by the Institute of Urban Transport (IUT) and The Energy and Resources Institute (TERI). Considering further calculations and analyses based on the same figures (from the IUT 2012 report, 'Lifecycle Cost Analysis of Five Urban Transport Systems', and the TERI 2013 report, 'Lifecycle Analysis of Transport Modes') that form the basis of urban transport deliberations in the NTDPC report --the involved in moving people in urban areas as per the figures available from the NTDPC report and other references.

Figure 1: Energy consumed, emissions produced, and costs involved in moving one person one km. in urban areas (Lifecycle cost assessment basis)

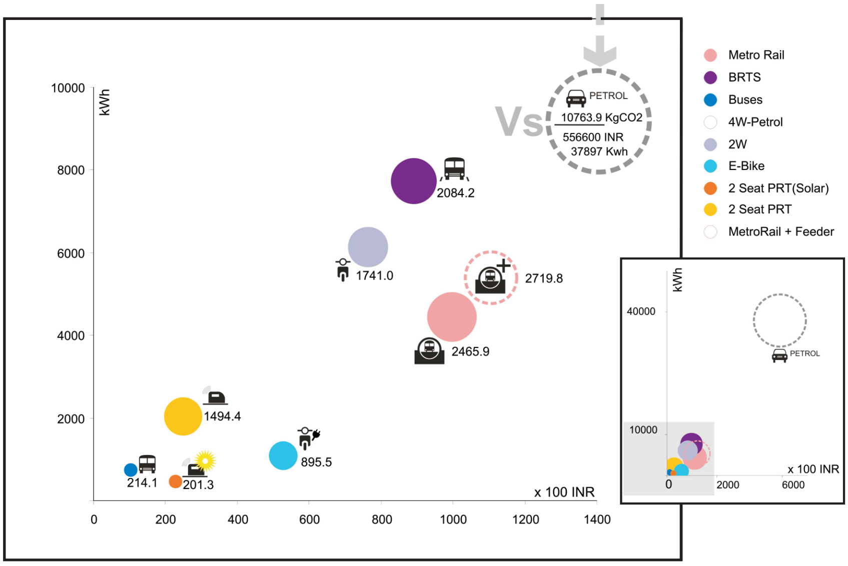


results are noteworthy, with respect to the inherent inefficiencies of each mobility system to move a person over a given distance in the least amount of time, at the least cost, consuming the least amount of energy, with the least damage to the environment.

Figure 1 shows the comparative scale of energy consumed, emissions produced, and costs involved in moving people in urban areas as per the figures available from the NTDPC report and other references.

Figure 2, meanwhile, shows the comparative scale of energy required to move people in urban areas by selected representative categories of modes. Evidently, a bus system or the electric cycle consumes the lowest energy for moving one person one km. In comparison, even the Metro consumes more for the same purpose while the petrol automobile consumes 40 times the e-cycle for the same purpose.

Figure 2: Emission size vis-à-vis energy consumed and costs involved in moving 100,000 persons one km. in urban areas (Lifecycle cost assessment basis)



LIFECYCLE ENERGY, EMISSION AND COST PER PASSENGER KM.

A four-wheeler running on petrol consumes 0.92 KwH of energy in running one km. This energy includes the share of energy required to produce the vehicle and maintain and operate it over its full life. However, its average occupancy is only 1.5 persons. This equates to 0.61 KwH of energy spent in moving one person one km. If the occupancy is four persons, this would equate to 0.23 KwH of energy spent in moving one person one km. This implies that in moving one person one km. in a four-wheeler, an additional 0.38 KwH of energy is spent in moving the empty seats on their behalf as well. This 0.38 KwH of energy is the unnecessary wastage of energy when a four-wheeler is used to move one person one km. Such is the inherent inefficiency of the automobile as a mobility technology. Similar inefficiencies exist within each urban transport mode and need to be factored into consideration in the future transportation plans of existing cities and planned smart cities.

Table 1 shows the seat capacity utilisation for each of the respective modes. As is evident, several modes perceived to be high-capacity in fact waste a high proportion of supply capacity because of the inherent limitations of deployment architecture in typical naturally spread out urban settlements.

Figure 3 shows the comparative scale of energy wasted in moving one person one km. in urban areas by the same representative category of modes. While the energy consumed by the e-cycle is the least of all modes, the bus is least expensive to move one person one km. In both cases, however, the system-wide wastage of energy is the least for every concluded passenger km. Metro rail systems, especially with a feeder service for similar accessibility, waste five times more energy for every concluded passenger km. than that wasted by an e-cycle or the city bus.

Figure 4, meanwhile, shows the comparative scale of emissions unnecessarily emitted to move one person one km. in urban areas by the same representative category of modes, based on the type of fuel used and the inherent energy content

Table 1: Seat Capacity Utilisation by Mobility System

Type of System	Mode	Capacity Utilisation (in %)
Guided Systems	Metro Rail	17.1[5]
	Monorail	14.5
	LRTS (Elevated)	NA
	LRTS (At Grade)	NA
	BRTS	50.5
	2 Seat PRT Solar	60.0
	4 Seat Pod Taxi	50.0
Road based Systems	Buses	88.3
	4W-Electric	37.5
	4W-Petrol	37.5
	4W-Diesel	37.5
	4W-CNG	37.5
	3W-CNG	66.7
	2W	60.0
	E-bike	60.0
	Cycle	100.0
	Walk	100.0

of the technology system. The figure shows that avoidable emission potential is proportional to the energy wasted by the system.

Figure 5 then shows the comparative scale of wasted capital in providing mobility capacity which is not utilised over its lifecycle. The scale of wasted capital is related to the utilisation of the capacity created and the effective working life of the mode itself. Therefore, the e-cycle with an average occupancy of 1.5, displays a slightly larger wastage of capacity than the scooter (which has a better working life but the same occupancy).

Figure 3: Wastage of energy in moving empty seats one km. for every one passenger moved one km. (Comparison by mode)

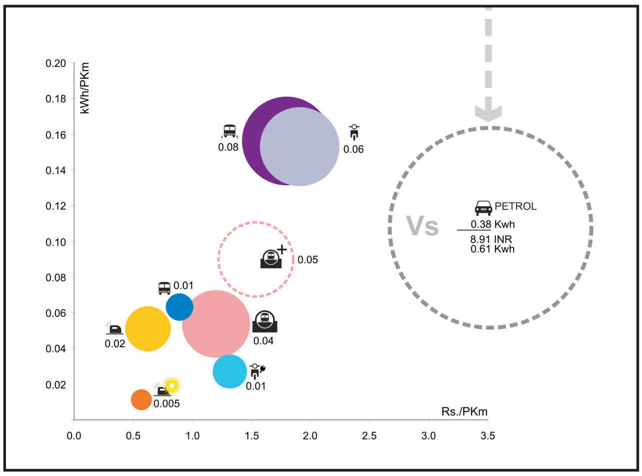


Figure 4: Avoidable emissions in moving empty seats one km.with every one passenger moved one km. (Comparison by mode)

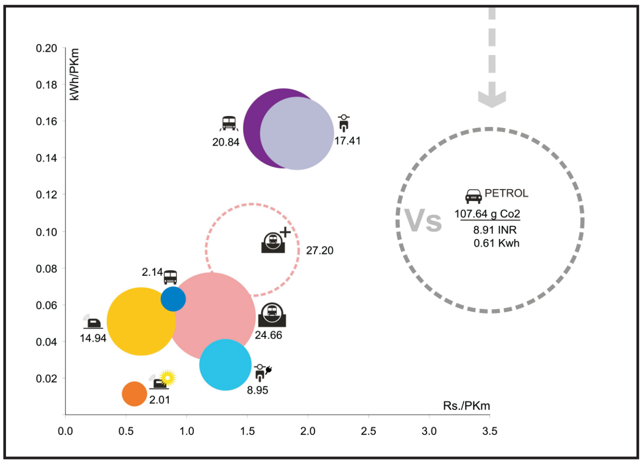
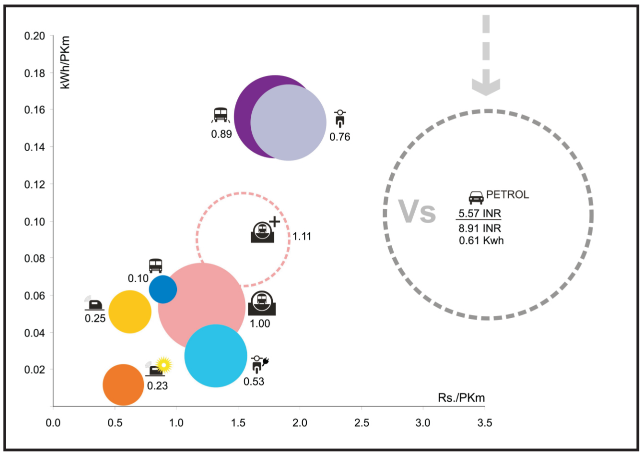


Figure 5: Unproductive capital in moving empty seats one km. for every one passenger moved one km. (Comparison by mode)



RESEARCH IMPERATIVES

There is a clear disconnect between current national imperatives and the ways forward being offered by the government's latest transport development policy. It is therefore imperative to look for alternative approaches towards provisioning for urban transport supply, and explore technologies and technology systems which not only offer the best value for capital invested but also carry the least carbon footprint. This could entail India building its own alternatives indigenously: alternatives to current mobility systems, mobility technologies, or the multimodal mix itself.

Traditionally, India has not explored promising mobility technologies that could solve its critical urban transport issues. Instead the country's policy has largely depended on supposedly 'proven' systems which have already, unfortunately, lived their lives. As the scale of travel demand and density in most Indian cities is massive, radical approaches need to be adopted.

The key question that must be asked is whether the country can save energy and capital in following a different approach, provide a scale of supply quickly enough to reverse the tide of private-vehicle-dependent mobility, and reduce avoidable inefficiencies in the multi-modal transport environment in the city. Furthermore, it needs to be examined whether India can find a mobility system that suits its peculiar requirements, and whether the country is capable of building mobility technology that is robust enough for the demand in question.

ALTERNATIVE FUTURE TRANSPORTATION TECHNOLOGIES

Across many parts of the world, urban policymakers are experimenting with three broad alternative approaches towards mobility systems of the future. These are the following:

1. Bus-based mass transport systems running as fixed route, high-frequency, high-capacity lines in the form of 'Bus Rapid Transit Systems' to operate within existing road right-of-ways.
2. Autonomously controlled driverless cars with vehicle-to-vehicle communication such as the 'Google driverless cars' meant to operate in mixed traffic conditions.
3. Driverless pods, autonomously driven on elevated tracks/guideways along existing right-of-ways or special alignments in the form of 'pod cars' or 'personal rapid transit (PRT)'.

The first two alternatives necessarily depend on the existing road right-of-ways to accomplish their objectives, but appear to entirely miss the point regarding 'non-scalability' of right-of-ways and perpetually growing number of vehicles. While the first attempts to address 'mass' transport, the second addresses 'personal' transport, with both alternatives necessarily constrained by the same ground space that they are supposed to run on.

The third alternative professes not to use right-of-ways, but provide personalised transportation with 'high mass transportation' system capabilities. On a per 'passenger-km.' travel basis, several conventional modes popularly perceived as efficient, rate poorly in comparison to the characteristics of the 'personal rapid transit system' or 'pod cars'. Calculations prove that a two-seat 'personal rapid transit system' powered additionally by solar panels can be more efficient, in terms of the fundamental parameters of lifecycle cost, energy and emission, than even travelling on an e-cycle. The two-seat 'personal rapid transit system' also promises to not only be 15 times more efficient than a petrol-run automobile in terms of energy, but be 55 times more efficient in terms of cost and emit 35 times less carbon in moving one passenger one km. in the system. Table 2 shows similar advantages of the 'personal transport system' over the conventional modes that have been historically under consideration.

THE 'MASS' IN CONVENTIONAL MASS TRANSPORT SYSTEMS

If the 'mass' in conventional mass transport systems relates to actual passengers moved over

Table 2: Unit cost, unit energy, and unit emissions in moving one person one km.

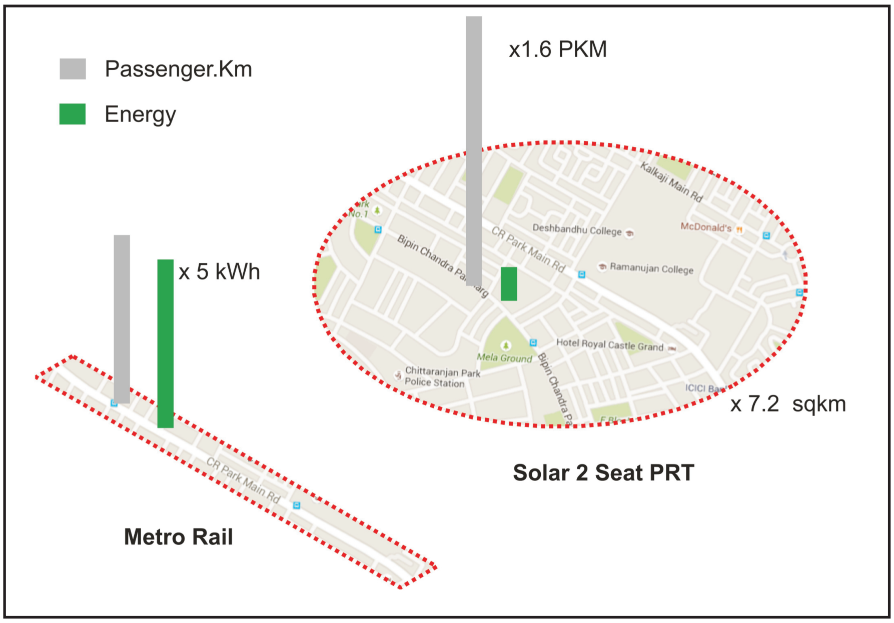
Type of System	Mode	Cost INR/Pkm	Scale	Energy KwH/Pkm	Scale	Emission gCO2/Pkm	Scale
Guided Systems	Metro Rail	1.2	2.1	0.05	4.5	29.73	5.9
	Metro Rail + Feeder	1.54	2.7	0.09	8.2	37.87	7.5
	Monorail	2.41	4.2	0.07	6.4	45.88	9.1
	Monorail + Feeder	2.7	4.7	0.1	9.1	53.00	10.5
	LRTS (Elevated)	1.32	2.3	NA		NA	
	LRTS (E) + Feeder	1.61	2.8	NA		NA	
	LRTS (At Grade)	0.89	1.6	NA		NA	
	LRTS (G) + Feeder	1.18	2.1	NA		NA	
	BRTS	1.8	3.2	0.16	14.5	42.10	8.4
	2 Seat PRT Solar	0.57	1	0.011	1	5.03	1
	4 Seat Pod Taxi[6]	1.17	2.1	0.15	13.6	125.41	24.9
Road based Systems	Buses	0.89	1.6	0.06	5.5	18.27	3.6
	4W-Electric	6.16	10.8	0.22	20.0	134.21	26.7
	4W-Petrol	8.91	15.6	0.61	55.5	172.22	34.2
	4W-Diesel	8.32	14.6	0.75	68.2	217.71	43.3
	4W-CNG	6.69	11.7	0.74	67.3	167.21	33.2
	3W-CNG	0.92	1.6	0.25	22.7	53.57	10.6
	2W	1.91	3.4	0.15	13.6	43.52	8.6
	E-bike	1.32	2.3	0.03	2.7	22.39	4.4
	Cycle	0	0	0.02	1.8	21	4.2
	Walk	0	0	0.06	5.5	0	0

respective distances, the true capability of the mass transport system should not only highlight this metric but also consider comparing the last-mile service coverage, energy efficiency, and in-vehicle transit time (IVTT). Calculations made for this paper show that for the same capital expenditure in a mass transit system like a Metro, an efficient PRT system infrastructure can be installed to service 7.2 times the geographical area the metro system can service (because of stations distributed across the geographic area enabling last-mile connectivity). Such a PRT system can service approximately 1.6 times the number of concluded 'passenger km' serviced by the metro system. In addition, it can potentially do the job at 20 percent the energy spent for doing the same work otherwise, considering energy consumed by either systems on a lifecycle analysis basis, besides enabling commuters to complete their journeys in almost half the time required otherwise (See Figure 6).

THE 'SMART CITIES' PROGRAMME

The government initiated in the middle of 2015 the 'Smart Cities Mission'[7]. While vested interests supporting the status quo in transportation systems and mobility technologies might scuttle questions on the 'business as usual' system selection methodology or city mobility planning, India, through its relevant ministries, should be

Figure 6: Mass transport capability of an efficient PRT systems vs. conventional line system: Last-mile access, energy consumption, and utilised capacity.



interested in scrutinising the same in light of the facts presented in this paper and the expansive programme that the GOI has embarked upon. A new approach is required in planning for mass transport and/or allocating mode share for candidate systems in existing as well as future 'smart cities'. Smart cities should not only look good, but function equally efficiently from a holistic and environmentally sound point of view.

Notable being the fact that the automobile being the worst mobility technology of the lot, a concerted inter-ministerial approach is required to be taken for rationalising the growth of the automotive sector vis-à-vis reforms in urban transport and quality of living in urban areas. Urban areas, after all, are key drivers in any progressive economy; they can no longer afford to be inundated with automobiles and low-efficiency mobility systems. Most city master plans had never anticipated such an influx of personalised modes, especially in the form of automobiles, and therefore a clear but bold approach needs to be adopted with a view on reducing the ill effects of automobiles from urban areas.

WAY FORWARD

A review of the National Urban Transport Policy (NUTP) has been undertaken. The review evaluated the progress of the programmes initiated under the preceding policy, but has not made any attempt to look at the policy itself and/or its future-proofing.

It would have been opportune to include the following policy aspects for consideration in the latest document:

- Formulation of mode share equations for any city should be based on 'well-to-wheel' energy utilisation and least cumulative 'wastage' of unutilised capacity.
- Considerations of 'spatial reach' of each mass transit system vis-à-vis its capacity utilisation potential should be taken into account during any system selection/introduction exercise for urban areas.
- The maximum share of right-of-way surface capacity needs to necessarily be reserved for zero-carbon, low-energy-consuming systems and slow modes.

Moving forward, these will ensure the following for India's bourgeoning cities:

- Modes consuming the highest energy or utilising the least capacity are necessarily limited in the city.
- Future urban transportation is built around the sound principles of equity, sustainability and efficiency.

- By using the air space over existing master plan right-of-ways for new efficient mobility systems in the form of 'personal rapid transit' that are low in lifecycle energy and operational cost, economical in space, and low in GHG emission, a substantial shift of more than 40 percent from road-based mechanised modes in favour of these new modes as suggested by some studies can be expected.
- In tangible terms, at-grade mobility channels within the right-of-way shall be reclaimed and restored for pedestrians, cyclists and non-motorised transport which comprise more than 45-50 percent of all urban trips.
- Substantial energy savings from reduced fuel consumption, along with the resultant reduction in GHG emissions from liquid fuels, can be expected.
- The currently substantial fuel import bill stands to be reduced, thus allowing for significant savings for the national exchequer. These savings can be utilised for social and environmental programmes.

In particular, it would do well for the concerned government agencies to set up an inter-ministerial committee to review the automotive policy with a view on the automotive sector being an important economic driver for the country vis-à-vis considerations of urban living, safety and health issues from transportation-based pollution, mobility environment for zero-carbon, low-energy and non-mechanised modes.

Further, a central committee is required to be set up to search for, promote and establish technologies that can provide relief to the already worn-out urban mobility infrastructure and help future-proof India's cities against the ill effects of such strain. ORF

ABOUT THE AUTHOR

Anupam Vibhuti is an Architect and Town Planner specialising in Transportation Planning, currently working on building an indigenous PRT system.

ENDNOTES

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2. National Transport Development Policy Committee, India Transport Report: Moving India to 2032, Volume 3 Chapter 5 Urban Transport Annexure B 3(b) New Delhi: Routledge.
3. Computations were carried out by the author based upon the conception of a Personal Rapid Transit system as conceived and designed by the author partially powered by solar energy.
4. A well-to-wheel analysis (also known as life cycle assessment, life cycle analysis, life cycle inventory, ecobalance, cradle-to-grave-analysis, material flow analysis and dust-to-dust energy cost) is the assessment of the environmental impact of a given product or service throughout its lifespan.
5. Recent press news quoted DMRC claim of 30 per cent capacity utilization (Metro Rail News, 'Delhi Metro: Exclusive media interview with DMRC Chief Dr. Mangu Singh', 28 July 2015).
6. A commercially functional 4 Seat PRT system exists at Heathrow airport between Terminal 5 and the parking lot. Under a re-tendering process by the Punjab Industrial Development Board, Government of Punjab, efforts are being made to develop a similar system for the city of Amritsar.
7. Smart Cities Mission is an urban renewal and retrofitting program by the Government of India with a mission to develop 100 cities all over the country making them citizen friendly and sustainable.A total of INR 980 billion (US$15 billion) has been approved by the Indian Cabinet for development of 100 smart cities and rejuvenation of 500 others.

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