



Mitigation Policy Packages For Transport Sector - Mumbai Metropolitan Region

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List of Abbreviations

BEST	-Brihanmumbai Electric Supply and Transport
BMC	-Brihanmumbai Municipal Corporation
CTS	-Comprehensive Transportation Study
EEH	-Eastern Express Highway
Emp	-Employment
GoI	-Government of India
JVLR	-Jogeshwari Vikhroli Link Road
LU&LUC	-Land Use and Land Use Change
MCGM	-Municipal Corporation of Greater Mumbai
MMR	-Mumbai Metropolitan Region
MMRDA	-Mumbai Metropolitan Regional Development Authority
MoUD	-Ministry of Urban Development
MUIP	-Mumbai Urban Infrastructure Project
MUTP	-Mumbai Urban Transport Project
Pop	-Population
RoR	-Rest of the Region
TDM	-Travel Demand Model
TERI	-The Energy Research Institute
WEH	-Western Express Highway

1. Introduction:

Mumbai is ranked as one of the top 10 most vulnerable coastal cities in the world (R. J. Nicholls, 2008) In this study, we formulate policy packages for undertaking climate change mitigation strategies in the transport sector of Mumbai Metropolitan Region. The report is structured in three sections.

Section 1 provides the introduction to Mumbai's demography, transport and climate systems.

Section 2 presents the literature review of the policy approaches for mitigation in the transport sector. It elaborates on the existing and proposed policies that can aid the process of mitigation in MMR.

Section 3 emphasises on the selected mitigation policy packages feasible in the context of MMR, their incorporation in the Travel Demand Model and evaluation of impacts.

1.1 About Mumbai:

Since its conception, Mumbai (formerly known as Bombay) has been one of the major trading centres in Indian peninsula due to its strategic territorial advantages. By the middle of 18th century, it received huge influx of migrant population from across India and continues to remain one of the most populous cities of the world. In 1872, Mumbai was reshaped by the reclamation of seven islands to form a single large landmass which has expanded rapidly in neighbouring geographies. Starting with 1 Municipal Corporation (Greater Mumbai), 13 Municipal Councils, 24 Census Towns and 1166 villages in 1981, the numbers grew and MMR, as we know today, has a total of 8 municipal corporations, 9 municipal councils, 35 census towns and 994 villages in MMR. It has a geographical spread of 4355 sq. km and a population of about more than 23.13 million with almost 92% of the population in MMR is urban population. (Census 2011). The sex ratio of female to male in Mumbai Urban Agglomeration was found lower with the figure of 863 females against national urban average of 926 females per 1000 males.

Economic growth is one of the key driving forces for the growth of a city. Being the finance capital of India, Mumbai aspires to be the global finance sector. The GDDP of MMR has been steadily increasing with a CAGR of 14.92% as per Economic Survey of Maharashtra 2011. However, 41.3% of Mumbai households i.e 54% of the population lives in slums occupying only 6% of total land (Census 2011).

1.2 Transport System:

MMR is historically heavily dependent on public transport and walking as a mode of transport. Over 40% of workers in MMR reach their workplace on foot resulting in almost 52% of the total trips per day using walking as a primary mode of transport.

Suburban local trains form the lifeline of Mumbai's North-South transport. The average trip length of train commuters is very high, almost 24km by owing to the unaffordability and restricted supply of housing in and around Central Business District of MCGM. Mumbai suburban railway network covers over about 400 km route network (280 km of Central Railway and 120 km of Western Railway) with 7 million average weekday passenger trips catering at extremely low fares.

In MMR, buses carry 26% mode share of public transport (except walk trips) which attributes to 3.55 million trips if feeder service is not considered. Brihanmumbai Electric Supply and Transport (BEST) along with other municipal public transport undertakings hold a fleet strength of 7544 buses on 5700 routes. In 2005, contract carriers increased from 7396 to 10633 and school buses increased from 912 to 1248. The growth of stage carriers, private contract carriers and school buses in MMR indicates that the public buses are losing their share of public transport. (LEAassociates, 2008)

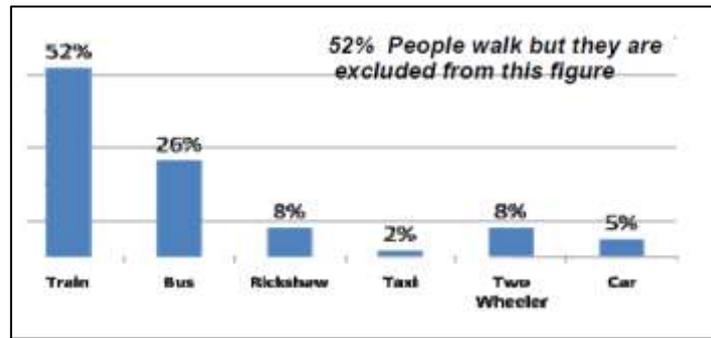


Figure 1 Modal Share - MMR (LEAassociates, 2008)

Intermediate Public Transport like autos and taxis play an important role in accommodating travel demands and providing access to trains and buses. Within Greater Mumbai, island city has the highest percentage of cars while eastern suburbs have the lowest. It is observed that during 1996-2005, the proportion of cars is decreasing in the Greater Mumbai whereas it is increasing in rest of the MMR (RoR) (LEAassociates, 2008).

On the front of external travel, about 16% of the total freight movement is through-traffic. Mumbai Port and Jawahar Nehru Port are two of the 12 major ports in India. Though Maharashtra is the main hinterland for these ports, Mumbai itself accounts for almost 28% of total traffic originating from the ports. As the railways are already overcrowded by passenger traffic, most of the port evacuation happens by road.

1.3 Climate System.

Situated at the foothills of Sahyadris and on the coast of Arabian Sea West and Thane creek (East), both these factors substantially affect the climate of Mumbai. The average annual rainfall is usually around 2000mm whereas the average minimum and maximum temperatures are around 22°C- 23°C and 30°C and 31°C respectively. Much of Mumbai's area is close to sea level.

It is well documented how the impacts of climate change will result in sea level rise across the globe. It will severely affect the low elevation coastal cities as they inhabit almost 13% of world's population. Mumbai has already witnessed erratic climate variations. On 26th July 2005, Mumbai (Santa Cruz Meteorological Centre) recorded 944 mm rainfall in 24 hrs, a 1 in 100 years event, resulting in massive flooding and heavy storms in the MMR. Roads and railway lines at many places were under water for more than 24 hours. The rail and road traffic came to a halt. The airport was also closed on account of water logging and climatic reasons.

To understand the vulnerability of Mumbai to climate variability, (Nicola Ranger, 2010) attempted to quantify the flood hazards in Mumbai in terms of future precipitation projections for the 2080s taken from the PRECIS model; a high-resolution regional climate model based on HadCM3. The Fig 2 demonstrates that by the 2080s, the intensity of extreme rainfall could be increased at all return periods. For the shorter return period (more frequent) events, the increase is particularly strong. For example, the intensity of a 2–5 year return period event is almost close to double for the scenario under consideration i.e. SRES A2 scenario.

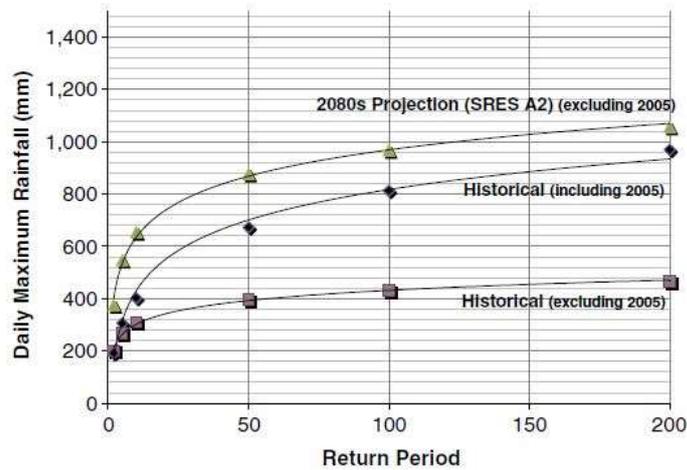


Figure 2 Estimates of the return period of daily maximum rainfall at Santa Cruz historically and in the 2080s (under a high-end scenario). (Nicola Ranger, 2010)

The analysis indicates that the return period of 944mm rainfall in a day i.e. of July 2005 scale is reduced to around 1-in-90 years in 2080 under this scenario. Though this analysis does exhibit several limitations and is based on only one climate model, these results indicate Mumbai's high sensitivity to flood risks in future. It is difficult to attribute the increase in temperature in a region to specifically climate change, as there can be various factors causing a temperature increase in a complex urban environment like Urban Heat Island and LU&LUC. However, the graph made by analysis in Environmental Status Report (TERI, 2015) clearly indicates the shifting averages of the minimum as well as maximum temperatures in Mumbai region. Post-1990s, MMR is experiencing new higher averages for both minimum as well as maximum temperature.

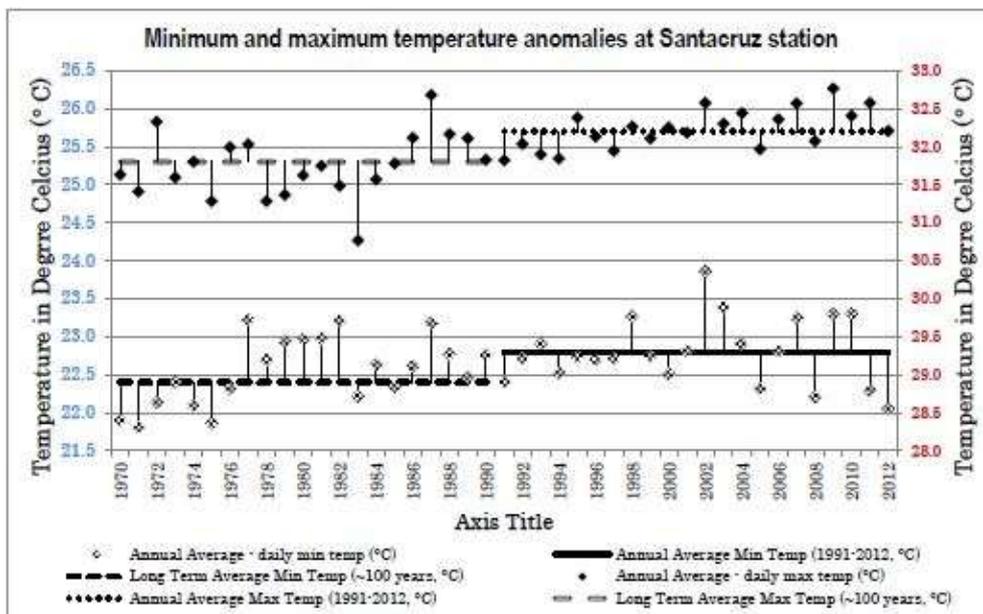


Figure 3 Min and Max temperature anomalies at Santacruz station, (Environmental Status Report)

2. Policy Approaches for Climate Change Mitigation in Transport sector for MMR

Climate change mitigation refers to efforts to reduce or prevent the emission of greenhouse gases. Air Quality Assessment, Emissions Inventory and Source Apportionment Studies report for Mumbai sponsored by Central Pollution Control Board and prepared by National Environmental Engineering Research Institute in 2010 (NEERI, 2010) attribute vehicular emissions as one of the primary reasons for CO₂ emissions in the city.

Apart from accommodating increasing travel demand due to increasing population and economic growth, the transport sector also has various other challenges of reducing traffic congestion, accessibility, affordability and decreasing vehicular emissions. Various policy approaches are available to make a conscious transition towards a cleaner, sustainable transportation within the city. No one approach is feasible and sufficient to achieve the goal. Therefore, a combination of policy measures, benefitting all sections of the society at different levels, needs to be designed for a short term and long term basis.

The policy approaches can have three main components:

Avoid: Avoid refers to improving the efficiency of the system by avoiding the necessity to travel long distances for any purpose. It entails definitive and purposeful changes in the land use policy to integrate social, economic and cultural opportunities of the people along with efficient use of land resources.

Shift: The main objective of this policy approach is to encourage a mode shift from personal vehicles to more space-efficient modes of transport such as non-motorised modes like walking, cycling and public transport. That is, in other words, the most energy consuming modes (private vehicles) to more environmentally modes (higher occupancy, low energy consumption per km)

Improve: The last policy strategy is to promote Research and Development of vehicle technology aimed at enhancing fuel efficiency, reducing emissions and operating efficiency.

AVOID	SHIFT	IMPROVE
<ul style="list-style-type: none"> ● Integrated Land Use and Transport policy 	<ul style="list-style-type: none"> ● Road User Charge policy <ul style="list-style-type: none"> -Congestion Pricing -Premium on car ownership -Proof of availability of car parking at residence and at workplace -Encourage car pooling -Car restricted zones/ car –free days -Promote walking and cycling ● Parking Policy <ul style="list-style-type: none"> -Park and Ride: Provision of parking spaces for PVs and IPT at railway stations -Differential parking charges ● Public Transport <ul style="list-style-type: none"> -Bus Transport: Dedicated bus corridors on JVLR, WEH, EEH; BRTS -Public Bicycle sharing by MoUD ● Passenger Water Transport- 	<ul style="list-style-type: none"> ● Investments in Public Walking and Cycling Infrastructure ● Alternative Fuel Use <ul style="list-style-type: none"> -More availability of CNG kits for auto rickshaw, cars -Promoting use of more electric and hybrid vehicles under National Electric Mobility Mission Plan, 2013 -Increase in conventional fuel costs ● Fuel Standards <ul style="list-style-type: none"> - Improvement in Fuel Standards - Stricter implementation of PUC certificates

	-Government of Maharashtra providing East Coast PWT connecting Gateway of India to Mandwa, JNPT, Nerul, Belapur, Vashi through Mumbai Port Trust	● Public Buses and local trains-online tracking and ticketing system
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2.1 'Avoid' Policy Measures Integrated Land Use Policy-

With distinctively different development options and growth scenarios available for the Greater Mumbai and Rest of the Region (RoR), various future scenarios can be built for the road and rail transport systems in MMR based on costs, time of travel and emission reduction needs.

There are two extreme possibilities based on extreme intensification of Greater Mumbai or complete shift of future growth away from Greater Mumbai, as also mentioned in the comprehensive transport study (CTS) for MMR,

1. Greater Mumbai would continue its primacy over RoR and attract all new investments and creation of jobs.
2. On the other extreme, with proposed SEZs and other low-polluting industries and creation of transportation infrastructures like a second international airport, third port, expressways and other transit links, there will be more greenfield development in RoR, employment generation and associated population growth.

There could be many possible scenarios between these two due to uncertainties of transport strategic investments and land use constraint. Therefore, CTS proposes that from 2005 to 2031, the population of MMR will increase from 20.8 million to 34 million and the population and employment distribution can take places as per various scenarios illustrated in Fig 4 shows 3 most possible scenarios shortlisted based on the expert opinions.

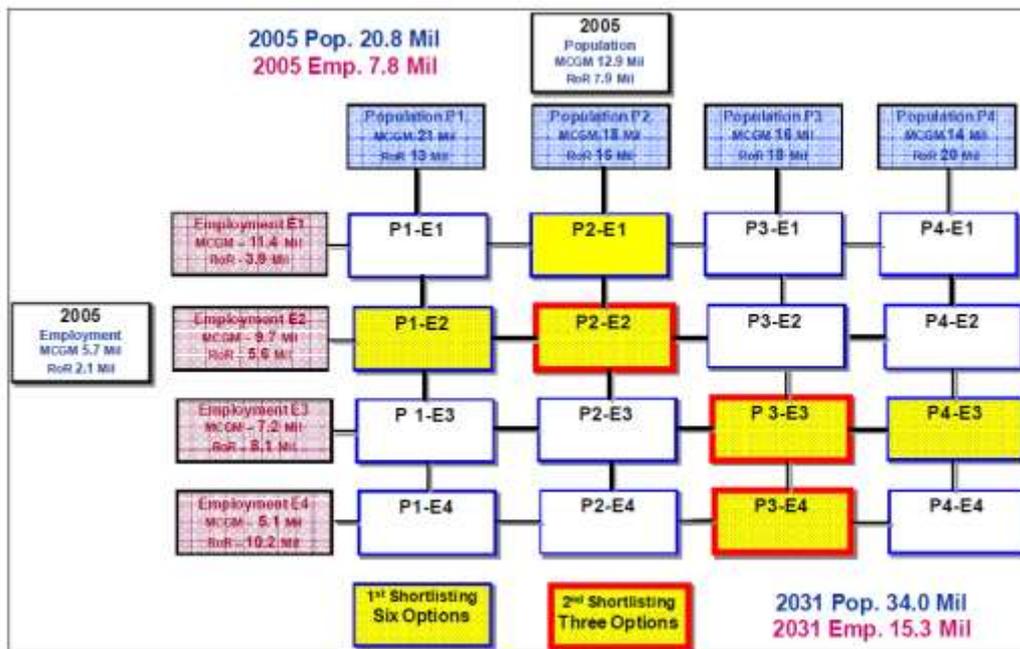


Figure 4 Population Employment Matrix: Shortlisted scenarios, CTS (LEAassociates, 2008)

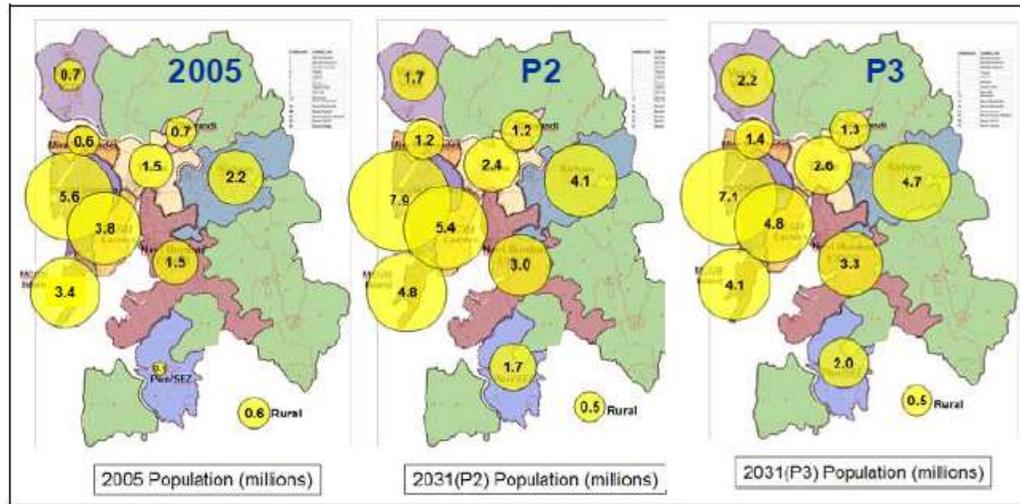


Figure 5 Population Distribution Matrix, CTS (LEAassociates, 2008)

However, MMR Regional Plan for 2016-36 (MMRDA, 2016) mentions that in the post-CTS period, it is evident that population growth is going to be substantially less and the Special Economic Zones in Uran-Pen region which were supposed to draw population out of MCGM are not implemented as envisaged. The RP predicts future growth might be concentrated in Vasai-Virar, Mira-Bhayandar, Badalapur and Navi Mumbai areas unlike in Uran-Pen SEZ areas as predicted by CTS.

The Regional Plan of 1996 had expected growth to be concentrated along transport corridors i.e road and rail systems. Therefore, to effectively manage the development, the Regional Plan of 2010-36 focuses on 4 planned growth centres and 7 Special Planning Authorities as per proposed land use zoning. The objective of such proposals is to bring jobs where people live, boost the economy and generate employment.

Recognising the transit needs for the new industrial corridors, following proposals are underway:

1. Suburbanisation of all existing rail tracks
2. New Suburban rail networks
3. East-West Connectivity with new tunnels and creek bridges
4. Improving North-South connectivity through Coastal Roads and Multi-modal corridors.

Integrating urban development and land use changes in the transport policy is crucial of mitigating the emissions originating from vehicular traffic. Mumbai is looked at as a sea of economic opportunities and economic growth has always driven the urban development in Mumbai. Affordable and accessible transport has always played an instrumental role in the development of Mumbai. Therefore, integrated land use and transport planning to provide better access to jobs, goods and services while providing facilities for users to avoid motorised trips by planned land use zoning can be instrumental in reducing the vehicular emissions in the coming future.

2.2 'Shift' Policy Measures:

Road User Charges:

Congestion Pricing:

There have been various recommendations on the issue of congestion pricing in Mumbai at various points in the past couple of decades. The 11-member panel, The High Power Committee (HPC) formed under the chairmanship of Dr Amitabh Rajan, additional chief secretary of home department, appointed on the instructions of the Bombay high court submitted a 51- point action plan in March 2013. It had two ideas for imposing the congestion levy on car users. One, a congestion charge to restrict the number of vehicles in certain areas, including the city's central business districts, and two, congestion pricing on certain goods in select zones. Together, these two measures "could be a possible

solution for reducing vehicle density on congested roads", the panel said, suggesting a two-to-three-year timeframe for the introduction of congestion charges. But no concrete action has been taken since then. (Moneylife, 2013) (India Express, 2013).

In 2013, the Ministry of Urban Development (MoUD) Secretary had written a letter to the chief secretaries of states to reduce traffic during peak hours. He recommended an introduction of 'congestion charge' in cities. The letter explained that it is to "charge a price in order to allocate a scarce resource to its most valuable use". It suggested a manual permit/ coupon system similar to early attempts in Singapore when it attempted congestion pricing for the first time.

The Mumbai City Development Plan 2005-25 laid out a Strategy for Transportation keeping in mind that it is essential that Travel Demand Management measures are coupled with improvements in Public Transport systems without which the shift from private vehicles to public transport cannot be expected. Singapore and London have successfully implemented demand measures like congestion pricing, Low Emissions Zones, parking policy but they first improved public transport prior to implementing these measures. In addition to that measures like premium on car ownership and proof of availability of car parking at the residence and at the workplace can also be implemented.

Car Restricted Zones or Car-free zones: Car free day was celebrated in Mumbai for 4 consecutive years from 2010-14 in Bandra and Churchgate. However, the initiative by various non-governmental organisations failed to gather much steam because of the mismanagement of traffic. The initiative organised several activities, such as music performances and games for every age group, it ended up in major traffic blockage and air and noise pollution in the adjoining areas. For the more successful implementation of such activities, key city officials, traffic police need to manage the task on a broader scale with proper transportation planning.

Car-Pooling: Mumbai Environmental and Social Network was the first NGO in the country which launched a car pool system in the Mumbai called Kool Pool in 2006. Many other commercial platforms and cab services like Ola and Uber now provide car sharing options for users at affordable rates.

Parking Policy:

Car ownership in Mumbai is fairly low (32 cars per 1000 persons) as compared to other Asian cities with similar densities (LEA Associates 2008). On street parking, has become one of the major concerns resulting traffic jams and congestion on the roads which essentially leads to more fuel combustion and emission from the vehicles. Easy availability of off street parking also doesn't actively present itself as a deterrent for car ownership. Therefore, regulation of parking spaces has become an important issue in the transport policy of Mumbai.

Mumbai, as mentioned earlier, has extremely high public transport ridership as compared to other Indian and Asian cities. Therefore, it is important to provide parking spaces for feeder system integration with rail and metros but also keep in mind to avoid overprovision which can cause congestion. The Mumbai DP currently follows a "conventional approach" of overprovision based on projected demand (EMBARQ, 2014)

However, after a long court stay order, BMC has started the implementation of differential parking fees across Mumbai except for a few designated tourist spots and public places. The city has been divided into three categories--A, B and C, for applying differential parking rates. The most crowded places attract highest parking fee. For example, it will cost Rs. 60 per hour to park a car at Kala Ghoda (category A) but a third of that near Shoppers Stop on Ghatkopar-Mahul Road (category C). All rates will be different on Sunday, public holidays and depending on the time of the day.

Better Bus Service: BRTS

(MUTP, 2016) undertook major transport sector projects in Mumbai. As Mumbai has restricted space for new roads infrastructure, faster traffic on existing roads becomes a priority. Keeping this in mind Mumbai has plans to implement Bus Rapid Transit System (BRTS) with dedicated bus lanes to improve

connectivity and to attract more commuters. Dedicated Bus corridors were suggested for various multi-lane highways like Jogeshwari- Vikhroli Link Road, Santacruz- Chembur Link Road, Western Express Highway and Eastern Express highway.

Experts believe the system will help reduce the number of cars on the roads, as it provides a comfortable and faster alternative to car travel, at a cheaper rate. It will increase capacity, reduce delays and promote more reliability among bus commuters which has been a primary concern for BEST (Hindustan Times, 2016)

Water Transport:

Maharashtra Maritime Board (MMB), the City and Industrial Development Corporation (CIDCO) and Mumbai Port Trust (MbPt) are jointly working to implement the long-pending water transport system in Mumbai. Terminals will be constructed at Ferry Wharf, Mandwa and Nerul which currently take around 2 hours travel by road from South Mumbai. The distance can be covered in 15-20 mins by ferry and Ro-Ro (roll on/roll off) ships.

The CIDCO terminal at Nerul currently only caters to passenger traffic. However, the Ro-RO ships will be used for vehicular transport also providing motorists with an alternate route from Navi Mumbai to Mumbai. The project is aimed to ease the burden on highways and save commuters from traffic jams and air pollution effects (Indian Express, 2016).

2.3 'Improve' Policy Measures:

Improvement of NMT Infrastructure

As already mentioned, over 52% of all work trips in Mumbai are done on foot. Therefore, it is crucial to promote safe and secure walking environments. Non-motorised transport (walking and bicycling) are also important modes of feeder system along with autos and taxis.

Conventional transport planning has focused on the movement of vehicles rather than the movement of people in Indian cities. The majority of low-income classes still prefer walking and cycling to reach their destination in Mumbai (Judy Baker, WB report) for distances less than 3-4 km. NMT modes are environmentally friendly, healthy options which also provide flexibility and affordability. In spite of this, physical conditions of roads and other necessary infrastructure are abysmally low in Indian cities. Mumbai is no exception. Pedestrian footpaths, sidewalks, traffic signals, cycle lanes, cycle routes, cycle signals, cycle parking and cycle sharing need immediate attention at planning and policy levels.

NMT guidelines by MoUD in 2016 (Ministry of Urban Development, 2016) acknowledge that most of the captive cyclists in India belong to low-income group and there is an aspirational value attached to car ownership. However, there is a need for disassociation of the social stigma and promote new road facilities for promoting the sustainable, environmental friendly Non- Motorised modes of transport.

Alternative Fuel Use

As per IEA report 2009, fossil fuel based transportation is the second highest source of CO₂ emissions globally. Therefore, globally this has become an increasing concern towards developing vehicles based on alternative, low carbon electric energy derived from renewable energy sources.

Hybrid and Electric Vehicles

The government of India launched the National Electric Mobility Mission Plan 2020 in 2012 (Department of Heavy Industries, 2012). It aims to achieve national fuel security by promoting hybrid and electric vehicles in the country. Greater adoption of electric vehicles as one of the key initiatives by the government is likely to have substantial CO₂ emission reduction. As this is new technology in India,

Biofuel:

Ministry of New and Renewable Energy (MNRE) and the Cabinet approved the National Biofuel Policy which targeted 20% blending of bio-fuels by 2017. The policy gave due consideration to various aspects like food security, meeting of energy needs, involvement and development of local communities etc. National Biofuel Coordination Steering Committee provided innovative recommendations such as the provision of contract farming, Minimum Support Price must be at par with other agricultural items etc. to avoid key challenges of food security and sustainability. However, further research needs to be undertaken with respect to commercial viability, wasteland use and other socio-economic and environmental consequences.

Transition to CNG Vehicles:

By 2016, India had 2.8 million Natural Gas Vehicles on the roads. The NGV programmes have huge potential in the transport sector in India as currently the expansion of natural gas grid and access to natural gas is still a hindrance for most of the cities. The India's NGV programmes were focused to retrofit the most polluting diesel buses, three-wheelers, taxis and small commercial vehicles. Though fuel consumption of three-wheelers is much lower compared to cars, the CO₂ emissions of the retrofitted three-wheeler models are comparatively higher than the diesel and petrol counterparts (Roychowdhury, 2010).

Fuel Standards

Under the Mumbai Urban Transport project (MUTP, 2016) funded by World Bank, BEST procured 644 low emission and user-friendly buses to replace used or over-aged buses, to provide additional seats for users and to improve the service quality. Originally the target was 450 but was increased to 644 at restructuring. The acquired buses were newer EURO III compliant, single-deckers with reduced noise levels and better emission control. Older buses were upgraded to slightly lower EURO II standards.

Improvement in Technology

A catalytic converter is a vehicle emissions control device which converts toxic by-products of combustion in the exhaust of an internal combustion engine to less toxic substances by way of catalysed chemical reactions. Though such converters are known to reduce pollution, they add to more CO₂ emission. More research and development needs to be undertaken in this direction.

Auto Fuel Vision Policy 2025: The mission statement of Draft Auto Fuel Vision and Policy 2025 (GoI, 2014) says "To develop an auto-fuel vision, road-map and an enabling policy framework, going forward to the year 2025 that aims to minimise the contribution of vehicular use to (primarily) urban air pollution in the shortest possible time frame and to do so in a financially sustainable manner." Green House Gas (GHG) emissions are more-or-less another way to express fuel use efficiency. In the wake of climate change, many countries around the world have undertaken the mission to improve fuel emissions i.e. to propose GHG emission standards.

In line with the Auto Fuel Policy, India 2000 norms were implemented nationwide in the year 2000, Bharat Stage II came in 2003 and Bharat Stage III auto fuel quality norms came into existence from April 2010 for 13 major cities initially and then in rest of city. Similarly, BS IV and BS III auto fuel quality norms came into effect from April 2010 in 13 major cities and in the rest of the country respectively.

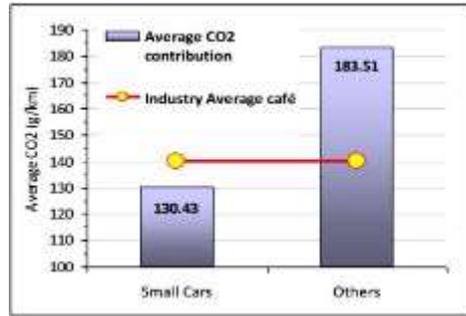


Figure 6 CO₂ contribution by vehicle type, Auto Fuel Vision Policy 2012

Auto fuel vision policy (GoI, 2014) makes an interesting observation that small vehicles affect the Overall Corporate Average Fuel Efficiency of the Auto industry in a positive manner. The figure, based on industry performance in 2010, shows that the average CO₂ emissions from small cars is 30% lower than that of other cars which suggest that there is a need to promote smaller cars on Indian roads.

BEST- Online Ticketing and Tracking System –

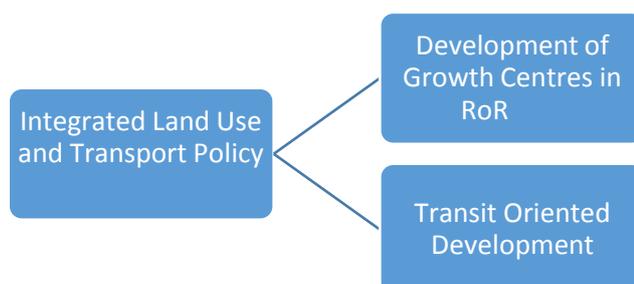
BEST has made plans for Mumbai bus commuters to avail the use of two mobile apps to book bus tickets online and track their bus in real time. BEST has been incurring losses close to 900 crores since 2014 due to the unreliability of bus services. There is an easy transition from bus to intermediate public transport such as taxis and autos as buses couldn't follow strict time schedules. In order to prevent such transition and promote sustainable, high-occupancy bus transport instead of using private vehicles, BEST has decided to go digital. Such cashless transactions will promote more reliability and convenience for bus commuters (IndianExpress, 2016).

3. Proposed Policy Packages for Transport Sector Mitigation in MMR

It can be concluded from the detailed literature review and expert opinions that Land Use and Land Use Changes, Public Transport Infrastructure, Parking Policy, Congestion Pricing, and promoting Cycling are some of the important interventions for mitigation in Mumbai.

3.1 Integrated Land Use and Transport Policy

Policy Package 1



The main objective of this policy package is to provide a spatial framework for future urban development in MMR to create liveable communities with better access to transport infrastructure. It will focus on new development to distribute the population and employment opportunities across the city and decongest the central business district of MCGM.

3.1.1 Development of Growth Centres:

Planned growth centres can be developed in the green field areas of Municipalities other than MCGM in MMR (MMRDA, 2016) The movement of goods and people in the city is the consequence of land development and transport network which will change according to this policy package which will decongest MCGM in future.

Fig. 7 illustrates the important locations for Growth Centres and Regional Industrial Corridors as mentioned in Mumbai Metropolitan Regional Plan 2016-36 (MMRDA, 2016). They are as following

Sl. No	Location	District	Village Name	Area (sq km)
1	Vasai	Palghar	Nallasopara, Vasai- Virar Municipal Corporation	6.18
2	Kharbav, Bhiwandi	Thane	Kharbav, Malodi, Paye, Paygaon, Nagle, Thane Municipal Corporation	13.08
3	Nilje, Kalyan	Thane	Bhopar , Sandap, Hedutane , Gharivali , Usarghar, Katai, Nilje, Kole	10.83
4	Shedung, Panvel	Raigad	Ajiwali, Barwai, Bhingar, Bhingarwadi, Borle, Khanavale, Mohope, Poyanje, Sangde, Shedung	5.77
Total area				35.86

Figure 7 Details of Proposed Growth Centres, (MMRDA, 2016)

Sl. No	Location	District	Village Name	Area (sq km)
1	Bhiwandi-1	Thane	Angaon, Nivali, Supegaon	4.09
2	Bhiwandi-2	Thane	Sape, Vahuli, Borivali Tarf Sonale, Bhoirgaon, Kukase, Amane	5.43
3	Virar	Thane	Bhatpada, Kopri, Vasai-Virar Municipal Corporation	12.48
4	Taloje	Raigad	Chindharan, Mahodar, Kherane Kh., Nitalas, Vavanje,	4.12
5	Khopoli	Raigad	Talawali, Anjrun, Ghodivali, Kandroli Tarf Boreti, Kelavali, Khalapur, Mankivali, Navandhe, Wangani	8.39
6	Along Amba River	Raigad	Bahiramwatak, Beneghat, Borwe, Khar Borli, Kolave, Masad Kh, Masad Bk, Masad Beli, Narvel, Sarebhag, Shirki, Shirki Chawl No.1, Wadkhal, Wave, Washi, Dherand, Mankule, Narangi, Shahabaj, Shahapur	32.90
7	Khopota	Raigad	Aware, Bandhpada, Dhasakhosi, Govthane, Jui, Kacherpada, Koproli, Pale, Pirkone, Sangpalekhar, Talbandkhar, Vindhane	10.85
Total area				78.26

Figure 8 Details of proposed Regional Industrial Corridors, (MMRDA, 2016)

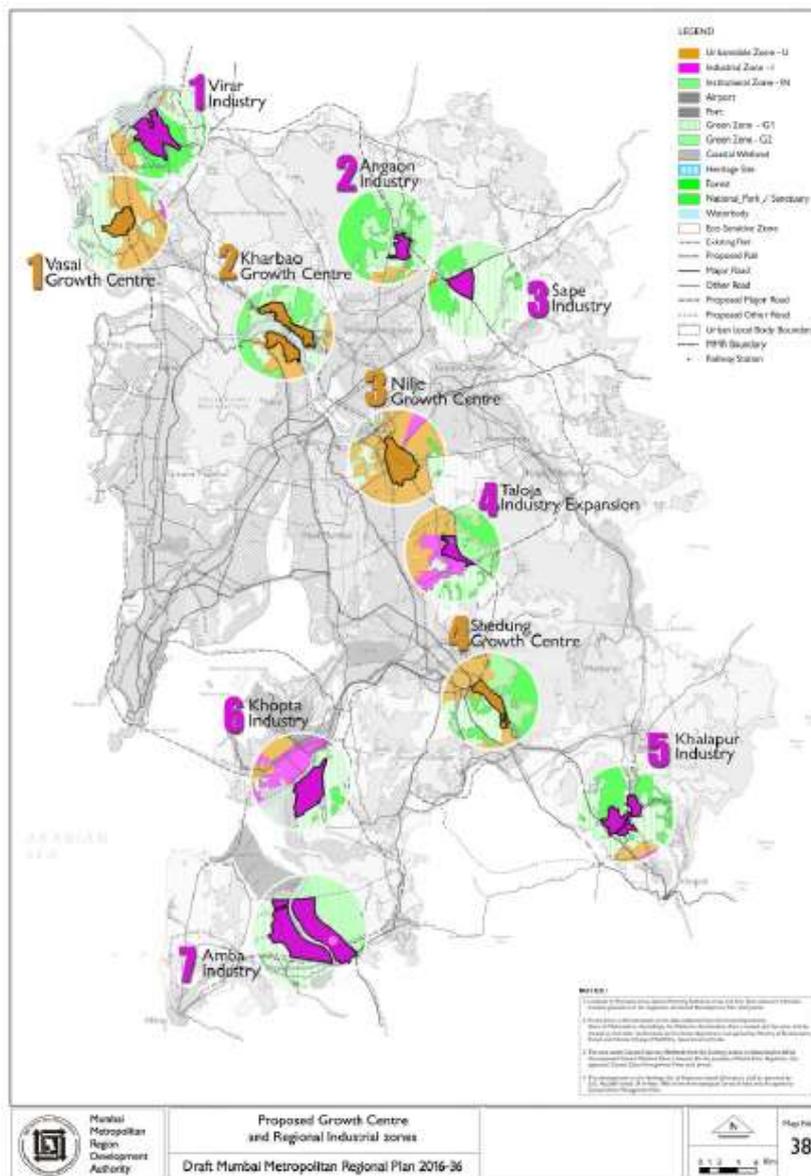


Figure 9 Proposed Growth Centres and Regional Industrial Corridors in MMR, (MMRDA, 2016)

3.1.2 Transit Oriented Development

A comprehensive Transit Oriented Development involves various components like compact development around transport networks, promote transit-friendly land use, build more public spaces etc. basically to encourage maximum use of public and non-motorised transport modes in the city. A typical TOD design will have high-density settlement around the train/metro/bus stations with a subsequent decrease in density as you move away. MMR has already been heavily dependent on public transport and has exhibited signs of Transit Adjacent Development (TAD) in various parts of the city. (EMBARQ, 2014)

The same strategy with a necessary provision in Development Control Regulations needs to be carried out in newly developing areas with better provision of walking and cycling infrastructure for pedestrians and cyclists to feel safe on the road. Also, on-street parking provisions in the areas should be restricted and provision of parking for IPT and buses should be done to promote high occupancy vehicle use. It is proposed in RP to permit intensive development around such rail or metro stations when they become operational in the form of Station Area Development Scheme (SADS) similar to gothan areas or village areas in newly developing green field areas.

The development of growth centres will provide jobs and drive economic growth in the outer city areas. Along with TOD, it will largely affect the horizon year population and employment distribution in the future. With the mixed land use of commercial, industrial and residential areas, the trip generation will be affected. The origin- destination of trips will be altered. Also, the long travel time which is the characteristic of Mumbai local train journeys will be substantially affected. Fig.10 demonstrates the conceptual methodology of incorporating the policy package 2 in the Travel Demand Model.

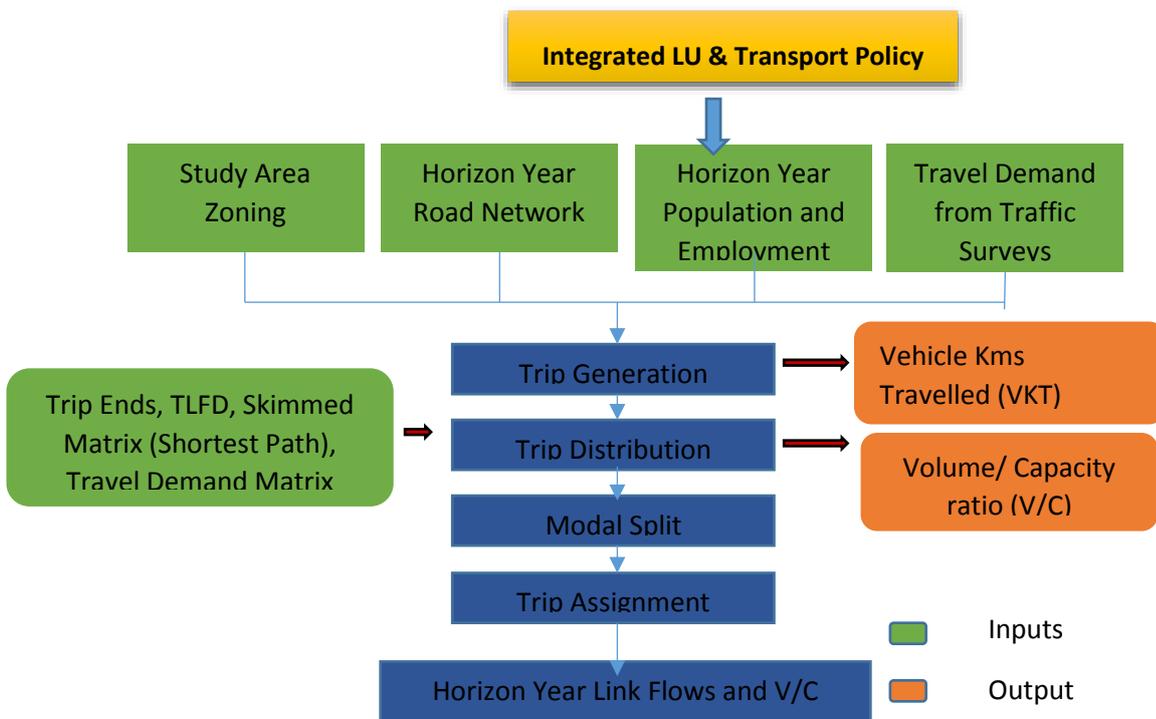
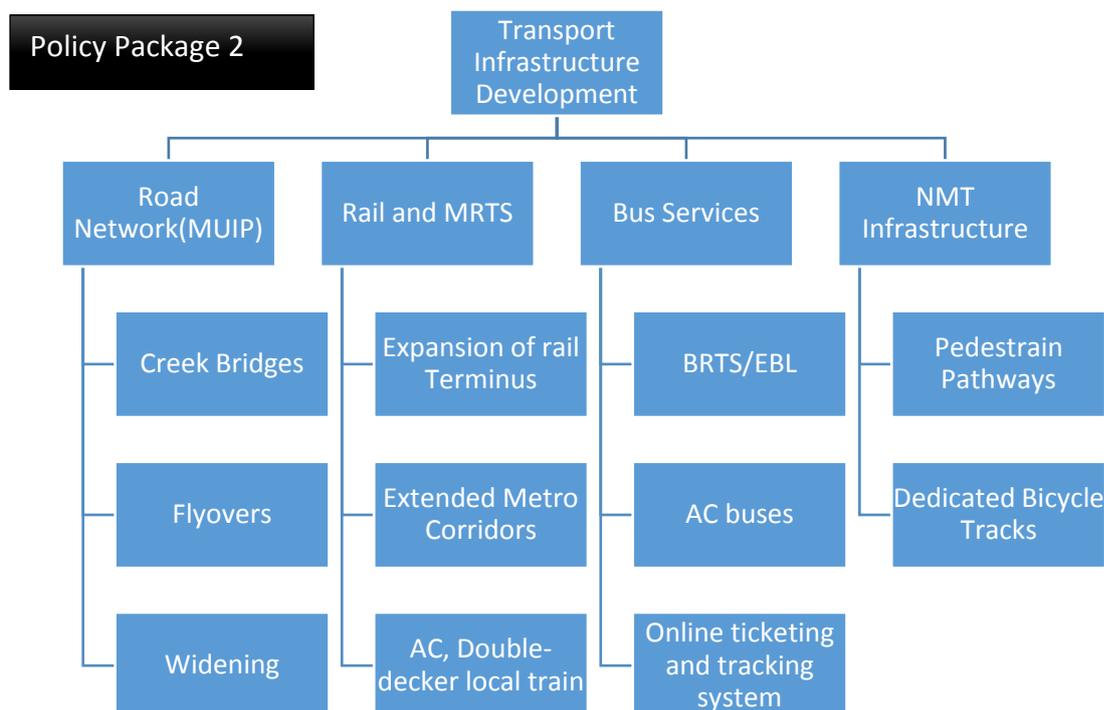


Figure 10 Methodology for incorporating Policy Package 1 in TDM

3.2 Transport Infrastructure Development



The main objective of this policy scenario is to improve the network conditions and provide quality ridership to public transport users. In a market economy, properly functioning roads, rails, metros, buses are the need of the hour to encourage people to use public transport. Also, improvement in road infrastructure is necessary to avoid congestion which leads to serious GHG emissions. Based on Mumbai RP and Mumbai Urban Infrastructure Project (MUIP) plans, following new developments in road and public transport networks are on their way in MMR:

- New Rail terminus at Panvel where four suburban corridors of Panvel-CST, Panvel-Diva-Vasai, Panvel-Karjat and Panvel-Roha converge.
- MUIP II for efficient transport mobility, Sahar Elevated Access road from International airport (WEH) to CST
- Dedicated Bus lanes on JVLR, WEH, EEH
- Bike Sharing/ stations, cycle lanes across transit corridors
- Revised Metro Corridors

SL. No.	Name of Corridor	Length (km)
1	Versova-Andheri-Ghatkopar	11.40
2	Charkop-Bandra-Mankhurd	32.00
3	Colaba-Bandra-SEEPZ	33.50
4	Charkop-Dahisar	7.80
5	Wadala-Ghatkopar-Teen Hath Naka (Thane)	20.70
6	Teen Hath Naka-Kasarwadavali-Thane-Bhiwandi-Kalyan	34.60
7	SEEPZ-Kanjurmarg	10.50
8	Andheri (E) – Dahisar (E)	18.00
9	Sewri-Prabhadevi	3.50
	Total	172.00
10	Andheri-Mankhurd-Panvel fast metro corridor* (Airport-Airport)	46

Figure 11 Revised Metro Corridors, MUIP

Such developments and improvements in transport infrastructure will have direct impact on the horizon year transport network and indirect impacts on population-employment matrix. It will significantly shape the modal split, trip assignment and distribution. It will influence the travel time, cost and distance in a big way for Mumbai Transport. Fig 12 demonstrates the conceptual methodology of incorporating the policy package 2 in the Travel Demand Model for the horizon year.

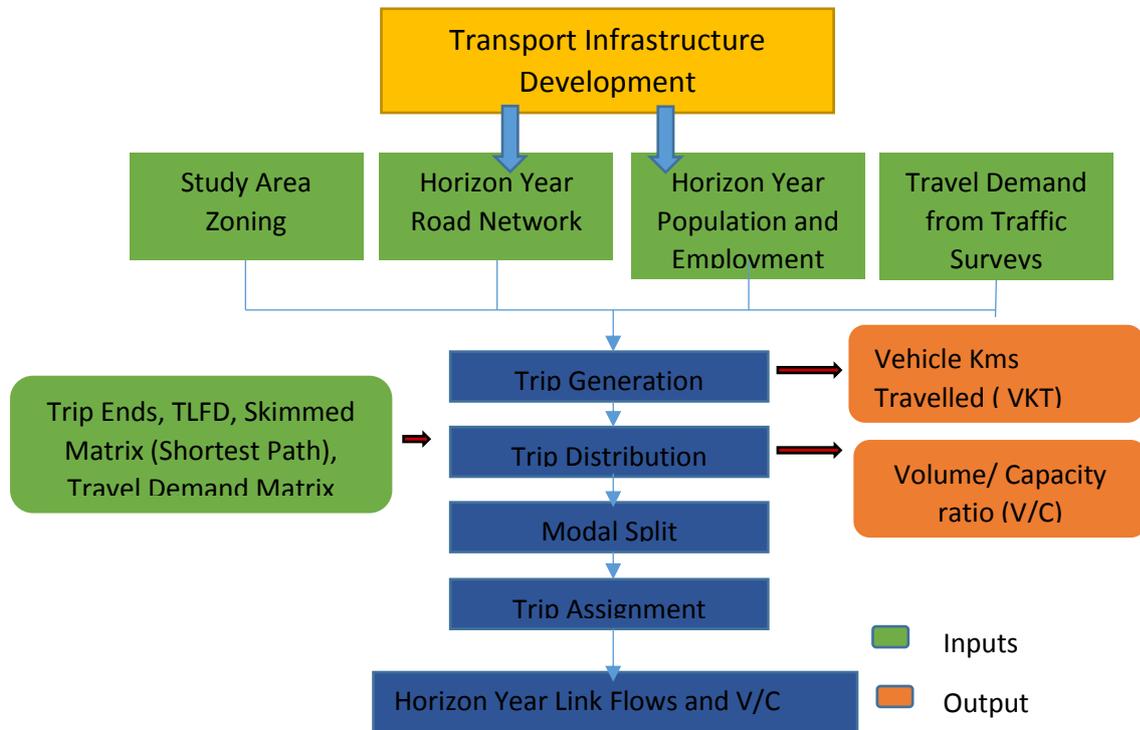
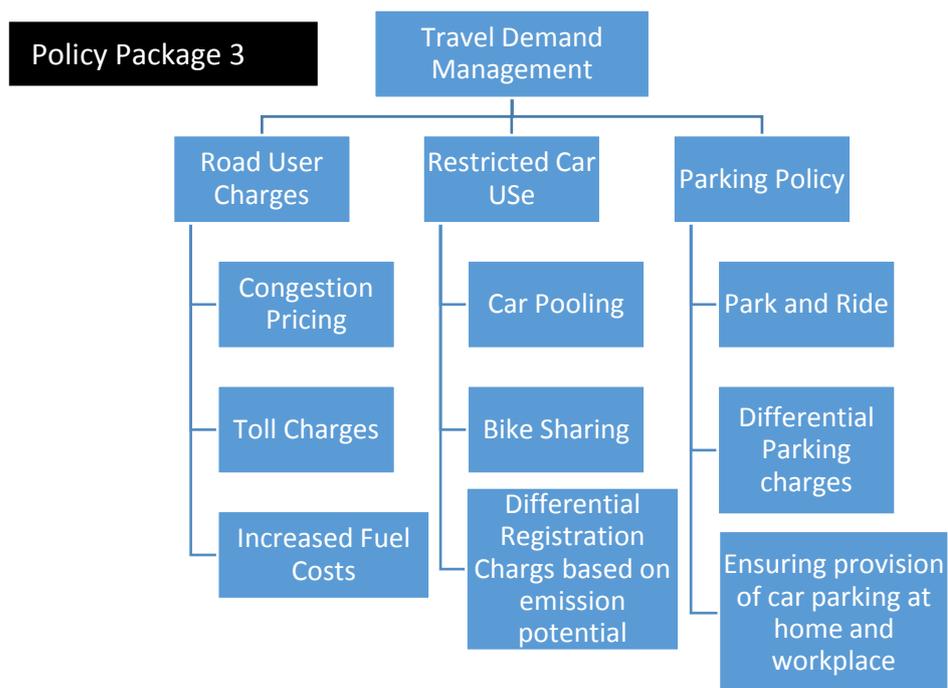


Figure 12 Methodology for incorporating Policy Package 2 in TDM

3.3 Travel Demand Management



The main objective of this policy package is to reduce travel demand by effective policies and regulations. Managing the growth of travel demand is essential in managing traffic congestion which in turn leads to carbon emissions from the transport sector. It tries to target the travel behaviour and system efficiency and largely comprises of parking management, promotion of high occupancy vehicle use road user charges and fuel costs and standards. Travel Demand Management directly impacts the vehicle kilometres travelled and reduces CO₂ emissions. Fig. 13 demonstrates the methodology to incorporate the travel demand management policy package 3 in the TDM.

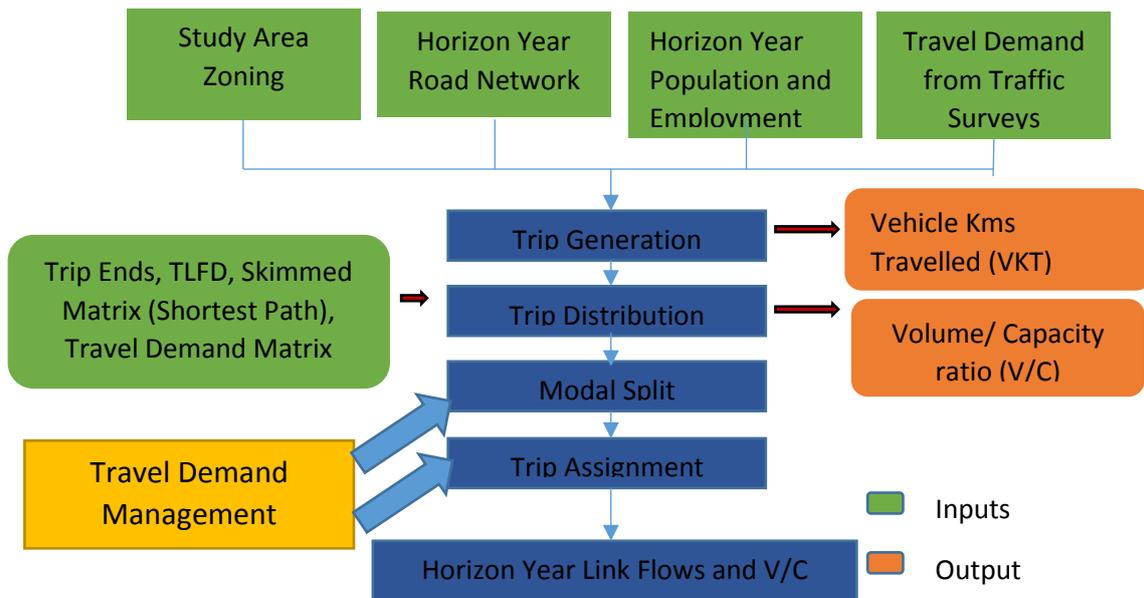
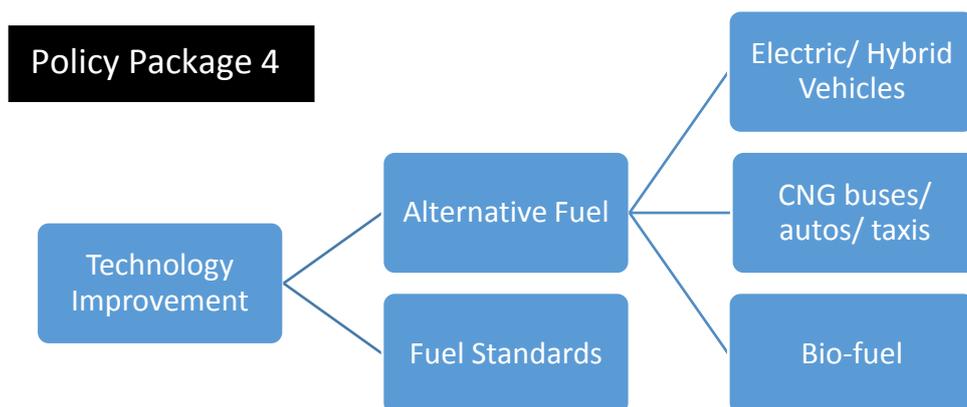


Figure 13 Methodology for incorporating Policy Package 3 in TDM

3.4 Technology Improvement



Fuel based changes will affect emission factors of the vehicles and indirectly affect the cost of travel. The main objective of this scenario is to reduce the vehicular emissions through technology improvement. Technology will play a significant role in climate change mitigation and transforming the transportation sector in the horizon years. Though it is not possible to directly incorporate technology changes in the Travel Demand model, decreased emission factors of the vehicles and increased travel costs associated with ownership of electric/hybrid cars can be modelled. Electric vehicles can increase the congestion on the roads which can further affect the modal split indirectly. Fig. 14 demonstrates the methodology to incorporate policy package 4 in TDM.

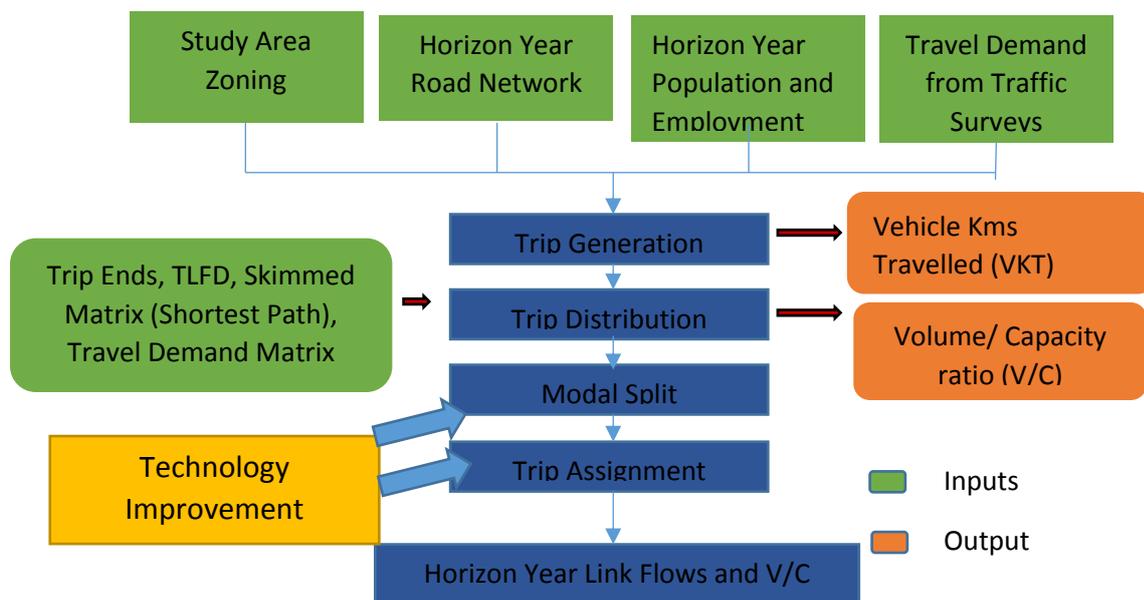


Figure 14 Methodology to incorporate policy package 4 in TDM

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