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Energy Management in Indian Urban Transportation Sector – Issues and Challenges

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Abstract: ***The urban development in most of the Indian cities is the result of laissez-faire development with ribbon extension along the major arterials emerging out of the city core, the Central Business District (CBD). Work trips constitute the majority of the trips in urban areas and these are originating from residential locations to the work places most often called as the CBD areas. Work mean trip length and Passenger-Km are used as a proxy to measure the energy consumed in the transportation sector. Increase in spatial separation between the residential location and work places result in the long commuting distance and poor accessibility to the peripheral residential locations are encouraging more dependence on private and intermediate public transport. In this paper, the problems associated with urban transport and the possible solutions are discussed. Also the concept of Compact City as an attempt to integrated – land use transportation is also presented.***

Keywords: Central Business District, Public Transport, Mode Choice, Land use Pattern, Transit Oriented Development.

I. INTRODUCTION

Urbanization and industrialization are the two causative factors making the people migrate from rural to urban areas. Large scale urbanization provides better living standards in terms of educational facilities, work opportunities, health care, recreation etc. In general urban areas are characterized by a concentration of people, infrastructure, services, and markets, which offer opportunities for production and consumption. India's urban population is growing at an average rate of around 3% per year. At this pace of growth, India's urban population is expected to increase from 370 million in 2011 to 500 million in 2021.

The number of metropolitan cities with million plus population in India has increased from 35 in 2001 to 50 in 2011. Out of these 50, eight cities – Mumbai, Delhi, Kolkata, Chennai, Hyderabad, Bangalore, Ahmedabad, and Pune – have a population more than 5 million. These 50 cities account for the larger share of total urban population and recorded substantial growth of 42% in 2011.

Even though Indian cities have lower vehicle ownership rate than their counterparts in developed countries, they suffer from worse traffic congestion, delay, pollution, over loading and accidents than the cities in developed countries. Larger Metropolitan cities like Kolkata's Central Business District (CBD), Western Express highway and Eastern Express Highway in Mumbai are the classic examples, where the average speed during peak hours in the area goes down as low as around 10 Km/h. The problem of congestion and delays is not only faced by Major cities but also by all the big as well as small cities India which indicates both the amount of time and energy that are wasted and the scale of opportunity for improvement.

Among the trips generated in urban areas, work trips constitute about 70% of the total trips. Work trips are originated from the place of residence and destination to the place of employment (CBD). At house hold level Passenger-km and work trip mean lengths (km) are taken as a measure of transportation interaction and often these parameters are used as indirect means of estimation of transportation energy. Transport energy consumption cities depend on the location of CBD the urban form, number of jobs located in the CBD, population size of the city, the city size and transport network structure, called as the city structure. These parameters often called as the City Parameters.

II. LITERATURE REVIEW

CITY PARAMETERS AND TRANSPORT ENERGY CONSUMPTION

The transport sector is a major consumer of energy; in 2006 it was responsible for about 60% of world oil consumption (OECD/IEA, 2008). Energy use in transport is a function of the mode used, distance travelled, and frequency of trip [1]. Also, a literature review has suggested that the urban parameters (i.e., urban form, structure, size, shape, density) significantly influences transport energy consumption [7].

The spatial arrangement of entities such as the housing, employment, and activity centres within the urban areas is closely connected to the travel behaviour and generate a hierarchy of individual trips, home to local stop, district center, and main city center [6]. The intra-urban hierarchy of activity centers is closely connected with individual travel behavior. In some cities, per capita, energy consumption has grown at approximately the same rate as their spatial growth [3]. Many cities are now pursuing transport demand management, which attempts to match demand for travel to the supply of infrastructure, rather than endlessly expanding supply to meet demand [6]. It has been argued that more dense and compact urban development is likely to result in more energy-efficient and sustainable cities. However, very little is known about the precise magnitude of possible energy savings from the more compact urban form. Moreover, practically limited research has been done to investigate which type of urban forms and structures are more transport energy efficient. Also, the policies which are very effective and contributing to energy savings in city road transport need to be established [8].

Reference [2] also suggested that efforts to create or preserve traditional urban forms have some short-run potential for reducing travel but are probably best seen as a form of contingency planning. Soft measures to reduce car travel are also important; options include demand management (pricing, parking and access control, congestion charging). Other policy options would be an investment in public transport; giving priority to pedestrians and cyclists, and a range of measures designed primarily to reduce the use of single-occupancy cars (1). Many cities are now pursuing transport demand management, which attempts to match demand for travel to the supply of infrastructure, rather than endlessly expanding supply to meet demand [6].

III. THE ISSUES: INADEQUATE AVAILABILITY OF PUBLIC TRANSPORT

Public transport systems in cities have not been able to keep pace with the rapid and substantial increases in demand over the past few years

The main reason for all these is the prevailing imbalance in modal split besides inadequate transport infrastructure and its sub-optimal use. Public transport systems in cities have not been able to keep pace with the rapid and substantial increases in demand over the past few years. As a result, people have turned towards personalized modes such as mopeds, scooters, motorcycles, and cars and intermediate public transport modes such as auto-rickshaws, tempos, and taxis. Cities cannot afford to cater only to the private vehicles and there has to be a general recognition that policy should be designed in such a way that reduces the need to travel by personalized modes and boosts public transport particularly bus transport system. Much needs to be done if public transport is to play a significant role in the life of a city. Measures need to be taken to enhance the quality as well as the quantity of public transport services and to impose constraints on the use of private vehicles.

From the table -1 it can be seen that in the year 2009 Total number of vehicles playing on Indian roads were 115 million and as per the statistics provided by the Ministry of Road Transport & Highways, Government of India, the annual rate of growth of motor vehicle population in India has been around 10% during last decade. The issue is not the number of vehicles but their concentration in a few selected metropolitan cities. During the years 1999 to 2009, vehicles per 1000 people in metropolitan cities has increased more than two-fold from 132 to 286 (Figure 1). Vehicle ownership rate, number of vehicles per 1000 people, in many big cities including Delhi has already crossed the mark of 400. There are at least 5 metropolitan cities having vehicle ownership rate in excess of 500.During the year 2009, nearly 15 million vehicles were plying in four big cities (Delhi, Bengaluru, Chennai, and Hyderabad) alone, which constitute 16.6% of all motor vehicles in the country (Table 2). Delhi, the capital of India, which contains around 1.4% of Indian population, accounts for nearly 7% of all motor vehicles in the country.

Table I: Total Number Of Registered Motor Vehicles In India: 1951-2009 (In Thousands)

Year	All vehicles	Two-wheelers	Cars	Buses	Goods vehicles	Others
1951	306	27	159	34	82	4
1961	665	88	310	57	168	42
1971	1865	576	682	94	343	170
1981	5391	2618	1160	162	554	897
1991	21374	14200	2954	331	1356	2533
2001	54991	38556	7058	634	2948	5795
2002	58924	41581	7613	635	2974	6121
2003	67007	47519	8599	721	3492	6676
2004	72718	51922	9451	768	3749	6828
2005	81501	58799	10320	892	4031	7457
2006	89618	64743	11526	992	4436	7921
2007	96707	69129	12649	1350	5119	8460
2008	105353	75336	13950	1427	5601	9039
2009 (P)	114951	82402	15313	1486	6041	9710

Source: Transport Research Wing, Ministry of Road Transport & Highways, Government of India, New Delhi. *Road Transport Year Book (2007-09).*

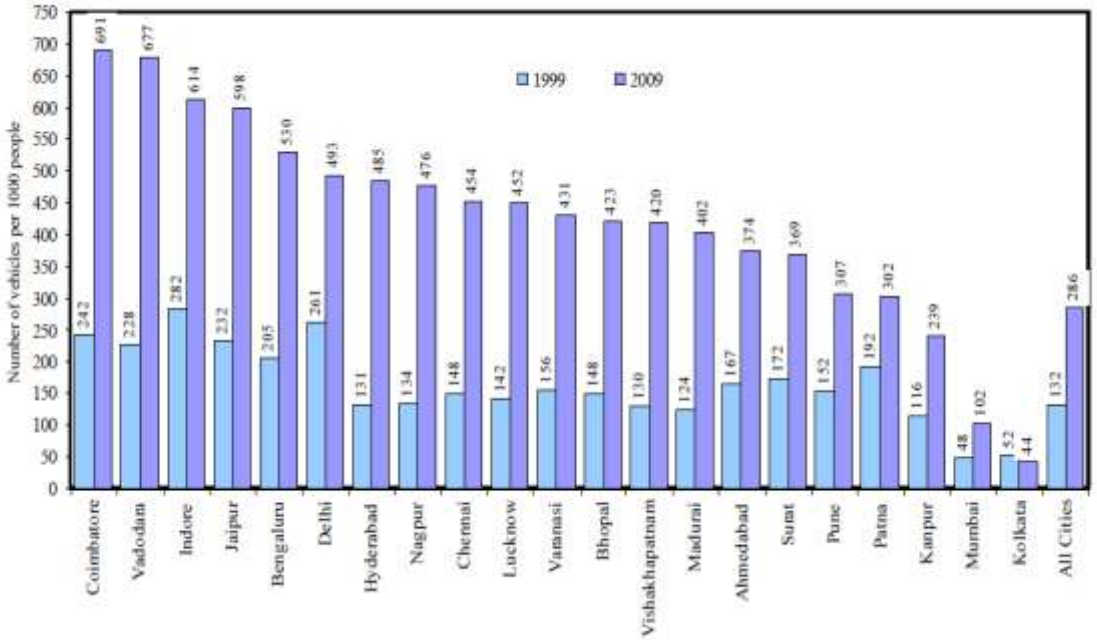

Figure 1: Vehicle ownership rate in selected metropolitan cities in India: 1999-2009 (Source: Transport Research Wing, Ministry of Road Transport & Highways, Government of India, and New Delhi. Various Issues. Motor Transport Statistics of India and Road Transport Year Book).

Traffic composition in Indian cities is of a mixed nature. There is a wide variety of about a dozen types of both slow and fast-moving vehicles. Two-wheelers i and cars account for over 85% of the vehicle population in most of the metropolitan cities. They account for at least 90% of total vehicles in Ahmedabad, Bhopal, Coimbatore, Delhi, Kanpur, Lucknow, Nagpur, Vadodara, Varanasi, and Vishakhapatnam. Two-wheelers alone account for more than 80% of the total vehicles in a number of metropolitan cities. For example, during the year 2009, in Nagpur (84%), Varanasi (84%), Surat (83%), Coimbatore (83%), Madurai (82%), Bhopal (81%), Kanpur (81%), Vadodara (81%), Vishakhapatnam (81%), and Lucknow (80%), two-wheelers accounted for at least 80% of the total vehicles. Analysis of data presented in Table 3 reveals that, during the year 2009, the share of buses is negligible in most Indian cities as compared to personalized vehicles. For example, two-wheelers and cars together constitute at least 90% of the total vehicles in Ahmedabad (91%), Delhi (90%), Lucknow (93%), and Nagpur (91%).

Table 1: Total Number Of Registered Motor Vehicles In India: 1951-2009 (In Thousands)

Metropolitan cities	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	CAGR (%) 1999-2009
Ahmedabad	739	799	846	899	978	1075	1632	1780	1451	1586	1691	8.6
Bengaluru	1332	1550	1593	1680	1771	1891	2232	2617	2179	2640	3016	8.5
Chennai	1056	1150	1257	1356	1895	2015	2167	2338	2518	2701	2919	10.7
Delhi	3277	3423	3635	36S99	3971	4237	4186	4487	5492	5899	6302	6.8
Hyderabad	951	N.A.	N.A.	1241	1319	1356	1433	1522	2181	2444	2682	10.9
Jaipur	542	598	644	693	753	824	923	1051	1177	1289	1387	9.9
Kolkata	N.A.	N.A.	N.A.	801	842	875	911	948	987	573	581	9.5
Lucknow	N.A.	N.A.	465	556	615	N.A.	N.A.	N.A.	801	962	1025	9
Mumbai	911	970	1030	1069	1124	1199	1295	1394	1503	1605	1674	6.3
Nagpur	298	331	416	459	503	543	770	824	884	946	1009	13
Pune	568	593	620	658	697	755	827	874	930	1141	1153	7.3

Source: Transport Research Wing, Ministry of Road Transport & Highways, Government of India, New Delhi. Various Issues. Motor Transport Statistics of India and Road Transport Year Book

Note: (1) N.A. indicates unavailability of data. (2) CAGR indicates compound annual growth rate. (3) From 2007 to 2008, there is a sudden drop in no. of vehicles registered in Kolkata because the Calcutta High Court in July 2008 ordered a ban on commercial vehicles registered before January 1, 1993, from Kolkata and its outskirts.

IV. MODE CHOICE

For the Cities with more than 2 Million population, 70% of the trips ideally should be by mass transportation facility, but from the studies it is observed that the growth of two wheelers is consistently more than 10% and cars is about 9% over the last decade indicating the high dependence on private mode of transport. Also, the availability of urban rail transport is extremely limited making the people shift to private and intermediate public transport.

V. LAND USE PATTERN AND CITY PARAMETERS

Uncontrolled urban sprawl development in most of the Indian cities is allowed to grow spatially over the time resulted in a long distance of commuter travel for work trips. The newly developed residential communities away from the Central Business Districts (CBD) with poor access and public transport facility making the urban commuter to depend on Intermediate Public Transport and personalized transport. All the vehicle moving in, from the periphery to the city core the CBD from all the directions during the morning peak and leaving the CBD during evening peak resulting congestion, reduction in speeds, pollution and more hours of travel [4].

The concept of compact city promoted by the European Commission (Commission of the European Communities 1990) on environmental and quality-of-life grounds; the UK government has been emphasizing integrated trans-port and land-use planning to reduce transport energy consumption. The term 'compact city' is used here as shorthand for a variety of approaches to the planning of towns and cities which stress the merits of urban containment. It is not new and has been promoted over many years, but could not be implemented in Indian context due to varied reasons

The City parameters like Urban Form, Urban Shape, Urban Size and Urban Structure are having a direct bearing on work mean trip length and there by the transport energy consumption [9].

In urban areas, work trips constitute the majority of the trips. These work trips are generated from the residential zones and destination to CBD areas. The CBD areas are generally found to exist on arterial roads in urban areas. The employees while making a trip from residential zones to CBD areas move on the hierarchy of roads and finally join the arterial road to reach the work location. Thus the growth and development in urban areas are governed by the growth and development taking place in arterial roads, which emanate from the city core. Hence work trips generated in urban areas depend on the location of the CBD and shape of the urban area. From the research studies [9] it is found that transport energy would be minimum in case of cities with evenly distributed employment locations. Other findings of the study are:

- Out of all the urban forms and shapes, a square city with central CBD gives minimum transportation interaction and linear city with eccentric CBD gives maximum transportation interaction [5].
- The difference of mean trip length and person kilometers in central CBD and multiple CBD forms is about 16% and hence, while designing the urban areas, a poly centric CBD is to be advocated instead of single CBD [10].
- From the analysis of transportation interaction among different shapes and forms, it is found that mean trip length increase with the increase of city size [11].

VI. RECOMMENDATIONS

There are no exclusive methods for reducing energy use in the transportation sector and a comprehensive approach to integrated land use planning is to be adopted for reducing the transportation energy consumption. As per the estimates of Ministry of Road Transport & Highways, Government of India, by 2021 more than 50% of the urban population would likely to be settling in metropolitan cites. The existing road infrastructure is already under pressure and not in a position to meet the peak hour traffic demands.

Some of the suggested initiatives to optimize energy consumption transportation segment would be:

- Encourage Transit oriented development with medium to high population density within 5 km radius of CBD areas.
- High subsidy on public Transportation System.
- Introduction to Congestion pricing.
- Pay and parking at CBD and business places.
- Special Tax on car ownerships, households with more than three cars should be levied with surcharge.
- Planning intercity and intra City mass transportation facility through public transportation between Planning for mass transport facility such as metro rail between the core to the periphery
- Initiate feasibility studies mass transit facility.

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