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Energy Conservation in Urban Transport

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Abstract

The intensity of travel being more in urban areas, it is better that the energy-saving measures are focused on urban transportation. The energy requirement of motorized private transport modes is much more compared to the energy requirement by public transport modes. Urban land-use pattern is also a factor influencing the intensity of travel in a city. Hence, orientation of the urban transportation planning process to facilitate use of public transport modes and non-motorized modes of transport with simultaneous restructuring of the urban land-use pattern will help energy saving.

1. Introduction

The world is entering a period of increasing energy consumption and declining reserves of traditional energy stock. Nearly 40% of the world's energy now comes from petroleum, and another 21% comes from natural gas[1]. Together, these finite natural resources supply about 60% of the world's energy. The global energy reserve in nonrenewable sources, as of 1999, is shown in Table 1. If oil and natural gas consumption continued to double every 15 to 20 years as it had been for the 100 years preceding 1973, the earth's entire original endowment of these resources would be 80% depleted in another 30 years or so. The increase in energy demand in Asian countries like China, India, South Korea, etc. is predicted to account for more than 40% of increase in global energy demand between 1990–2005[2]. The present share of commercial energy use in India by different sectors is depicted in Figure 1[3]. It can be seen that the energy share by transport sector is 24%. The transport sector is the largest consumer of oil, and accounts for about 50% of the consumption. India has only 0.4% of the world's oil reserves and a very low level of oil consumption (2% of world consumption). Even at this low level of consumption, the country's import dependence has gone beyond 55% [4].

Table 1. Global Energy Reserve (1999)[8]

Country/Region	Crude Oil and Natural Gas Liquid(NGL) in million tonnes	Coal in million tonnes	Natural Gas in billion m^3	Oil Shale in million tonnes (oil)
India	645	84396	647	-
Asia	8183	252308	17106	1079
Africa	10122	55367	402560	500
North America	8573	257966	280516	60000
South America	13370	21752	222431	-
Europe	9495	312686	1891153	300
Middle East	92242	1710	1880974	4600
Oceania*	502	82664	68493	1725
Total World	142487	984453	5350180	67125

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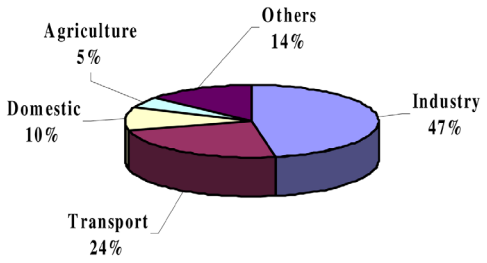

Figure 1. Share of Commercial Energy Use by Different Sectors.

Transportation is essential to modern economies, and this sector is almost totally dependent on oil as a source of energy. The ability to freely and inexpensively move goods and people is a fundamental link in the economic chain. Today, large changes in the price or supply of oil send shock waves rolling through the world's financial institutions. Transportation is the most rapidly growing consumer of the world's energy. Transportation now consumes more than 20% of the world's total primary energy and produces much of the world's air pollution. If global trends are projected to year 2100, the world will need 10 times more total energy, and transportation will consume about 40% of this much larger pool[5]. Transportation is more intense in urban areas, and hence any effort on enhancing the energy efficiency in transport sector will naturally be focused on urban areas.

2. Urban Transportation

Urban areas are densely populated and heavily built up land spaces with intense socioeconomic activities resulting in dynamism and sophistication in the life style of people living there. The high level of concentration of socioeconomic activities in urban areas has led to large scale migration of rural population into urban areas resulting in a steady growth of urban population all over the world. The global trend in the growth of urban population is shown in Table 2. It can be seen that about 61 % of the world's population will be living in urban centers in the year 2030. The corresponding figures are 82, 57, and 43 for more developed, less developed and least developed regions respectively (the last column of Table 2). The urban areas, by virtue of the high concentration of economic activities, contribute to the GDP, in most parts of the world, to an extent of about 60 %. In this context, enhancing the productivity of urban areas is now central to the policy framework of most of the governments all over the world. Cities hold tremendous potential as engines of economic and social development. Hence, the national economic growth will be increasingly determined by the productivity of cities and towns. To sustain the lead role played by urban areas in the overall economic growth of a country, it is important that the urban infrastructural facilities are well planned, developed, and maintained. Urban transportation system being a vital infrastructural facility in any urban area, at-most attention is needed in planning the system in such a way that it is energy efficient, environment friendly while sufficiently meeting the demand for transport.

Table 2. Global Urbanization Trend[9]

Region	Population in billion				Percentage of urban population	
	Urban		Rural			
	2003	2030	2003	2030	2003	2030
World	3.044	4.945	3.258	3.185	48.3	60.8
More Developed Regions	0.896	1.015	0.307	0.228	74.5	81.7
Less Developed Regions	2.147	3.930	2.951	2.958	42.1	57.1
Least Developed Regions	0.191	0.544	0.527	0.713	26.6	43.3

3. Strategies for Energy Saving in Transportation

The strategies for reducing transportation energy consumption can be put under five categories[6]: 1. Shift traffic to more efficient modes by lowering the energy consumption per seat-mile; 2. Increase the load factor by raising the passenger-miles per seat-mile; 3. Reduce demand by reducing the passenger-miles; 4. Increase the energy conversion efficiency by lowering the energy consumption per seat-mile; and 5. Improve the use pattern by lowering the seat-miles. The flowchart in Appendix I, shows the implementation methodologies of each of the five strategies. Here, however, the methods of transportation energy saving that are more appropriate to Indian conditions that can be easily incorporated into urban transportation planning process are discussed. Thus, the

rest of the discussions are oriented towards the aspects of enhancing the level of service of public transport to stop the increasing trend of using private transport modes, and to induce shift from private to public transport usage for urban travel.

4. Public Transport

Urban mobility is facilitated by different modes of transport which includes motorized private and public transport modes and the non-motorized modes (foot, pedal-cycle, animal drawn vehicle). The energy consumption of the major modes of urban transport is one of the major concerns in urban transportation planning process. The energy consumption rate of some of the modes in passenger transportation is depicted in Figure 2. It can be seen that, taking the energy consumption of rail as 100 kcal per passenger km, the corresponding figures for bus, waterway and car will be 323, 758 and 1184 respectively. It is clear from the details of figure 2 that public transport modes (road and rail) are more fuel-efficient than the personalized modes of transport. Improved public transport facility can attract more passengers and reduce congestion owing to its capacity to carry more passengers. Although the best car still does not compete even closely with a loaded bus in terms of energy use or emissions per passenger, the personal comfort and level of service associated with private-vehicle use is often the crucial factor in people's choice of mode of transport. It is not possible to realize the full potential of a public-transport bus unless proper traffic management measures like bus priority schemes, etc., are designed to ease the movement of buses through congested streets. Public transport can be made more attractive by improving/increasing park and ride facilities, improving the quality (like low floor -easy access buses) and priority of bus service, improving bus/rail coordination, removing passable traffic and by ensuring speedier and frequent operations.

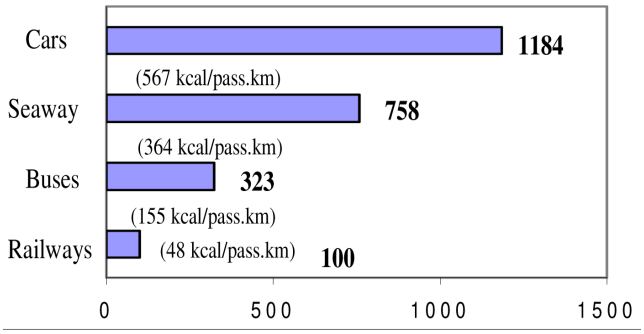

Figure 2. Comparison of Energy Consumption to Transport One Person over One km.

Rail facilities, in general, and metro rail facilities in urban areas in particular, can play a vital role in energy conservation. Since suburban trains are many times more energy efficient than conventional diesel buses, any modal shift towards trains would result in significant amounts of energy savings. However, there had been a steady shift of passenger traffic from railways to highways due to increase in the level of service of highway mode in respect of flexibility, generalized cost, etc. Hence, there is an urgent need to enhance the level of service of railways to attract more traffic. While planning suburban train facilities, the primary aim should to make them at least as fast as the equivalent car journey between key points. The need to change lines should be minimized. Trains should provide a comfortable and high quality environment and if possible they should be operated 24 hours a day to appeal to a wide range of groups and needs.

5. Use of Non-motorized Modes

Non-motorized transport modes (walk, bicycle, cycle rickshaw and Tonga) are important components of the urban transport systems in India. Motorized transport is capital intensive, import oriented, environmentally hazardous and needs heavy investment in infrastructure development. In contrast, NMT reduces the call on non-renewable resources, creates virtually no localized air pollution, greenhouse gas emissions or noise pollution when compared with cars, buses and other vehicles powered by fossil fuels. Bicycles occupy less road space than motor vehicles per person. Safe cycling increases the efficiency of existing roads. To the extent that bicycle use replaces single-occupant vehicle trips, this will help to conserve energy and ease the demand for additional road space and car parks.

6. Urban Land-use Pattern

Proper co-ordination of land use and transport planning in order to encourage spatial settlement patterns that facilitate access to basic needs such as workplaces, schools, health care, places of worship, goods and services and leisure, can reduce the need to travel, thus resulting

in major energy savings in urban areas. Design of urban structures should be compact, to reduce the trip lengths for economic activities and employment. If trip lengths are reduced by effective planning, most of the trips could be converted to walking and bicycling resulting in conservation of fuel. Mixed-use development plans, in which residential and commercial land uses are allowed in the same neighborhood, can reduce the need for commuting from residential districts to commercial districts. The shape of the future city may be decided by energy related considerations.

A long-term perspective is essential if the urban transportation planning process is to deal with problems of providing transportation in an environment characterized by fuel shortages. Land use plans provide a pattern or arrangement of land uses, which are adopted by a city to achieve the goals and objectives of that city. The cost of public services, such as transportation, water supply, sewers, telephones, gas, and electricity, is almost directly dependent on landform. Urban sprawl tends to increase public service cost as well as energy consumption, whereas multicenter plans have generally lower infrastructure costs and lower energy consumption.

In the study made by Jerry[6], it has been shown that the structural changes in transportation and land use patterns can produce significant reductions in energy consumption for urban passenger travel. Four dimensions of urban form were examined: 1. Shape of city (Figure 3): (a) Concentric ring or grid shape, (b) Pure linear shape, (c) Polynucleated shape, and (d) Pure cruciform shape; 2. Extent to which the city is compact or sprawling (its geographic extent); 3. Population concentration, and 4. Employment concentration.

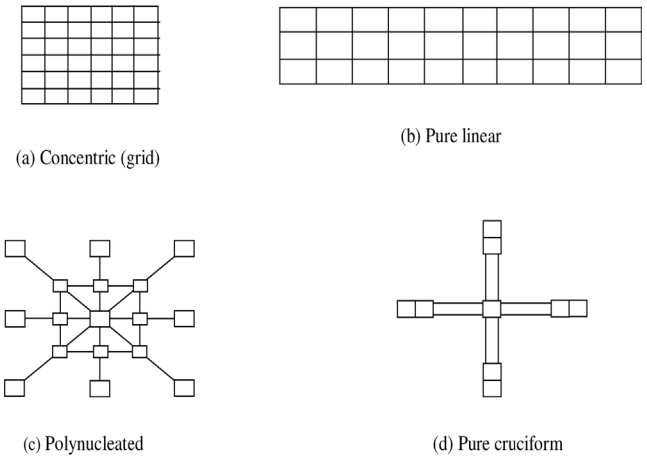

Figure 3. Urban Shapes.

Some important conclusions drawn from this study are as follows: From the average work trip length, one can determine the total amount of energy required for transport in that city: Energy consumption in concentric ring shaped cities rises fairly rapidly with increasing average work-trip length, whereas the rate of increase in is much lower in polynucleated cities. A city with most employment concentrated in the downtown area will consume energy quite differently from one in which most business and industry is located along a beltway. Transportation level of service is an important factor because, traffic congestion, with its inefficient fuel use, can swallow up any advantage to an urban area's shape. The research suggests the desirability of controlling the spread of cities and channeling development into higher density, nucleated forms. This may also serve in the short term as a policy on rezoning requests and building permits and as a criterion for incremental construction to the urban infrastructure[7] have expanded and defined Edward's work and come to the conclusions that ploynucleated urban structures hold more promise for energy conservation than do other spatial arrangements.

7. Concluding Remarks

Transportation sector is the rapidly growing consumer of the world's energy. Energy saving measures in urban transportation will go a long way in this regard, as transportation is very intensive in urban areas. The better way to attempt energy saving is to incorporate the strategies into the urban-transportation-planning process with specific objectives of facilitating maximum possible usage of public transport and non-motorized modes of transport, and creation of less travel intensive urban land-use patterns.

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Appendix