by S.L. Dhingra

FEATURE

ROAD CONDITIONS AND VEHICLE PERFORMANCE

IMPROVING THE EXISTING ROAD NETWORK, COUPLED WITH PROPER DRIVER TRAINING CAN HELP AVOID A LOT OF UNNECCESSARY EXPENDITURE, ACCORDING TO A ROAD USER STUDY.

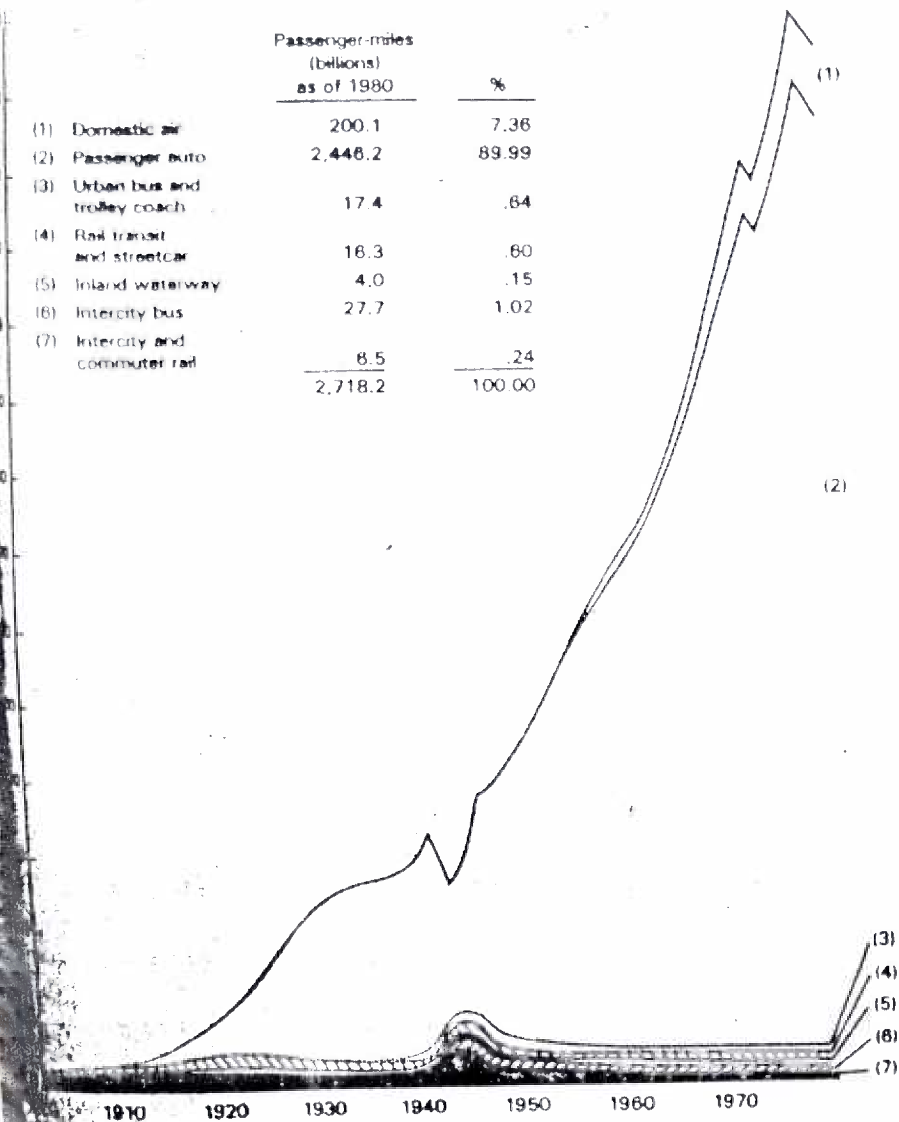
A Road User Cost Study, jointly funded by the World Bank and the Govt of India, has thrown up some very interesting and revealing results. The study aimed at quantifying how road characteristics affected cost of operation of vehicles, rate and cost of traffic accidents and travel speeds. The project covered a wide variety of road, traffic and environmental conditions, generally found in India, and can thus be used to predict the fuel consumption and other vehicle operating cost components for any set of such conditions. The project employed a twin procedure of data collection, namely, data from real life vehicle operations and data from controlled experiments.

Speed is known to affect fuel consumption significantly. The study has proved that there is an optimum speed for each type of vehicle, at which the fuel consumption is minimum. Lower or higher speeds result in a significant increase in fuel consumption. The optimum speed is in the range of 35-45 kph. Table 1 shows the fuel consumption at various speeds for the common vehicle makes in India.

The result clearly demonstrates that rich dividends can be obtained by driver training and by fitting speed governors. It is also evident that on good roads where steady speeds can be observed without the need for frequent acceleration and deceleration, a substantial amount of fuel can be saved.

The effect of pavement specifications, road roughness and riding quality is shown in table 2.

It is borne out by the above results that a good road surface facilitates fuel economy. Due to paucity of funds, it has not been possible to provide a superior specification such as asphaltic concrete on the National Highway network, let alone the other roads. A good proportion of the road surface in the country (roughly [illegible] per cent) is still unsurfaced. It would be a wise investment to immediately convert these roads into surfaced ones to bring about



	Passenger-miles (billions) as of 1980	%
(1) Domestic air	200.1	7.36
(2) Passenger auto	2,446.2	89.99
(3) Urban bus and trolley coach	17.4	.64
(4) Rail transit and streetcar	16.3	.60
(5) Inland waterway	4.0	.15
(6) Intercity bus	27.7	1.02
(7) Intercity and commuter rail	6.5	.24
	2,718.2	100.00

Figure 1-3 Estimated passenger-miles of travel in the United States, 1900-1980 (Courtesy: Transportation Systems Center, U.S. Department of Transportation)

TRANSPORTATION ENERGY SOURCES—NEAR TERM

Several energy sources for transportation are possible now and for the near future (before 2000). The current source is petroleum, from which derived gasoline and other distillates for use in existing and improved

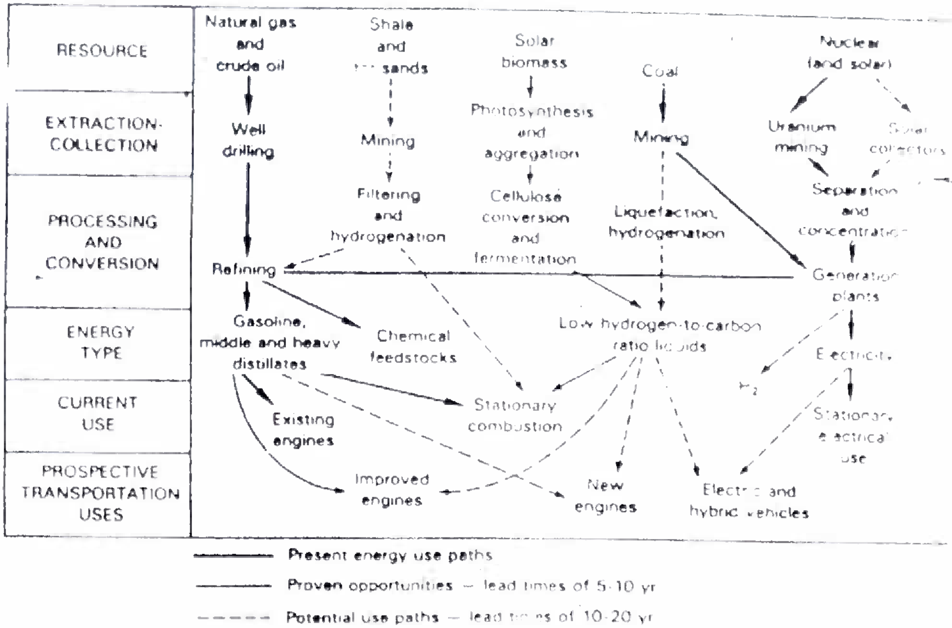


Figure 1-4 Transportation energy sources (*Source:* Dr. Eugene Goodson, Purdue University)

engines. Petroleum derivatives are also used outside the transportation sector for stationary combustion, chemical feedstocks, and so on. Another energy source consists of shale and tar sands, which through mining, filtering, and hydrogenation and refining can produce liquid fuels that can be used in much the same way as petroleum-derived liquids. Coal is yet another fossil energy source that, through proper treatment, can produce transportation-quality fuels and can, of course, be burned in stationary plants to produce electricity that can be used in electric and hybrid vehicles. Nuclear plants also produce electricity that can be used in transportation. Finally, solar biomass, properly treated, can be used to produce low hydrogen-to-carbon-ratio liquid fuels that can be used to power transportation vehicles. All these energy sources and their prospective transportation use are shown in Figure 1-4, developed by Goodson at Purdue University [16]. A more detailed discussion of the long-range fuel sources shown in Figure 1-4 will be included in Chapter 4.

Table 1. Effect of speed on fuel consumption of vehicles					
Speed km/hr	Ambassador car	Premier Padmini car	Mahindra Jeep	Tata Truck	Ashok Leyland heavy duty truck
10	239	126	187	298	145
15				203	120
20	134	105	139	156	108
25				131	102
30	106	100	104	115	100
35			100	107	100
40	100	100	102	102	102
45				100	104
50	105	102	119	102	108
60	117	106	148	108	118
70	134	111	188	122	132
80	156	118		140	148
90	183	126		162	
100	214	135			

Table 2.							
S. No.	Rough-ness	Surface type	Fuel consumption expressed as percentage of fuel consumption on the best surface				
			Amb-assador	Prem-ier car	Mahin-dra Pad-mini car	Tata Truck Jeep	Ashok Leyland heavy duty truck
1.	3000	Asphaltic Concrete	100	100	100	100	100
2.	5000	Premix Carpet	102	106	104	102	104
3.	6000	Surface Dressing	102	108	105	103	106
4.	8000	Good Water-Bound-Macadam	104	114	110	105	111
5.	12000	Poor Water-Bound-Macadam	107	125	116	108	119
6.	15000	Gravel,Earth	110	133	122	111	126

Tabel 3. Effect of upward gradient on fuel consumption					
Gradient (Per cent)	Fuel consumption expressed as a percentage of fuel consumption on level road				
	Ambassador car	Premier Padmini car	Mahindra Jeep	Tata Truck	Ashok Leyland heavy duty truck
0	100	100	100	100	100
1	118	113	118	125	114
2	137	126	137	150	128
3	155	140	155	175	142
4	173	153	174	200	156
5	192	166	192	227	170
6	210	179	210	250	184
7	228	193	229	275	198

fuel economy.

The effect of the upward gradient on fuel consumption is brought out remarkably in Table 3. A wise policy should, therefore, be to construct roads with gentle gradients.

The fuel savings possible by widening the roads are given in Table 4.

Considerable wastage of fuel takes place during idling at forced stops such as check barriers. The rate of idle fuel consumption for various vehicles is given in Table 5.

By rationalising or eliminating the check barriers on the roads, a good deal of savings in fuel can be brought about. The abolition of octroi can eliminate many check barriers.

Based on the above results, the savings in fuel consumption that are possible by the various road improvement measures are detailed in Table 6. The values are weighted and take into account variations in terrain and type of vehicles.

Estimated costs and benefits of road improvements

With the results obtained from the Study, it is possible to estimate the cost of improvements needed for the road network and the benefits that will flow from such improvements.

The National Highway network comprises 31,398 kms of roads, serving as the major artery of traffic. The system is only two

The total fuel bill in the road transport sector is around Rs 2500 crore, excluding taxes.

Table 4. Fuel consumption savings (in per cent) possible by pavement widening

Terrain	Widening single lane to Intermediate lane			Widening single lane to two-lanes			Widening intermediate lane to two-lanes		
	Car	Truck	Bus	Car	Truck	Bus	Car	Truck	Bus
Plain	1	1	1	2	2	2	1	1	1
Rolling	5	3	2	6	3	2	2	2	2
Hilly	15	8	10	20	10	14	10	3	3

Table 5. Idle fuel consumption

S No.	Vehicle	Idle fuel consumption (cc/min)
1.	Ambassador Car	130
2.	Premier Padmini Car	105
3.	Mahindra Jeep	123
4.	Tata Truck	153
5.	Ashok Leyland heavy duty truck	354

per cent of the total road length but caters to nearly 45 per cent of the total freight transport by road in the country. Though it carries such a heavy traffic, its development is a continuous process, and at present, major deficiencies exist. Some of them have a direct bearing on fuel economy and are listed in Table 7, along with the cost of removal of the deficiency and likely savings in fuel. In working out the fuel economy, suitable traffic volume has been assumed as follows:

- Low traffic volume 1500 vehicles/day
- Medium traffic volume 3500 vehicles/day
- High traffic volume 10000 vehicles/day

The cost of improvement has been taken at current figures.

It is seen that the fuel savings alone give a first year return of nearly 10 per cent.

The situation in respect of the lower category of roads can be similarly worked out as shown in Table 8.

The above figures indicate that an investment of the order of Rs 3000 crore on roads other than National Highways will yield a return of about 8 per cent during the first year, in fuel savings alone.

The total fuel bill in the road transport sector is around Rs 2500 crore, excluding taxes. The road improvement programme suggested above (cost: Rs 5300 crore), will bring about fuel savings to the extent of Rs 500 crore annually. This is nearly one-fifth of the total fuel bill. If roads are not improved, the amount represents a national loss which could have been prevented.

Table 6

S.No.	Nature of improvement	Fuel saving (%)
1.	Widening single lane pavement to intermediate width and improving its riding quality	5
2.	Widening single lane pavement to two-lanes with minor improvement in riding quality	6
3.	Widening single lane pavement to two lanes, strengthening the pavement and improving riding quality	10
4.	Providing thin bituminous surface on water-bound macadam roads	10
5.	Paving earthen and gravel roads with a water-bound macadam, surfaced with thin bituminous course	15
6.	Strengthening weak bituminous pavements and providing superior bituminous surfacing	5

Table 7. Deficiencies in the National Highways, cost of their removal and fuel economy possible.

S.No.	Deficiency	Length (km)	Cost of removal of deficiency (Rs crores)	Fuel economy possible for year excl of taxes (Rs crores)
1	Low grade sections to be upgraded & widened	671	100	4
2.	Single lane road to be widened & strengthened	7371	737	52
3.	Strengthening two-lane pavements	19291	1450	182
			2287	238
		Say	2300	240

Table 8

S. No.	Road category	Total Length (km)	Min. Investment needed for fuel savings (Rs crores)	Likely fuel savings (excl. of taxes) (Rs crores)
1.	State Highways	96,000	960	100
2.	District Roads	6,00,000	1000	55
3.	Village Roads	4,00,000	500	30
4.	Urban Roads and others	3,00,000	500	70
			2960	255
		Say	3000	260

Pocket Book on Transport in India - 1989
Transport Res. Divn., MOST, GoI

25. On the railways, it should be possible to design more efficient vehicles and locos. As for rail track, improvements in the offing are: new rail-to-tie fastening systems, longer rails, more widespread use of concrete sleepers, hadrened and heavier rails, etc. Improved track should permit increase in axle load of wagons from 20.3 tonnes to 22 tonnes.

26. New designs of higher horse power locomotives should enable haulage of high capacity freights and passenger trains and increase the train speeds generally.

27. In road transport, the emphasis should be to increase carrying capacity and, at the same time to promote fuel efficiency and reduce environmental pollution. Bus designs will need, particularly, to be modernised to ensure increased capacity as well as safe and comfortable ride.

28. The advent of containerisation and changes in cargo handling techniques should have a significant effect on port and shipping. The average size of ships will increase and ship designs will be modernised to accommodate modern control system.

29. In aviation, emphasis is on substitution of more energy efficient aircraft with advances in aerodynamic designs, use of new lighter and stronger materials and improved flight management, communication and navigation systems.

VIII- Energy Conservation in Transport Sector

30. Transport sector accounts for nearly one-third of the total energy consumption in the country. The maximum consumption of POL is by the road sector followed by civil aviation, railways and inland water transport. In the interest of optimum use of energy, it will be desirable to

integrate rail and road services with the railways taking care of bulk movements upto primary centres of distribution and road transport catering to further distribution of traffic to ultimate destinations. The guiding criterion should, of course, be to minimise total cost of transport and not just simply energy cost.

31. The fuel consumption by road vehicles happens to be quite high for various reasons like low engine performance due to poor maintenance and a much larger proportion of overaged vehicles, lack of traffic planning leading to frequent traffic jams on highways and cities, and shoddy upkeep of urban roads and highways. Moreover, the existing trend towards more extensive use of two-wheelers must be discouraged.

32. The bulk of energy consumed on the railways is on traction. Of the three existing modes of traction - steam, diesel and electric - steam is the most inefficient. It is, therefore, rightly being phased out by the end of the Ninth Plan. Of the remaining two, electric traction is superior to diesel in situations where traffic density is high as in the case of a double or a multiple line.

33. Energy can be saved by reducing the weight of trains through the use of lighter materials like aluminium in place of mild steel for wagons and coaches and by restraining the present frequency of slowing and accelerating trains through appropriate measures.

34. MG lines should be upgraded through:(a) track renewal with welded rails; and (b) introduction of roller bearing rolling stock in place of plain bearing.

35. Shunting work in marshalling yards has slumped heavily due to increasing shift towards block loading instead of piecemeal wagon loading. A review of "sanctions" of diesel shunters in large marshalling yards is, therefore, necessary to reduce shunting operations.

Fuel consumption savings (in per cent) possible by pavement widening

Terrain	Widening single lane to intermediate lane			Widening single lane to two-lanes			Widening intermediate lane to two-lanes		
	Car	Truck	Bus	Car	Truck	Bus	Car	Truck	Bus
Plain	1	1	1	2	2	2	1	1	1
Rolling	5	3	2	8	3	2	2	2	2
Hilly	15	8	10	20	10	14	10	3	3

Idle fuel Consumption

S. No.	Vehicle	Idle Fuel Consumption (cc/min)
1	Ambassador Car	13.0
2	Premier Padmini Car	10.5
3	Mahindra Jeep	12.3
4	Tata Truck	15.3
5	Ashok Leyland heavy duty truck	35.4

Fuel savings by various road improvement schemes

S. No.	Nature of Improvement	Fuel Saving (%)
1	Widening single lane pavement to intermediate width and improving its riding quality	5
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36. There is considerable scope for economising the use of POL through better ship designs and through upgradation and modernisation of shipping and port operations.

37. Civil aviation sector is particularly energy intensive and energy conservation should be encouraged through substitution of energy efficient equipment and better mrintenance and operations.

IX - Transport and Environment

38. Transport affects environment significantly. Apart from its effects on the three main natural resouces - land, water and air, transportation has the 'noise' fall out too. Planning for transport development as for all other sectors,. must take into account environmental efects of development. Development plans should ensure the sustainability of natural resources and provide for remedial measures against environmental degradation.

Land Pollution

39. Land pollution is contributed mainly by railway and road construction. Railway line constructions in the past have not only disfigured the life of the land, but have also unduly disturbed the drainage of land by interfering with the free flow of water across embankments. Railways should develop construction guidelines to minimise adverse effects on drainage, etc. and, in particular, to have compensatory vegetative coverage by planting fresh trees in lieu of those felled.

40. Railways also contribute to deforestation by still having to use wooden sleepers on many existing lines. There is need to extend the use of cementy concrete and steel sleepers to be exclusion of wooden sleepers.

41, Like railways, in the case of all major road construction activities it is necessary to assess the resultant disturbance of the natural drainage of land and soil or sediment erosion likely to lead to chemical and biological pollution and possible adverse effects on physical and natural features of the area.

42. The environmental impacts of raod construction vary in their severity from one region to an orther. They are particularly severe in the ecologically frail hilly areas of the Himalayan region where the problem is compounded by the aggravation of the menance of landslides every year. Land being an increasingly scarce resource, it is important to reckon with the cost of depletion of land in all development projects

Air Pollution

43. Vehicle emissions of carbon monoxide and other pollutents e.g hydro carbons, nitrogen oxide, etc. have increased greatly during the past decade because of the rise in the vehicle population and absence of pollution control. Steps must be taken to enforce" Air (Prevention and Control of Pollution) Act 1981" with a view to reducing pollutant emissions of automobiles. At the same time ,it is necessary to supply improved quality lead free petrol to road vehicles.

44. It is necessary to curb the proliferation of two-stroke engine scooter/ moped population to reduce air pollution. Encouragement should be given to produce three or four stroke engines instead of two stroke to reduce their pollutant emissions. The right policy direction for the future will be to develop viable city bus services and other public transport

ENERGY CONSUMPTION / CONSERVATION IN TRANSPORTATION

USA

- Energy consumption by transportation sector 24% – 26% of total energy used.
- & > 40% if use of energy to create transportation vehicles & systems also consider
- Petroleum dependent fuel consumption by transp → 53%
- 69.5% of fuel for transportation is used by highway vehicles.
- 63.8% of fuel used by automobiles for home-to-work & other urban & 36.1% of all energy used for transport.
- only 2/3rd of 1% energy consumed by transp. sector was accounted by for urban (bus & rail)
- 36.8% of energy consumed by transport vehicles is for intercity transport

Short-Haul Intercity Modal Energy Efficiencies

Mode	Energy Efficiency BTU / pass. mi
Bus	700
Rail	1695
Auto	2415
Air	7130

N.Y – D.C

auto occupan = 2.6 travellers

Buses & autos speeds ≯ 88 km/h

Metric conversion 1 mi = 1.6 km
1 Btu = 1055 J

Energy Savings in Potential home-to-~~home~~ work Trips

(probably the largest single portion of transport energy consumption)

Only bus & automobile trips

P_A = total auto passengers / rush-hr trip

P_B = " bus " " " "

M_A = av. dist. of auto trip

M_B = " " " bus "

G_A = total auto fuel consumpd

G_B = " bus " "

F = fraction of total travelers using bus

$$\therefore \quad P_B = F\,(P_A + P_B)$$

or

$$F = \frac{1}{1 + \dfrac{(PM/G)_A}{(PM/G)_B} \times \left(\dfrac{M_B}{M_A}\right) \times \left(\dfrac{G_A}{G_B}\right)}$$

Assume that

$$\left(\frac{PM}{G}\right)_A = 0.1 \left(\frac{PM}{G}\right)_B$$

$$M_A = M_B$$

$$G_B = 0.0065\, G_A \quad \ldots$$

(Also assume half the energy is in home-to-work trips)

Therefore, $F = 0.6$

<u>Assume</u> 3200 bus are used during rush hours, each carrying 50 & av. automobile (car) carries 1.5 pass.

→ it is found that <u>1.1 million commuter</u> automobiles are reqd.

∴ shift to bus, increasing car occupancy &

Other aspects, apart from energy saving and regulatory & institutional policy analysis, societal implications, economic impacts & landuse considerations

I urban

Four representative cities of US study

240 urbanised areas were examined
→ three cities selected
1. Albuquerque, New Maxico
2. San Diego, California
3. Baltimore, Maryland

with no rail & < 4%,
bet. 4% & 7% &
> 7% respectively, transit m.s

and 4. one city (Chicago, Illinois) with rail transit & > 14% transit m.s

Results Mode-shift analyses &
% total urbanized popl. represented by each city
→ extent of national energy savings

Interesting & imp. finding
1) automobile proved to be less energy efficient than transit, against some beliefs
2) Also η_* $\frac{\text{transit energy}}{\text{automobile energy}}$ ratio = bet. 1.5 to 5
3) Peak hr ratio = bet. 16 − 28

→ strategies were designed for transit improvements
And 1) for mode shifting from energy inefficient to energy-efficient ...

Baltimore & Chicago

Transit improvements & automobile disincentives → more effective

Albuquerque & San Diego (less congested CBD) → 1% only

5-6% energy savings

When aggregated to national level

→ maxm. energy savings occurred when maxm. transit improvements + maxm. automobile disincentives & estimated to be 2%—4%.

or maxm. savings of 28 million barrels (4.5 million m3) of gasoline/yr which is < 2 days' worth U.S gasoline usage.

II Intercity

shift to transit in high-density, short-haul arenas

Incentives to rail & bus

Disincentives to air & auto

with dual goals of
1) Reducing energy consumption &
2) Minimizing (-)ve impacts on transp. system quality

Two considerations:

1) shift → desirable
but increase in total travel → may not be desirable

2) disincentives → may result in slightly reduced system quality although reduction in energy use?

To forecast total demand

Formulation designed to include a term each for

1) Evolutionary or slowly varying forces, caused by changes in demographic and socio-economic conditions, differences in trip distance & alt. travel destinations

&

2) Policy, or rapidly varying forces, mainly concerning transp. system quality

Algorithm
Minimizing perceived trip-cost when assigned to local or intercity modes
→ then measured transp. system quality
indicative of overall effects of
- fare,
- blocktime,
- service freq.
- access time & cost

N-E corridor & California corridor
(BOSWASH)
both → v. high travel demand
→ but diff. travel characteristics

⇒ BOSWASH → air, auto, rail, bus
(320 km) represented

⇒ Los Angeles & San Francisco → Concentrations
(560 km) Av. travel dist. → more
(all intercity travel is by air or auto)

Significant results

1. seven city pairs studied 1982 & 1990 time frames
air & auto → 89% of all travel
& 97% of energy consumed

2. Northeast : Air mode split is lower than air energy split
26% of travelers & consumes 60% of energy

3. Short travel by automobile → 50%

4. Bus & rail → minority modes

5. Annual demand is approx. 20% higher in N-E than in Califo.
but 1/3rd more energy is consumed in Califo.

6. Total energy consumed per pass.-mi (energy index) → similar for both corridors

The following Fuel Conservation strategies studied: