

# Energy for a sustainable road/rail transport system in India

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*The main motivation for this study is that the strong transport-energy nexus has not received the attention it deserves, though energy is a crucial constraint on transport, and transport is a major determinant of energy demand. Also, many detailed treatments of the transport sector have not scrutinised the sustainability of the present pattern of development of this sector. Further, the prevailing paradigm guiding the development of the sector is made explicit and critiqued because it is often the root cause of its unsustainability. And, because treatments of transport policy issues tend to proceed without a clear statement of underlying goals and strategies, the entire hierarchy of interventions – from goals to strategies to policies – has been discussed. Finally, an attempt has been made to deal with both the supply and demand aspects of the transport sector.*

*The study is restricted to road and rail transport since air and water (inland waters, and coastal and international seas) transport handle very small fractions of domestic traffic demand. The detailed discussions are preceded by overviews of the main features of the Indian transport system as well as of the energy sector as pertaining to transport.*

*It is suggested that the goal of the Indian transport sector should be an efficient, capital-saving, non-import-intensive, affordable, service-oriented and environmentally sound transport system, i.e., a sustainable transport system.*

*A strategy or broad plan to achieve this goal of a sustainable transport system should consist of several components: (1) minimisation of dependence on petroleum fuels, (2) maximisation of the level of safe, comfortable and time-saving transport services, (3) maximisation of the environmental soundness of the transport system, and in particular, reduction of local and global environmental pollution, (4) minimisation of the capital requirements for the transport modal mix that should also include non-motorised transport (NMT), and (5) minimisation of the energy used by the transport system without a reduction of the services provided.*

*The detailed policies (plans or courses of action) to implement the above strategies for achieving a sustainable transport system fall into the following categories: (1) transport-energy database generation and use, (2) demand management, (3) technological improvements in road transport, (4) improvement of the capacity and quality of road infrastructure, (5) traffic management, (6) improvement of the railways, (7) improvement of urban transport, (8) providing a niche for non-motorised modes of transport, (9) pollution control and abatement, (10) costing and pricing, (11) modal shifts to achieve a least-cost freight modal mix, (12) modal shifts to achieve a least-cost passenger modal mix, (13) solutions to the transport sector's problems through measures in other sectors, (14) alternative fuels.*

*Appropriate policy instruments or mechanisms for initiating and maintaining the policies as well as suitable policy agents to wield the policy instruments have also been identified. The market has the power of being an excellent allocator of money, materials and manpower, but unfortunately also has definite limits – it is not very good at looking after the poor, the environment, the long-term and the infrastructure and national strategic concerns such as self-reliance and external debt, all of which are of crucial relevance to the transport system. Hence, the visible hand of government and the people must complement the invisible hand of the market.*

*In conclusion, both short-term low-cost measures to attract political decision-makers with short time-horizons and long-term measures have been mentioned. The short-term measures consist mainly of better maintenance, better driving practices, optimal routing of buses, dedicated routes*

*for buses with traffic restrictions on these dedicated routes, special lanes for slow traffic, supply constraint on personal vehicles, export orientation to the production of personal vehicles, removal of kerosene and diesel subsidies, no long-haul truck permits, increase of truck taxes and shift of passengers travelling less than 300 km from rail to bus. The long-term measures consist mainly of increases in fuel efficiency, introduction of lower-power bus engines, increases in number of buses and/or suburban trains, investments on mass transportation infrastructure, home electrification, improvement of rail freight operations, truck-rail freight linkage, introduction of CNG for urban fleets, switches to biomass-derived fuels for transportation, biomass-derived fuels as petrol and diesel extenders, silviculture for biomass-derived fuels, and alternative cooking fuels and/or devices to replace kerosene.*

## 1. Introduction

Transport and energy are closely connected – energy is a crucial constraint on transport, and transport is a major determinant of energy demand. Despite this interrelationship, the transport-energy nexus has not received the attention it deserves. This important lacuna has provided the main motivation for this study. There have also been other concerns that are addressed here. Firstly, many detailed treatments of the transport sector have not scrutinised the sustainability of the present pattern of development of this sector. Against this background, the issue of sustainable transport has been emphasised here. Secondly, as in the case of other infrastructural matters such as power and water, there is a prevailing paradigm guiding the development of the sector and it is this paradigm that is often the root cause of the problem. In the case of transport, this prevailing paradigm is made explicit and critiqued. Thirdly, treatments of transport policy issues tend to proceed without a clear statement of underlying goals and strategies. Here, the entire hierarchy of interventions – from goals to strategies to policies – has been discussed. Finally, an attempt has been made to deal with both the supply and demand aspects of the transport sector. The detailed discussions are preceded by overviews of the transport sector in India and of the energy sector as pertaining to transport.

This study is restricted to road and rail transport since air and water (inland waters, and coastal and international seas) transport handle very small fractions of domestic traffic demand.

## 2. Main features of the Indian transport system

1. The demand for transport – freight tonne kilometres and passenger kilometres by road and rail – has been growing faster than the gross domestic product (GDP). Between 1990-81 and 1995-1996, freight increased from 257 billion tonne kilometres (btkm) to 672 btkm (corresponding to an annual average increase of 6.6%) and passenger transport from 752 billion passenger kilometres (bpkm) to 1,656 bpkm [PC, 1988; 1999, Vol. II, Table 7.1.9; GoI, 2000] (an annual average increase of 5.4%. However, GDP increased at an annual average of 5.2% [GoI, 2000].
2. Road freight has been rapidly displacing rail freight (Figure 1). In 1950-51, the Railways carried 88% of freight traffic, in 1980-81, its share fell to 63%, i.e., 159 billion tonne kilometres (btkm) of the total 257

btkm [PC, 1988, Annexure 6.1], but by 1996-97, it carried only 40% of the total [MST, 1998; IR, 1998].

3. Rail and road shared passenger traffic in 1950-51 in the ratio 74:26, but during the period 1970-71 to 1977-78, the ratio had stabilised at about 40:60 [PC, 1980]. However, the Railways' share has already dropped to 20% or less. The national growth of passenger traffic at 8.1% per year in the period 1967-1987 has been much higher than that of freight traffic (5.3% per year), but passenger traffic on rail has grown at only 3.9% per year
4. In 1996, 69% of the road vehicles were automated two-wheelers (ATWs, i.e., motorised two-wheelers, or motor-cycles, scooters and mopeds), 11.4% cars and jeeps, 4.8% trucks, 3.1% passenger three-wheelers, 1.3% buses<sup>[1]</sup>. The proportion of ATWs has grown rapidly from about 9% of the total motor vehicle (MV) population in 1950-51 to 31% in 1970-71, 66% in 1990-91, and 69% in 1996-97 [MST, 1993, Table 3.1 till 1991; EIS, 1999, pp. 133-134] (Table 1). Thus, personal transport vehicles have increased from two-thirds in 1971 to over four-fifths at present, and this proportion is likely to increase further.
5. The disproportionate growth of ATWs explains the fact that, whereas India has only 0.60% of the world's cars and 0.18% of its trucks, it has 13% of the world's ATWs [ET, 1995]. As travel distances exceed the limits of walking and bicycling, an ATW is the only low-cost means of personal mobility. Also, in congested city areas, an ATW is easy to manoeuvre and to park. Further, cars, ATWs and three-wheelers are poised for a very high growth rate, in the absence of an efficient public transport.
6. The present road network is inadequate for the traffic load. In 1951, the total length of roads was 399,900 km with only 44% surfaced [IRC, 1993, Tables 2.1, 2.2, 2.5]. By 1996-97, the total length was over six times as long at 2,465,877 km, but only 56% (1,394,061 km) was surfaced. Of these surfaced roads, 39% was water-bound macadam (i.e., neither blacktop nor concrete) or inadequately surfaced and fit only for slow and light traffic [EIS, 1999, pp. 100-103]. Thus, only about 34% of the total road length is useful for motorised traffic. Of the 34% properly surfaced road length, the core network that carries the bulk of inter-city traffic consists of *national highways* (NH) and *state highways*

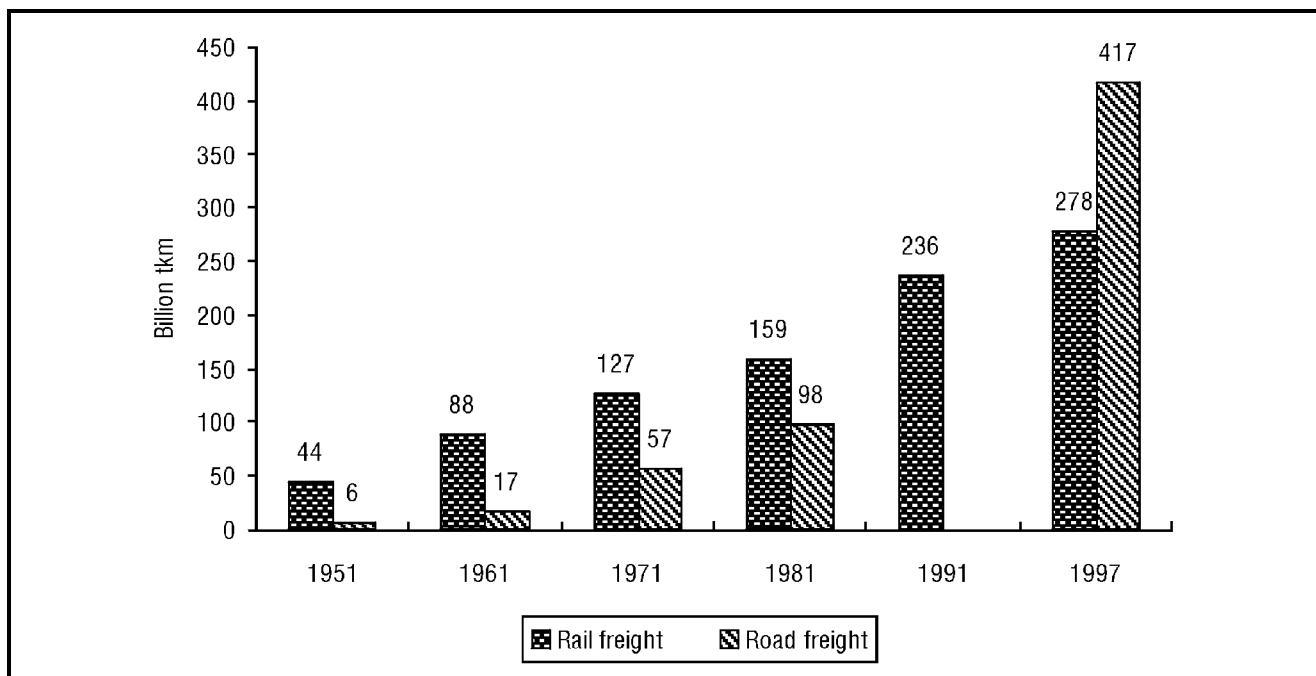


Figure 1. Displacement of rail freight by road freight

Sources: Report of Steering Committee -- Perspective Planning for Transport Development, Planning Commission, Government of India, August 1988 (Annexure 6.1), for 1951-81, unpublished material for 1991, 1997.

Table 1. Increase in the number of vehicles in India

(in thousands)

Year (as on 31 March)	ATWs	Cars, jeeps and taxis	Buses	Trucks	Others <sup>[1]</sup>	Total
1951	27	159	34	82	4	306
1956	41	203	47	119	16	426
1961	88	310	57	168	42	665
1966	226	456	73	259	85	1,099
1971	576	682	94	343	170	1,865
1976	1,057	779	115	351	398	2,700
1981	2,618	1,160	162	554	897	5,391
1986	6,245	1,780	227	863	1,462	10,577
1991	14,200	2,954	331	1,356	2,533	21,374
1992	15,661	3,205	358	1,514	2,769	23,507
1993	17,060	3,344	380	1,592	2,970	25,346
1994	18,338	3,617	419	1,650	3,203	27,227
1995	20,831	3,841	423	1,794	3,406	30,295
1996	23,252	4,204	448	1,681	4,197	33,783
1997	25,693	4,662	488	1,805	4,583	37,232

Sources: Till 1991, *Pocket Book on Transport Statistics in India 1993*, Ministry of Surface Transport, Government of India (Table No.3.1); from 1992 onwards, *Infrastructure, December 1999*, Centre for Monitoring Indian Economy, pp. 133-134.

Note

1. "Others" includes tractors, trailers, three-wheelers (passenger & goods vehicles) and others not separately classified.

(SH). *Urban roads (UR)* are considered separately for urban traffic. In 1996-97, the lengths of NH, SH, and UR were respectively 1.41%, 5.56%, and 9.42% of the total road length [EIS, 1999, p. 100]. Further, while the total road length in India has grown at an average rate of a little over 4% per year from 1951 to 1991, the length of NH has grown by less than 1% per year between 1951 and 1971, and at about 1.5% from 1971

to 1997. Of the 33,689 km of NH in 1991<sup>[2]</sup>, only about 1% was fit for four lanes, 78% for two lanes, 3% for intermediate lanes, 17% for one lane and 1% missing links. Yet this NH network has to cater for 35% of inter-city vehicle-kilometres [IRC, 1993, Tables 2.1 and 3.4].

7. In contrast to the under 4% annual increase in the total road length during the last 25 years, the number of

vehicles has been growing at about 12% per year. As a result, the average traffic density (motor vehicles per km of total road length) has risen from about 0.8 in 1950-51 to 2.0 in 1970-71 and 15.1 in 1996-97 [IRC, 1993; EIS, 1999].

8. Urban roads are getting increasingly congested due to rapid increases in population and vehicles. Whereas urban roads constitute only 9.4% of the total road length (1996-97), they support about 40% of registered vehicles. The total number of motor vehicles (MVs) in the top four metropolitan cities<sup>[3]</sup> was 13.7% of the total in India, and in all the 23 metropolitan cities, 32.5% [EIS, 1999, p. 139]. Most of the traffic moves on a limited length of arterial roads in metropolitan cities. The presence of slow-moving non-motorised traffic and pedestrians and an increasing range of non-transport activities along busy urban roads further complicate the picture.
9. Road vehicles are a major source of urban air pollution. Vehicle emission standards and their enforcement in India are much more lax than in developed countries. With a burgeoning vehicle population in the major cities, the air pollution problem is mounting beyond permissible standards. Delhi is one of the ten most polluted cities in the world, with levels of SO<sub>2</sub> and total suspended particulates (TSP) far exceeding the danger limits. Motor vehicles in Delhi emit 1,046.3 tonnes/day of the five major pollutants, constituting 64% of total emissions [Chandrasekar, 1995]. Two-wheelers and three-wheelers, constituting 70% of the motor vehicle population, present the most intractable problem of pollution (as well as fuel wastage). Because of their two-stroke engines, 25-40% of their fuel is discharged without combustion. Their conversion to four-stroke engines will reduce hydrocarbon and CO emissions. At long last, action in this direction seems to have just started as a result of the Supreme Court's orders for improved emission standards. Another feature of India's transport scene is the length of service extracted from vehicles. Older vehicles, because of design and worn-out components, tend to emit disproportionately higher rates of pollutants and have relatively greater fuel consumption.
10. Between 1970-71 and 1990-91, the number of vehicles in India rose 11.5 times, at about 12% per year, and the number of accidents 2.5 times, at about 4.5% per year. Accidents increased more slowly than the rise in the number of vehicles [MST, 1993], mainly because the road network has expanded and improvements in traffic operation and management (such as directional movement of vehicles, grade separation and traffic signalling) have been introduced. For the same reasons, the number of accidents per 1000 MVs has decreased – there were 64.4 accidents/1000 MVs in 1970-71, 31.1 in 1980-81, 13.8 in 1990-91, and 11.5 in 1994-95 [EIS, 1999, p. 129]. Yet, the rate in India is high even when compared with countries where traffic moves faster; for instance, it was 8 to 9 per 1000 MVs in

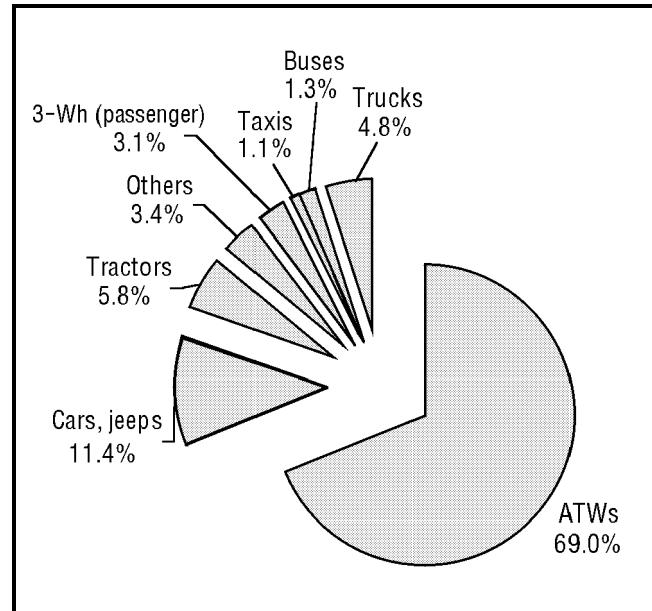
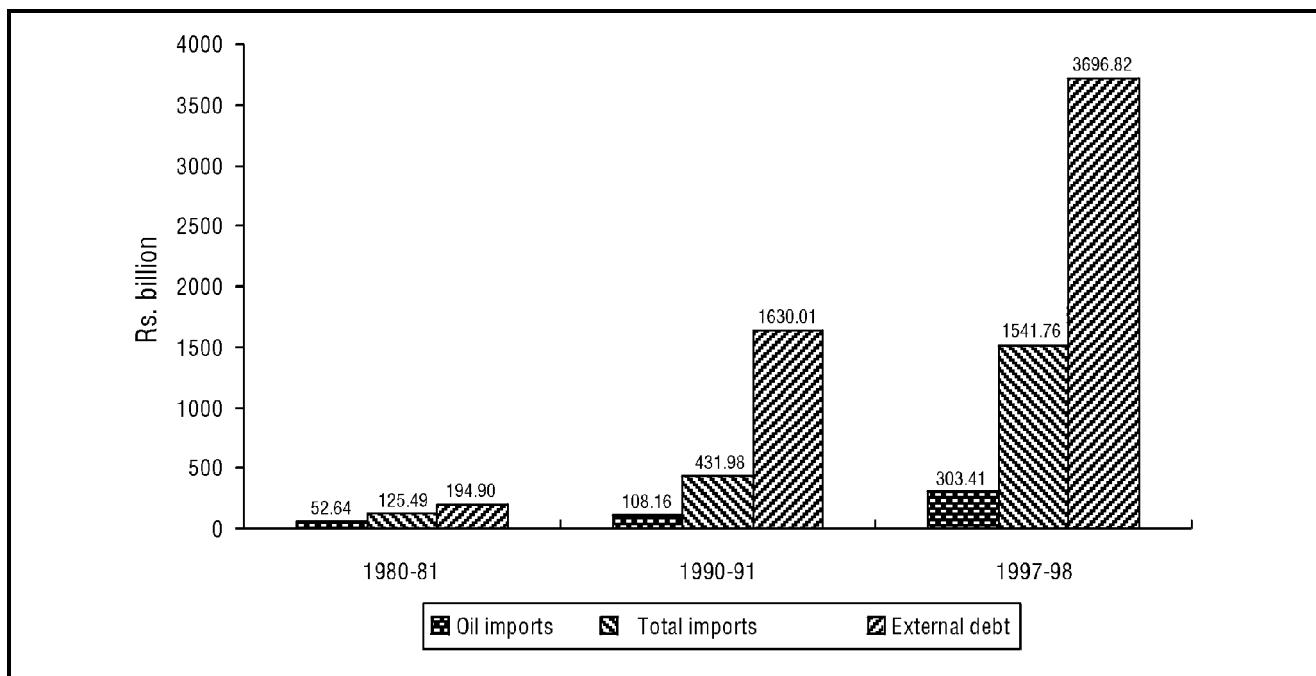


Figure 2. Registered motor vehicles in India (1996-97)

Source: Infrastructure, Economic Intelligence Service, Centre for Monitoring Indian Economy, December 1999, pp. 133-134.

Japan during the late 1980s.

11. Non-motorised transport (NMT) constitutes an important sub-sector of the Indian transport scene. But it is denied adequate recognition, and is lacking in an overall database for any of its modes. NMT modes of primary concern in India are animal carts, cycles, and cycle-rickshaws, and pedestrians in urban areas. Compared with about 37 million motorised vehicles, there are 90 million cycles, 85 million draught animals, 15 million animal carts, 3.2 million pack animals and 5 million (cycle-)rickshaws in India. Nearly 10 million cycles are produced annually as against about 4 million motorised vehicles. There are about 15 million animal carts in India, of a total of 35 million in the world<sup>[4]</sup>. A traditional cart hauls a load of about 0.25 to 1 tonne while an improved cart can haul up to 3 tonnes. Animal carts are estimated to haul a load of about 6 billion tonne-km per year [Ramaswamy, 1998]. India is now the world's largest producer of cycles. But there are only about 60 cycles/1000 people in India as against 270 in China, 700-800 in the Netherlands and West Germany, 490 in Japan and 420 in the USA. The use of cycles is getting restricted in Indian metropolitan cities as roads are taken over by MVs and even traditional cycleways are lost to them. Cycle-rickshaws have been proliferating in several cities in India. One estimate puts the number of rickshaw drivers in India at 10 million (at 2 drivers per rickshaw and 5 million rickshaws). The rickshaw becomes the obvious choice for movement over short leads and in congested areas. However, as in the case of animal carts, rickshaws can be made more efficient, safer, and less strenuous for their drivers by simple improvements in design and a fraction of the concern shown for motorised transport.



**Figure 3. India's oil import bill<sup>[1]</sup> compared with all imports<sup>[2]</sup> and external debt<sup>[3]</sup>**

Source: Economic Survey 1999-2000, Government of India, Tables 7.2 and 8.4(A).

Notes

1. This is the gross oil import bill (before exports are deducted).
2. This is the gross total import bill.
3. This includes both long-term and short-term debt; the former consists of debts to multilateral and bilateral sources and the IMF, as well as export credit, commercial borrowing, NRI & FC borrowings, and rupee debt..

Walking too is a distinct mode of mobility in cities. However, footpaths are missing, encroached upon, blocked and discontinuous. Crossing at intersections is hazardous. As motorised traffic increases, pedestrians, like cyclists and rickshaws, are paying the price – in 1991, over 60% of those killed in road accidents were pedestrians and cyclists.

### 3. Paradigm underlying growth of transport system

There is a definite paradigm<sup>[5]</sup> underlying the main features of the growth of the Indian transport system outlined above. Freight transport is thought of in terms of trucks (in preference to rail) and therefore in terms of roads and diesel consumption; and passenger transport, in terms of personal motorised transport by ATWs and cars running on motor spirit (in preference to public transport by road and rail). Also, the widespread role of NMT in rural and urban transportation is completely ignored.

### 4. Main features of the Indian energy system

Transportation is the second largest sectoral user of commercial energy considering only the energy directly consumed in vehicle operation (i.e., *traction* energy).

The energy for transportation comes primarily from petroleum products and to a small extent from electricity (for trains). In 1970-71, 38.3% of the transport sector's energy usage came from petroleum products; this "oil use ratio" rose rapidly to 82.1% by 1986-87 [PC, 1991, Table 7.7] and to over 95% in recent years.

In 1970-71, 30.3% of India's petroleum usage was in the transport sector; this "oil application ratio" increased to 37.6% in 1986-87 and to 41.1% in 1996-97 [PC, 1991, Table 7.8, for 1970-71 and 1986-87; IEI-CMIE, 2000, for 1996-97]. Transport demand in India has been growing faster than the economy. Between 1981-82 and 1990-91, the annual growth rate of "gross value added" (GVA) for the transport sector was 7.3% (as against 5.6% for the total economy); it was estimated to be 6.7% during the period 1992-93 to 1996-97 [PC, 1992, Part I, Table 3.14].

India's commercial energy resource base is meagre compared with the population; while India has a sixth of the world's population, it accounts for only about 0.8% of total geological reserves, with 5.7% of world's proven coal reserves, and 0.4% of the world's proven hydrocarbon reserves [PC, 1999, Vol. II, Paras 6.4 and 6.6]. Hence, India is increasingly dependent on imported petroleum (crude and products). The situation is bleak because domestic crude production peaked in 1995-96 and refinery capacity has only increased from 51.85 to 69.14 million tonnes per year between 1990-91 and 1998-99 [CMIE, 2000, p. 30].

India's import bill for crude and petroleum products has also been mounting ominously. The oil import bill (after deducting for exports) as a percentage of all imports in India increased from 8.3% in 1970-71 to 42% in 1980-81 and has been over 20% during the 1990s [GoI, 2000]. As a percentage of the total external debt, the oil import bill was 27% in 1980-81, fell to 6.6% in 1990-91 and rose to 8.2% in 1997-98 [GoI, 2000] (Figure 2).

According to a recent report [*The Hindu*, 2000, p. 18], India's oil import bill is expected to be US\$ 13.46 billion (of a total import bill of US\$ 53.47 billion) for the year 2000-01!

India's oil problem has been further aggravated by its disproportionate consumption of middle distillates, chiefly HSD and kerosene. The proportion of HSD in the total consumption of petroleum products has continued to rise from 21% in 1970-71 to 39% in 1990-91 and 46% in 1997-98 [CMIE, 1999, pp. 36-38]. As a result, the gap between HSD consumption and domestic production had widened to 12.9 million tonnes in 1997-98 [CMIE, 1999, pp. 29, 37].

While India's dependence on imported petroleum is growing to uncomfortable levels, its energy usage efficiency in the transport sector is estimated to be only half that in the industrialised countries. In the transport sector, taking estimates for 1996-97, 85% of oil use is in the road sector where energy-inefficient designs, poor vehicle maintenance and inadequate and low-grade roads are widely prevalent.

However, improvement of energy efficiency can only reduce, but not eliminate, the gap between the demand and supply of transport energy services. Energy is therefore a major constraint on the present pattern of growth of transport services. The limits to the growth of the transport sector in India may be dictated by, more than any other factor, its energy requirements, characterised as they are by growing dependence on petroleum imports. Hence, energy conservation, substitution of imported by domestic fuels and the pursuit of transportation policies and approaches appropriate to the resource base have to become vital national concerns.

##### **5. The goal – a sustainable transport system**

The business-as-usual approach to transport (based on "more of the same" and "the future will be a continuation of the past") is unsustainable. If the present transport trends are assumed to continue, then the oil demand and the associated transport bill, pollution (local and global), capital requirements for infrastructure, traffic delays and traffic accidents will all be unacceptable.

The model or paradigm that should guide the development and growth of the Indian transport sector must obviously result in a sustainable transport system. Energy consumption, pollution, investment needs and cost, congestion, safety, and the national resource base have to be taken as the critical parameters determining such an appropriate transport system.

The goal of the Indian transport sector should be *an efficient, capital-saving, non-import-intensive, affordable, service-oriented and environmentally sound transport system*.

The following are the critical constraints to the growth of the transport sector in India.

1. India has a meagre energy base, particularly of petroleum, the main transport fuel.
2. Even at its present levels of oil consumption, India is far from self-sufficient. In 1997-98, the total imports

of petroleum products were 23.982 million tonnes or 27% of the consumption of 88.372 million tonnes<sup>[6]</sup> and for HSD alone, the imports were 14.075 million tonnes or 39% of a total consumption of 36.218 million tonnes [CMIE, 1999, pp. 31-38].

3. The world's oil supplies are concentrated in the Middle East and a few other locations and are a major determinant of the world's geo-political scene. Oil prices fluctuate widely and the sensitivity of the Indian economy to sudden surges in oil prices must remain within manageable limits.
4. The rapid growth in energy consumption, particularly of oil, also involves enormous investments in fuel processing/ refining, transport and distribution, and growth in the transport sector on the basis of present trends involves similar investments in infrastructure and allied facilities.
5. Resource depletion, environmental damage and air pollution run practically parallel to the level and intensity of energy use in the case of the transport sector.
6. Transport should be available for all citizens at affordable prices.

A sustainable transport system should satisfy transport demand at least cost – energy, financial and social. Thus, it has to be based on an *end-use methodology*, which means a service-oriented approach for meeting transport demand.

Developing countries like India have opportunities for technological leap-frogging, thereby avoiding the energy-intensive stages through which industrialised countries have passed. But they must make locally relevant, affordable and cost-effective choices. Economic, institutional, and human developments should proceed along with a technological leap forward. Energy-efficient equipment or options often have relatively higher initial costs. Since individuals tend to consider initial front-end costs rather than long-term or life-cycle costing, state intervention is needed to provide the right incentives.

Costing of options should follow resource costs, i.e., real economic costs or societal costs based on shadow pricing of factor inputs. Individual choices tend to be based on financial costs to the operator/user. A sustainable system on the other hand is based on least cost to society. For example, the cost of reducing one unit of end-use energy is normally less than that of producing an additional unit, but it hardly enters into individual calculations. Nor do external costs like costs of pollution, noise, congestion, accidents, resource depletion, import dependence, capacity limits or traffic management.

A sustainable system has to be based on *self-reliance* as distinguished from *self-sufficiency*. While the latter would mean, for example, meeting energy needs only from domestic sources, the former would take into account the uneven distribution of oil resources in the world and benefit from trade as long as this dependence does not lead to external control or a compromise of a country's strategic interests, or adversely affect the long-term viability of the system.

A sustainable system must also be socially equitable and meet the transport needs of all sections. Public

policies should particularly cater for the transport needs of the poorer sections. This equity or access issue is being ignored in traditional transport planning, particularly in urban planning where private motorised transport, affordable only by a small fraction of the population, appears to be emphasised. Equity also demands that scarce resources like road capacity are shared equitably and those consuming a greater share bear at least corresponding costs. Similarly, those responsible for generating external social costs like polluted air, noise, congestion, lack of road safety and need for traffic policing have to pay to cover the costs imposed on others.

Yet another issue in equity is the paradigm underlying the growth of the transport system. For example, in the US, the poorest one-eighth of households spent 15% of income on petrol as against an average of only 5% for all households [Goldemberg et al., 1988]. In India, the present concern for private transport, while neglecting public transport and simply ignoring non-motorised transport, not only helps the rich at the cost of the poor but also leads to an unsustainable transport system.

Finally, a sustainable transport system is a part of the overall paradigm of sustainable economic development that does not imply only a high rate of growth.

## **6. Components of strategy for a sustainable transport system**

A strategy or broad plan to achieve this goal of a sustainable transport system should consist of several components:

1. minimisation of dependence on petroleum fuels to overcome the constraint of a meagre petroleum resource base and a substantial import bill;
2. maximisation of the level of safe, comfortable and time-saving transport services;
3. maximisation of the environmental soundness of the transport system, and in particular, reduction of local and global environmental pollution;
4. minimisation of the capital requirements for the transport modal mix that should also include non-motorised transport (NMT); and
5. minimisation of the energy used by the transport system without a reduction of the services that are provided.

Attention will next be turned to the detailed policies (plans or courses of action) to implement the above strategies for achieving a sustainable transport system.

## **7. Policies for achieving a sustainable transport system**

### **7.1. Transport-energy database generation and use**

The database available for the transport sector in India and its energy use is acutely inadequate and even imprecise, particularly in the case of the road sector which is the major consumer of transport energy. This is mainly because freight transport via roads is handled mostly by small-scale operators from the private sector. Passenger transport by roads is shared between state transport undertakings, and a large number of private bus and para-

transit operators. It is also widely diffused amongst private owners of cars and ATWs. In contrast, the railway and air sectors, perhaps because they are under centralised management, maintain comprehensive databases for their own planning and other uses.

Taken together, the available transport sector database leaves wide gaps in information essential for demand forecasting, analysis of alternative modal, fuel, technology and investment choices, and identification of least-cost solutions, of economic, social, environmental and energy costs, of operator, user and resource costs, and of optimal price, subsidisation, taxation and other fiscal policies. It is also not possible to work out total or modal demand relations with prices, investments or incomes or various policy choices.

Above all, the commonly available data is concerned only with direct energy consumption for traction ("operating energy"). It ignores even the infrastructural and institutional energy ("line-haul" energy and "modal" energy) usage in the transport sector, let alone the energy inputs into the manufactured equipment and supplies [OTA, 1992]. In the USA, about 42% of all energy used is in transportation, and of this, 25% is for fuel and 17% for building and maintaining vehicles and the "road" system [Money, 1984]. In the Indian Railways, revenue expenditure on non-traction energy is about a quarter of that on traction fuel.

Finally, the complete absence of data on non-motorised transport, which, in India, constitutes a significant and enduring transport sub-sector in both rural and urban areas, results in its total omission in transport and urban planning.

### **7.2. Demand management**

There are many ways of sustaining economic growth with lower growth in passenger kilometres (pkm) and tonne kilometres (tkm), i.e., there are many ways of reducing the transport elasticity of GDP. For example, improved land-use planning and the matching of jobs, schools, shopping centres and transport corridors to the location of residential areas could significantly reduce urban transport demand. Better telecommunication facilities also reduce the demand for transport. Demand management is primarily a matter of government policies and actions such as those concerning pricing, taxation and imports, land-use and urban planning, public transport support systems, industrial policies, attention to non-motorised and non-transport options, development of alternative fuels and institution of administrative and regulatory measures.

Traffic demand is a function of travel costs, subsidies and incentives (e.g., free and concessional travel), travel time, convenience and available options. It is also determined significantly by government's economic and development policies. A part of the traffic on a new or expanded road infrastructure may be that generated by its very presence, a sort of latent demand. Thus, trend projections of traffic demand, apart from being unrealistic unless correlated with the available and affordable resources, can be subject to significant margins of error. The way to a sustainable transport system lies in

management of traffic demand by looking at future options rather than forecasting this demand.

### 7.3. *Technological improvements in road transport*

Road vehicles offer exciting opportunities for enhancing fuel efficiency. In India, considerable progress has been made in the case of cars, but the situation regarding two- and three-wheelers, trucks and buses calls for urgent attention. Fuel efficiency can be improved in cars by reducing weight and aerodynamic drag, improving engine performance and vehicle drive and transmission, reducing rolling resistance, etc. In the case of two- and three-wheelers, the replacement of two-stroke engines with four-stroke ones could improve fuel efficiency by as much as about 25% and reduce air pollution by about 90%. The use of improved carburettors and electronic ignition could reduce fuel consumption by about 10% and hydrocarbon pollution by about 50%.

The need for technology improvements is most acute in the case of heavy vehicles, namely trucks and buses. The largest Indian trucks typically have a 9-tonne rating, though they overload up to 14 tonnes, compared with 20 tonnes in the USA. The engine speeds and specific weight of the engines are also too high. In addition, they are fuel-inefficient and have highly polluting manifold and combustion chambers, crash-type transmission with inappropriate ratios and obsolete suspension, brakes, wheel equipment, body design and other components.

The use of trailers, which is common in the industrialised countries, is rare in India. A 120-HP "single" truck carries about 10 tonnes, as against 18 tonnes with a trailer. Trailers also permit flexibility in the operation, use and maintenance of the driving units. Articulated trailers could simulate the "convoy" pattern [UNDP, 1993].

Buses have cheaply fabricated bodies, each built on a 110-BHP truck chassis designed for a payload of 10 tonnes, although the actual loading, which tends to be less than 7 tonnes, needs only about 90-BHP. Body designs are 40 years old in Delhi and 70 years old in the case of double-deckers in Bombay. Even urban buses have narrow aisles, high floor levels and narrow doorways. In place of the needed maximum speeds of say 50 kmph for inter-city buses, and lower speeds and high pick-up for urban buses, the present buses allow speed up to 80 kmph and low pick-up, leading to higher fuel use and pollutant emissions. Substantial fuel saving is possible by mandating the use of properly designed urban and inter-city buses [Reddy, 1991].

Commercially available technologies for saving fuel on trucks and buses include use of lighter bodies and engines, turbochargers, improved fuel injections and injector pumps, improved lubricants, radial tyres and cab-mounted front-air deflectors. Overall, a 20% saving in fuel is considered likely if available technologies are implemented on road vehicles.

The adoption of technological improvements requires a policy regime of adequate incentives and of ensuring that the social costs, such as those of damage to roadway, energy diseconomy and air pollution, are internalised. It also needs an indigenous research and development (R&D)

base so that technologies are made appropriate to the prevailing infrastructure, traffic, fuel quality, energy and pollution norms, and cost and income conditions.

### 8. **Improvement of the capacity and quality of road infrastructure**

Road capacity and quantity also play a critical role in the fuel performance of the vehicles as well as in road congestion, safety and pollution from vehicle emissions. A study by the Central Road Research Institute indicated that 90% of even the national highways are non-motorable by world standards. 60% of the length of state highways has poor riding quality and substandard geometry. One estimate predicts a saving of at least 10% automobile fuel consumption by better-maintained roads [Patankar, 1992].

Most of the expansion of the road network has been meant to achieve rural connectivity and access to remote areas. As a result, the length of national highway (NH) roads has increased from 24,000 km to only 35,000 km in 25 years, even though 35% of inter-city vehicle-kms are on NH and 75% on NH plus SH [MST, 1991].

The average traffic density of 1.37 passenger car units (PCUs) per km road length in 1950-51 has increased 8.53 times by 1988-89 and may reach 25 times by 2000. Considering the likely increase in traffic density on the national highways, it was targeted in 1992 that at least 4,000 km should be two-laned, 19,000 km weak pavements be strengthened, 14,900 km be four-laned, 1,000 km of expressways be constructed on routes having greater than 40,000 PCUs by 1995 and 44 bypasses be provided. The total cost (1991 prices) of all these along with other miscellaneous works amounts Rs.41.39 billion. The enormity of the task is seen from the actual capital expenditure of only Rs. 4.7 billion and maintenance expenditure of Rs. 1.81 billion. The government is trying to obtain loans and private sector participation. But commercial viability can be established only with considerable increase in user taxes/tolls.

### 9. **Traffic management**

Even with the existing vehicles on the road, fuel efficiency could be much improved by maximising the effectiveness of the existing road system through more satisfactory and better regulated operating conditions. Non-availability of footpaths and cycle-paths and use of the limited road space for non-transport purposes (hawking, stacking of materials, parking, etc.) result in the congestion of roads and the slowing down of traffic. This, combined with poor maintenance of vehicles and roads, poorly trained and checked drivers and mechanics (this training alone could save 10% of fuel), idle running of engines, overspeeding, frequent acceleration and deceleration, stoppages at check-posts, use of low-quality lubricants/ additives/ greases, and poor lighting, signalling, policing and parking controls on road traffic are among the various operational, regulatory and monitoring factors pertinent to conservation in transport. That is, reduction of transport energy can take place without a decrease in transport services.

**Table 2. Comparative fuel efficiency of various transport modes**

Mode	Unit	Fuel consumption
Freight: truck	litres/tkm	0.03429
Freight: rail	litres/tkm	0.00689
Passenger: rail	litres/pkm	0.00402
Passenger: bus	litres/pkm	0.00689
Passenger: petrol vehicle	litres/pkm	0.01383
Passenger: air (ATF)	litres/pkm	0.05653

Sources: *National Transport Policy Committee Report, 1980*, Planning Commission, New Delhi; News report, *Economic Times*, New Delhi, 16 March 1995.

Proper attention to the right-of-way (RW) factors (guidance; separation of slow-moving or non-motorised and fast or motorised traffic; and grade, direction and lane separation) and planned routing of trucks could also yield significant savings in fuel consumption. Special attention is needed at busy intersections. Avoidable road “congestion” has high direct and indirect costs, such as in fuel and time losses, increased energy use, pollutant emissions and noise, accidents and vehicle maintenance costs, health impacts on road users and residents, and other opportunity costs of traffic slowdowns. Slowing down of average speeds also drives people from public transport towards fuel-inefficient private vehicles and from non-motorised towards motorised transport [Anand, 1994].

Traffic management requires a detailed study of the contribution of each driving mode (idling, acceleration, deceleration, cruising) in total fuel use. A study done in the US estimated a loss of about 50 litres of fuel in 1,000 speed changes of 80-25-80 kmph [Khisty, 1990]. Optimum speeds need to be determined for the available road transport systems and traffic management implemented to achieve traffic flows with least obstruction.

## 10. Improvement of the railways

The Indian Railways have achieved substantial reduction in specific energy consumption – from 1204 MJ<sup>[7]</sup> per 1,000 gross tonne-kilometres (MJ/1000 gross tkm) for freight services in 1960-61 to 552 MJ/1000 gross tkm in 1993-94. This reduction has been achieved mostly through replacement of steam traction, adoption of welded track and elimination of wagon-load traffic and heavy shunting operations. Specific energy consumption of HSD seems to be stagnant or may have even increased since 1980-81 [IR, undated].

Further improvements in fuel economy will have to come via the more difficult route of better designs and maintenance practices and operating efficiency. Operating indices such as average speeds and wagon utilisation have remained constant. A highly skewed tariff policy, according to which freight transport is overpriced and passenger transport underpriced, has led to an avoidable diversion of freight traffic to roads, even though railways have a distinct advantage of fuel economy over roads. Also, the railway system's initiative in building up multi-modal

container and other traffic has been halting. There is a large untapped scope for fuel efficiency on railways through, for example, adoption of lighter wagons, low-friction bearings and on-board flange lubricators (which are reported to have resulted in 25% reduction in fuel consumption in the US).

Computer-directed operations (for which a start has been made) could achieve greater fuel efficiency. US railroads have achieved significant reductions in specific fuel use after deregulation of tariffs. The Indian Railways, too, should be able to meet the challenge, as they have the benefit of unified control [PC, 1988].

## 11. Improvement of urban transport

Urban transport policies should deal mainly with the management of demand, traffic and transport. Demand management attempts at containing transport demand through appropriate land-use planning, including relocation of existing amenities and provision of efficient telecommunication facilities. Traffic management attempts to optimise traffic flows with the existing transport patterns. Transport management tries to maximise the effectiveness of an urban transport system through changes in modal mixes and controls, as well as travel patterns. Energy use, environmental pollution (air pollution, noise) and accidents are vital concerns of an urban transport system. All three parameters are aggravated by road congestion.

In the case of passenger traffic, relative fuel efficiency figures attained under different modes vary widely under different operating conditions (Table 2). It is obvious that public transport, whether rail or bus, consumes only a fraction of the energy spent in private transport.

Whereas energy consumption in kWh/pkm on Indian metropolitan “surface” railway systems is between 0.01 and 0.05, the figure is 0.173 for 1991-92 and 0.263 for 1992-93 on the Calcutta metro, with about 75% of the energy being consumed for non-traction uses such as ventilation and lighting (Table 3). Thus, to what extent India can afford “metros” will depend on not only their financial costs but also their energy costs [Money, 1984].

Much can be learnt in this context from the well-known example of the Brazilian city of Curitiba (population: 1.6 million in 1990). There, an innovative urban transportation system has been developed that is based exclusively on buses but is as fast as subway systems at only a fraction of the cost. It appears unwise to jump from a bus system to a new capital-intensive rail-based system in a city without a proper cost-benefit analysis of different road and rail options, including their capital and operating cost, energy, pollution, space utilisation and other relevant parameters.

While various transport modes have a complementary role in a large city, it is obvious that urban transport planning and management should encourage public transport in preference to private transport. They should also recognise the significant role of slow-moving modes (pedestrians, cycles, rickshaws, carts) and adequately provide for these in respect of RW and crossing, parking and other traffic facilities.

Table 3. Electric energy consumption in suburban trains

	Bombay		Calcutta		Madras	
	1991-92	1992-93	1991-92	1992-93	1991-92	1992-93
Passengers ( $\times 10^6$ )	1,979	1,866	457	412	67	66
Passenger-km (bn)	43.06	41.21	15.57	14.58	0.85	0.89
Energy consumption (traction) (million kWh)	426	416	295	293	40	43
kWh/passenger-km	0.010	0.010	0.019	0.020	0.048	0.048

Electric energy consumption in the Calcutta metro (kWh/passenger-km)

	1991-92	1992-93 <sup>[1]</sup>
Traction	0.044	0.063
Non-traction	0.129	0.200
Total	0.173	0.263

Source: Personal communication from the Indian Railways.

Note

1. In 1992-93 the number of passenger-km fell by 34.3% over 1991-92 (241.44 million passenger-km and 150 million passenger-km) due to a sudden fare raise.

## 12. Implementing a niche for non-motorised modes of transport

Despite the major contribution of non-motorised transport, transport planning seems to consider only motorised transport. There is a complete neglect of non-motorised modes.

As cities grow in size, NMT remains relevant but its role progressively shifts towards shorter lead and feeder services and providing access to public transport. Cycle and rickshaw journeys are best suited for short distances, in interior and congested areas and on narrow streets, and for transport of small loads (say, up to 100 kg on cycles and 400 kg on rickshaws). Such journeys, along with pedestrianisation of shopping centres, should be an essential and low-cost ingredient of the urban transport scene in India.

The importance of draught animals (mostly bullocks and buffaloes) and animal carts in rural transport is also grossly underestimated in Indian planning. Even when ignored as an archaic mode, waiting to be “tractorised”, and even when alternative diesel and electric power are heavily subsidised in rural areas, they still serve for the cultivation and transport needs of about 100 million hectares, i.e., about two-thirds of the sown area. Draught animals are estimated to haul more freight than road and rail combined. If a small fraction of the attention and investment provided to the motorised sector were given to the development (in equipment and operator systems) of animal transport, its efficiency and output could improve substantially [Singh, 1995].

Motorised transport is capital-intensive, import-oriented, and environmentally hazardous and needs enormous investments in infrastructure. In contrast, non-motorised transport, which is labour-intensive, indigenous, benign to the environment and requires much lower infrastructure expenditure, is a far more sustainable transport system. There should be adequate recognition of

the existence and merits of NMT, and there should be a *level playing-field* for investment, credit, and technology development, so that an optimum modal mix is obtained in the national interest.

## 13. Pollution control and abatement

Air pollution caused by vehicle emissions (exhaust, evaporative, and crankcase ventilation emissions) constitutes the most hazardous environmental impact of the transport sector. Since most of the train services around metropolitan cities are now electric, and even diesel locomotives have a lower specific fuel consumption and are better maintained, air pollution is basically a product of road transport (Table 4). Diesel vehicles can be less polluting, being more efficient burners of fuel, provided they are well designed and maintained. Air pollution in Indian cities has already crossed critical levels and, in view of the fast-growing vehicle population, calls for urgent remedial measures. The emission standards currently in force (from April 1996) are closer to the European Union standards than the tougher US standards [CMVR-AR, 1996].

Solutions to the problem of vehicle pollution must be found on lines broadly similar to those for achieving fuel economy – technology improvement, demand, traffic and transport management, cleaner and alternative fuels, modal shifts, and suitable pricing, taxation and other fiscal policies, and above all, effective regulation and enforcement. Stringent controls on vehicle inspection and maintenance can yield significant reduction in pollution levels. For instance, the withdrawal of old commercial vehicles from Delhi's roads<sup>[8]</sup> since April 2000 has resulted in a reduction of SO<sub>2</sub> emissions by 25%, SPM by 26.2%, and of NO<sub>x</sub> from 86  $\mu\text{g}$  to 57  $\mu\text{g}$  [Sagar, 2000]. A start has been made with catalytic converters and unleaded petrol, but it needs a sustained programme till all new cars roll out with converters. Vehicles based on CNG are being

Table 4. Pollutant emissions from motor vehicles

Mode	Carbon monoxide (CO)	Unburnt hydrocarbon (HC)	Nitrogen oxides (NO <sub>x</sub> )	Sulphur dioxide (SO <sub>2</sub> )	Lead (Pb)	Total suspended particulates (TSP)
1. Emissions from different vehicles (grams per km travelled)						
2-wheelers	8.30	5.18	-	0.013	0.0040	-
Cars	24.03	3.57	1.57	0.053	0.0117	-
3-wheelers	12.25	7.77	-	0.029	0.0090	-
Urban buses	4.38	1.33	8.28	1.440	-	0.275
Trucks	3.43	1.33	6.48	1.130	-	0.450
LCVs	1.30	0.50	2.50	0.400	-	0.100

Source: *Fueling Development Energy Technologies for Developing Countries* (Chapter 5: "Energy Services -- Transport"), 1992, OTA, US Congress.

2. Index of emissions/passenger-km from various vehicles as a multiple of those from a bus						
	CO	HC	NO <sub>x</sub>	SO <sub>2</sub>	TSP	Energy demand
Bus	1	1	1	1	1	1
Car	90	43	3	1	0	6
Taxi	113	55	4	1	0	9
3-wheeler	60	121	0	1	0	4
ATW	49	100	0	0	0	2

Source: Datta, B.C., "Emission control issues and strategy in the context of transportation scenario in India", September 1994, *J. Inst. of Town Planners (India)*, New Delhi

introduced<sup>[9]</sup>. Investments in fuel reformulation in refineries are required, so that lead pollution abatement is not achieved at the cost of pollution from carcinogenic benzene and other aromatic compounds.

Secondly, there is inadequate concern for bringing in the needed technological changes in two- and three-wheelers, trucks and buses. Nor is any policy effort visible in traffic and transport management, particularly in urban areas. In the case of two- and three-wheelers, replacing two-stroke with four-stroke engines could reduce air pollution by 90%. Use of improved carburetors and electronic ignition could reduce hydrocarbon pollution by 50%.

#### 14. Costing and pricing

Thus far, fuel prices have been administered by the government in India. Though the distillation costs of various petroleum components are nearly the same, the price of high-speed diesel (HSD), the fuel most used in the transport sector, has been kept artificially low at about 40% of the price of motor spirit (petrol), as against about 80% in Western countries (Table 5). Even the price of motor spirit (MS) is well below that in most of the oil-importing countries (1992, \$/litre) – India 0.48, Brazil 3.2, Uganda 1.33, Italy 0.99, Japan 0.91, Denmark 0.93.

These administered prices discourage energy conservation because pricing policies play a vital role in determining energy consumption in the transport sector. The demand for less energy-efficient private transport in place of public transport, for road transport in place of rail, and for avoidable motorised transportation arises largely be-

cause users do not have to bear the true costs of road and parking space, road signalling and lighting, policing, accidents, and adverse environmental impacts.

India needs to invest much more in providing adequate road capacity and in road maintenance. This has raised the issue of earmarking of the revenue collected from road users for road construction and maintenance. According to one view, the final solution is to move towards a *congestion pricing model*, where new investment in road infrastructure is only justified when the revenues collected from road users on current infrastructure are sufficient to cover the cost of infrastructure expansion and the mitigation of environmental externalities [Carbajo, 1993]. According to a World Bank report, Indian fuel taxes in 1987-88 at 34% of total road user revenue were the least among the 20 countries examined, except Pakistan (33%).

Administered rail tariffs have also produced negative consequences. Freight services have been overpriced to compensate for underpriced passenger services. This political decision has led to the progressive diversion of interregional freight traffic from rail to road, with the consequent three- to four-fold consumption of HSD on the traffic thus diverted, apart from pollution and road congestion. Since 1950-51, the cost of passenger traffic has increased due to improvement in service quality, and that of freight traffic has fallen due to the heavy reduction in the share of wagon load traffic and increase in trailing loads. The average revenue/tonne-km (1991, price parity adjusted) was equivalent to 6.1¢ (US cents) as against 1.9¢ on US Class 1 railroads, 4¢ in China and 5-7¢ in Europe [World Bank, 1995]. On the other hand,

revenue/passenger-km was only 2¢ in India as against 4¢ in China, 7-12¢ in Europe and 11.5¢ in the US. By all considerations, the rate per passenger-km should be higher than that per tonne-km instead of being one-third as now (Table 6).

### 15. Modal shifts to achieve a least-cost freight modal mix

Freight movement by rail consumes about one-fourth as much operational energy per tkm as that by road, as shown in Table 2. The latter, however, offers greater flexibility and reliability. In spite of the overwhelming fuel efficiency of rail transport, its share of freight traffic is decreasing partly because of the low unit capital demand in road transport, i.e., "creeping incrementalism", and weakening of the government support to the Railways.

Adoption of integrated freight transport policies, using the strong complementarities of both rail and road, is obviously required [PC, 1992; Papacostas, 1987]. In this connection, the "container" transport system should be encouraged; here, rail movement is used as a bridge between the access movements by road at origin and destination. More initiative is needed from the government, as it requires co-operation between the public and private sectors as well as co-ordination among various government agencies.

Finally, it is stressed that choices should be determined by overall user costs including the opportunity costs of factors like time, safety and convenience. While policy options are obvious, their implementation depends on the extent to which necessary pricing, fiscal and regulatory measures are adopted and enforced. Shifting of longer lead freight traffic away from trucks to rail will not only save on precious imported oil, but also reduce the pressure on road space, road damage and maintenance cost, pollution and accidents.

### 16. Modal shifts to achieve a least-cost passenger modal mix

Least-cost solutions necessarily involve an integrated approach to achieve a multi-modal hierarchy that answers the transport needs of all groups within the framework of the mandated goal. It mainly involves modal shifting in favour of (1) public transport (bus, rail, paratransit) from private transport (cars, ATWs), (2) non-motorised from motorised transport, and (3) non-transport approaches (better land-use planning, post and telecommunications) from direct supply of transport.

Buses must be the core of public transport as rail transit will be limited to high density arteries in metro cities. Unfortunately, in 1997, there were four times as many cars and almost ten times as many ATWs, but only three times as many buses, as in 1981. Thus, compared with one bus for every seven cars and sixteen ATWs in 1981, there was one bus for every ten cars and 53 ATWs in 1997. This trend received a further fillip with the recent encouragement to the car industry under the new economic policy. The NTPC report [PC, 1980, Table 3.15] and common experience suggest that the fuel consumption

**Table 5. Relative prices of high speed diesel (HSD) and motor spirit in various countries**

(prices in Rs per litre in December 1993)

	HSD	Motor spirit (petrol)	HSD price as % of MS price
USA	9.13 (3.62) <sup>[1]</sup>	8.91 (3.15)	102.5
France	18.71 (11.67)	31.69 (25.40)	59.0
Germany	18.14 (10.82)	25.35 (19.43)	71.6
Italy	19.59 (12.71)	29.79 (22.80)	65.8
UK	21.40 (13.41)	27.07 (20.05)	79.1
Japan	24.80 (10.54)	37.49 (17.97)	66.2
India <sup>[2]</sup>	7.58 (2.47)	19.09 (12.84)	39.7

Notes

1. Figures in brackets indicate the corresponding tax element.

2. Indian prices are for Bombay (Mumbai).

Source: *Hydrocarbon Perspective: 2010 -- Meeting the Challenge*, February 1995 - Report of the Study Group, Ministry of Petroleum and Natural Gas, Government of India.

**Table 6. Tariffs on the Indian Railways**

(in Indian rupees of the same year)

	1950-51	1993-94
Average rate per tonne km	0.0316	0.4863
Average rate per passenger km	0.0148	0.1650

Source: Indian Railway Year Book, 1993-94

per passenger-km in a bus would be only one-fifth to one-tenth of that in a car/ATW. Thus, of the estimated 7.5 million tonnes projected petrol consumption in the transport sector in 1996-97 [PC, 1992, Table 3.24], at least 3-4 million tonnes could be saved by diversion of half the journeys from cars/ATWs to buses or trains (where feasible). The recent introduction of "luxury" limousine shuttle buses and hovercraft in Bombay to cater for the upper end of the market is also a step in the right direction as these replace a much larger number of private cars [Joshi, 1995].

Policy measures to achieve a shift towards public modes demand, above all, government commitment to this goal, including investments in infrastructure for public (road and rail) transportation and preferential treatment to it in road space (such as bus lanes) and traffic management. The benefits accruing from reduced pollution, road space utilisation and less accidents should be internalised in relative taxation and other costs.

The importance of providing adequate facilities for movement of pedestrians, cycles and rickshaws has already been stressed.

### 17. Solutions to the transport sector's problems through measures in other sectors

Though truck costs are lower than rail costs for short hauls, they rise more rapidly with distance and exceed rail costs at large distances. Thus, there are break-even dis-

Table 7. Lead distances and break-even distances for freight in 1986-87

Commodity	Rail			Road			Break-even km	Break-even/ rail lead	Break-even/ road lead
	Percentage		Lead	Percentage		Lead			
	Tonnes	tkm	km	Tonnes	tkm	km			
Coal	41	38	717	7	8	460	232	.32	.50
Foodgrain	8	13	1146	11	10	386	280	.24	.73
Cement	8	7	678	5	4	276	193	.28	.70
Fertilizer	5	7	989	4	3	292	184	.19	.63
Iron & steel	4	6	1191	5	6	487	220	.18	.45
POL	9	6	526	5	3	274	67	.13	.25
Iron ore	8	3	325			373			
Limestone	3	2	544	2	1	303			
Salt	2	3	1388	1	1	354			
Others	12	15	1013	60	64	429			
Total	100	100		100	100				

Source: Report of the Steering Committee, Perspective Planning for Transport Development, Planning Commission, Government of India, August 1988.

tances above which rail transport is more economical in terms of resource use.

Unfortunately, the average lead distances over which trucks are now carrying freight are much greater than the break-even distances for most commodities (Table 7). Trucks are able to move freight over distances exceeding the break-even distances because truck operators do not have to pay for the social cost of diesel; hence, their break-even distances based on their lower financial costs are much greater than those based on the resource costs to society.

The obvious solution is to remove the advantage that trucks are enjoying over the railways via subsidised diesel prices. But diesel prices cannot be increased without roughly equal increases in kerosene prices because, if the administered diesel price is very much greater than that of kerosene, trucks adulterate their diesel fuel with kerosene and immediately create a kerosene shortage. This shortage causes great hardship to the poor because kerosene is still used for lighting in 75% of rural and 27% of urban homes (1991 Census) [GoI, 1992].

Diesel consumption in the transport sector is linked, therefore, to kerosene consumption in the domestic sector. Hence, the solution to the diesel problem lies in a massive programme of home electrification. When all homes are electrified, kerosene will be unnecessary as an illuminant. To make the replacement of kerosene complete, additional measures are required for replacing kerosene as a cooking fuel in cities.

Once kerosene becomes completely redundant, the subsidy on diesel can be removed and its price can be brought on a par with that of petrol. Indeed, diesel and petrol should have approximately the same price because they cost roughly the same to produce. The funds used for implicit subsidies on kerosene and diesel can then be diverted to the improvement of the railways' freight

operations.

The increase of diesel prices is only a necessary condition for reducing truck use for freight, but it is not a sufficient condition. Nevertheless, the price increase would create a very favourable environment for further steps. These additional regulatory measures may include: (1) increase of taxes on trucks so that they make a fairer contribution towards the maintenance of roads and related infrastructure, (2) cancellation of all long-haulage, or inter-state, truck permits except for special cases, (3) issuing of truck permits only for intra-state and adjacent-state transport, and (4) incentives for linking trucks with the railways' freight operations to provide door-to-door freight movement.

## 18. Alternative fuels

The primary energy source for road transport today is oil. However, experiments are going on for using biomass-based fuels, gaseous hydrocarbons, wood/coal-based fuels, solar cells, electrical energy, hydrogen, and other potential energy sources for transport. It seems, however, that immediately viable options are restricted to alcohols and their blends, liquefied petroleum gas (LPG) and compressed natural gas (CNG), and electrically driven vehicles. The issue is more of availability, logistics and of relative pricing.

Alcohol fuels (ethyl alcohol,  $C_2H_5OH$ , and methyl alcohol,  $CH_3OH$ ) can be used as straight substitutes for petrol/HSD or as their extenders in "gasohol" or HSD-alcohol blends. Ethyl alcohol is obtained from distilling fermented agricultural products and would need, therefore, cultivable areas for this purpose. In view of the limited resource base, it is a viable option only where land-food needs allow adequate surpluses. Methyl alcohol can be produced from coal, natural gas (NG) and forest wastes and its 10-20% blends with petrol/HSD would be

its most rational use. Both alcohols may have a negative overall energy balance if the agricultural production of the feedstock is very energy intensive.

LPG and CNG are the most used alternative transport fuels at present. LPG, consisting of propane or butane gas or a mixture of both, is usually a by-product of oil/petrochemical refining but also comes from treatment of natural gas. It is particularly suited to being an engine fuel because of its high octane rating and negligible exhaust emissions. Most retrofitted petrol vehicles can work on both petrol and LPG. A larger (and much heavier) fuel tank is needed for the same range of refuelling. LPG is traditionally used in small vehicles such as tractors. But more pressing and important demands for it generally preclude its large-scale availability for transport vehicles.

CNG consists of mainly methane gas with small amounts of ethane and carbon dioxide. Being a gas, it is compressed to 160-180 atmosphere pressure. Conversion kits are available for its use in both petrol and diesel engines. Its main drawback is the need for a new chain of filling stations unless compressors can be installed in the vehicle depots. Retrofitted vehicles are usually equipped with a dual-fuel option.

The main problem with vehicles based on electrical energy is the need of heavy and cumbersome batteries. Though research on battery systems is going on worldwide, lead-acid batteries remain the present option. Compared with petroleum fuels, batteries have low specific energy and more difficult and costlier maintenance. However, whether battery-operated or operated directly from the mains (trolley buses), electrical vehicles have a future in congested urban areas because they avoid pollution and can replace the use of imported petroleum fuels with electrical energy produced from domestic resources.

Alternative fuels must be pursued for the long-term substitution of petroleum but in the short/medium term, the remedy lies perhaps in pursuing the host of energy conservation measures discussed hitherto.

### 19. Policy instruments

It is not enough to formulate policies and call it a day; it is essential to identify appropriate policy instruments or mechanisms for initiating and maintaining the policies as well as suitable policy agents to wield the policy instruments.

One of the most important policy instruments is the market. The market has the power of being an excellent allocator of money, materials and manpower, but unfortunately also has definite limits – it is not very good at looking after the poor, the environment, the long-term and the infrastructure and national strategic concerns such as self-reliance and external debt, all of which are of crucial relevance to the transport system. The causes of market failure in the transport sector include imperfect information among market agents, conditions of imperfect competition or virtual monopoly, long-gestation investments, and capital-intensive infrastructure.

As already discussed, there is a tremendous scope for achieving energy economies in the transport sector in

India. But this achievement depends critically on the role that the government plays in evolving necessary policies and setting up an effective regulatory and institutional framework for this multi-modal sector. Currently, the decision to implement energy conservation is left to the individual operator or user who is guided by short-term and direct gains. Norms for energy use are lacking. Poor enforcement of standards is common. Traffic forecasts are mere extrapolations. Even traffic data for the largest transport sub-sector, the road, is speculative. There is a policy vacuum in respect of vital aspects such as modal mixes, NMT, public transport, and least-cost options. Hence, the visible hand of government and the people must complement the invisible hand of the market.

In playing this crucial role, the government has at its service the policy instruments of pricing, taxation and regulation – all of which therefore merit special and detailed attention. The public has the responsibility of monitoring the delivery of transport services (in adequate quantity and quality) and providing articulate feedback to its agent, the government.

The transport sector is divided among four central ministries and between the centre and the states. Energy and environment are the concerns of yet other ministries. The NTPC report (1980) had strongly recommended setting up a National Transport Commission to handle the three main functions of co-ordination: pricing, investment and regulation, and an institute for taking up transport research and training and studies on transport planning and management. However, no action was taken on this recommendation.

The scope and content of the government's regulatory role can be debated, as there is also a concurrent move towards deregulation or privatisation of government ownership in the transport sector. There are trade-offs between the social costs of market failure and the costs of correcting these through government intervention. The overall effects of such intervention also depend on the rationale for regulation, the type of regulatory instruments and processes, transport sector issues of concern, and legal and political environment. Setting of goals, strategies and policies and their enforcement lies essentially with the government, to ensure that true social costs are correctly and equitably apportioned. Beyond these, government regulation should be removed to the extent doing so results in overall improvement in allocation of scarce resources. It is also stressed that regulation of the government sector in transport is no less necessary than that of the private sector.

Setting up of the following institutions (policy "agents") should be considered for achieving various policy objectives discussed above:

1. A *National Transport Commission* (NTC) to assist the government, broadly, in policy areas of: (1) coordination between ministries, with states and with other interest groups or institutions; (2) transport data collection and analysis and institution of studies, surveys and other action for obtaining a comprehensive transport information database; (3) transport planning

issues including modal shares and multimodal traffic, energy use, environmental impacts and accidents; (4) costing and pricing of transport inputs and services, resource costs, subsidies, investments and their funding; (5) technology options in the transport sector and R&D needs; (6) legislation and regulations relating to the transport sector, formulations of norms and targets.

2. A *Transport Regulatory Authority* (TRA) for the administration and enforcement of various transport policy parameters. The roles of the NTC and the TRA are complementary. The former helps in formulation of policies and policy instructions, and the latter in their implementation.

3. An Urban Metropolitan Transport Authority (UMTA) in each metropolitan city (population greater than 1 million) for coordination in planning and provision of transport services by different modes.

### 20. Short-term and long-term measures

Political decision-makers inevitably have short time-horizons; in fact, it is difficult for them to have concerns beyond the next election! Consequently, they are unlikely to be excited about packages that only contain long-term measures and distant visions. On the other hand, if there are also politically attractive short-term measures, then the addition of long-term measures confers on them a visionary character. In other words, long-term visions become acceptable if they are appended to short-term attractions.

The short-term measures consist mainly of better maintenance, better driving practices, optimal routing of buses, dedicated routes for buses with traffic restrictions on these dedicated routes, special lanes for slow traffic, supply constraint on personal vehicles, export orientation to the production of personal vehicles, removal of kerosene and diesel subsidies, no long-haul truck permits, increase of truck taxes and shift of passengers travelling less than 300 km from rail to bus. It is obvious that many of these measures can be implemented at very low cost.

In the case of vehicles, the long-term measures consist mainly of increases in fuel efficiency, introduction of lower-power bus engines, increases in number of buses and/or suburban trains, investments on mass transportation infrastructure, home electrification, improvement of rail freight operations, truck-rail freight linkage, introduction of CNG for urban fleets, switches to biomass-derived fuels for transportation, biomass-derived fuels as petrol and diesel extenders, silviculture for biomass-derived fuels, and alternative cooking fuels and/or devices to replace kerosene. ■

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#### Notes

1. The remaining vehicles were taxis (1.1%), tractors (5.8%), and trailers and other goods vehicles.
2. The available length further suffers not only from structural weakness as well as high

congestion created due to "ribbon" development and encroachments along the road, but also level crossings and inadequate road width.

3. The four largest "metro" cities are Delhi, Mumbai (Bombay), Chennai (Madras) and Calcutta, although the number of vehicles in Bangalore has now exceeded that in all the metros other than Delhi.
4. This is a conservative estimate for the 1990s: sample surveys indicated over 25 million in 1987.
5. A paradigm is a pattern of thinking or a mindset.
6. This does not include imports of crude oil which in recent years have been equivalent to over 50% of crude throughput.
7. Converted from the figure of 41.11 kilograms of coal equivalent (kgce) in the original reference using the conversion factor 1kgce = 29.3 MJ. Similarly, the figure of 546 MJ later in this paragraph is derived from 18.84 MJ.
8. The vehicles withdrawn included 1,847 buses of the Delhi Transport Corporation, 17,841 autorickshaws (passenger three-wheelers) and 1,200 taxis.
9. For instance, according to a Supreme Court ruling (28 July 1998), the Transport Department of Delhi has to acquire 10,000 buses run on CNG by 1 April 2001.

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