ENERGY AND TRANSPORTATION

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J. Diandas, a Chartered Accountant by profession has been a keen student of "Transport", "Energy", "Environment" and connected issues and has over the last few years presented several authoritative papers on these subjects. Here he discusses the need to give priority to the energy requirements of public transport as against those of private vehicles.

"Urban space and laid tracks are a scarce resource almost anywhere. Energy is equally scarce in all except OPEC countries, and on a world footing, oil is thought to be running out within the next 30-60 years. In Sri Lanka, certainly, energy is a scarce resource, but so is it in USA, so much so, that some leaders have almost undisguisedly welcomed OPEC price increases as bringing in a sense of reality.

Energy works this way. What you require to move a ton of goods by road, will move four times that tonnage by rail or by water.

Where passengers are concerned the ratio in Sri Lanka is approximately that a private car rider requires 10 times as much energy as a bus or train rider.

Energy has another dimension. When supplied by thermal generation of electricity it may conserve fossil-fuel marginally, as against the direct use of oil. But where supplied by hydro, or nuclear generated electricity, there is no drawing on oil or coal at all, and very little noise or air pollution to boot. But how can electricity be used for transport? Only by using railways, tramways and trolley buses for passenger transport and railways, canals and cable-ways for goods. Transport of goods by lorries on roads, and transport of people by cars on roads do not figure in this dimension and are not likely to figure significantly because all the enthusiasm about new types of batteries and fuel cells has died out at least for the time being.

Thus energy conservation needs correct choices both in the mode of transport and in the form of energy.

This viewpoint expressed in the *Economic Review* of November 1975 on Transportation also sums up well the situation vis-a-vis Energy."

End-use Transportation

It is interesting that in 1976 exactly one half of all internal oil sales (when measured in gallons) was for the two transport fuels, petrol and auto-diesel.

Commercial energy usage in 1976 has been tentatively estimated on page 12 of this issue. The transport content of this estimation is repeated in Table I below.

TABLE 1

Sri Lanka 1976 transport energy by fuel (million gallons equivalent)

	Person	*Goods*	*Total*
Petrol	27	3	30
Auto-diesel ..	31	29	60
Furnace Oil ..	1	—	1
Coal	—	1	1
Total ..	59	33	92

A breakdown of these figures by type of vehicle is given in Table 2.

TABLE 2

Sri Lanka 1976 transport energy use by type of vehicle (million gallons equivalent)

	Person	*Goods*	*Total*
Bus	25		25
Train	7	3	10
Public ..	32	3	35
Lorry and Van ..		30	30
Car	27		27
Total ..	59	33	92

Source *Estimated on same basis as table* 1

What has the country obtained for this energy consumption? Looking first at person, or passenger transport, the 27 million gallons of petrol estimated to have been used for private travel in cars can, at an average of 25 miles per gallon, be thought to have performed 675 million vehicle miles. This would represent 7,500 miles per annum (625 per month) by each of say 90,000 active cars.

With certain very broad assumptions it is possible to draw a picture of car travel. The assumptions are firstly, that 90% of petrol sales are for cars; secondly, a constant average performance of 25 mpg. over the years despite fleet ageing; and thirdly, a constant occupancy average of 2 traveller-miles per vehicle-mile. The latter estimate excludes non-destinated family or paid chauffeurs or chaperons. Table 3 shows car travel on this tentative basis.

actual gallons of fuel consumed. However, the latter is not difficult to obtain. Table 4 sets out some relevant CTB performance indicators from 1964 to 1976.

The bus performance ratios are a reflection both of the inherent efficiency of mass-transit as against private travel, and to some extent also of overcrowding at peak times and directions, the 1976 energy indicators being:

Passenger-miles per gallon	..	367
Btu. per passenger mile	..	452

TABLE 3
Estimated Sri Lanka Car Travel 1964—1976

Year		*Mid year pop.*	*Million gallons*	*Million car miles*	*Million pass. miles*	*Passenger miles per gallon*	*Miles per capita*
1964	..	10.9	38	950	1,900	50	174
1965	..	11.2	37	925	1,850	50	165
1966	..	11.4	37	925	1,850	50	162
1967	..	11.7	37	925	1,850	50	158
1968	..	12.0	38	950	1,900	50	158
1969	..	12.3	40	1,000	2,000	50	163
1970	..	12.5	40	1,000	2,000	50	160
1971	..	12.7	37	925	1,850	50	146
1972	..	13.0	35	875	1,750	50	134
1973	..	13.2	34	850	1,700	50	129
1974	..	13.4	25	625	1,250	50	93
1975	..	13.6	25	625	1,250	50	92
1976	..	13.8	27	675	1,350	50	98

Source *Estimates based on prior tables and assumptions given in para above.*

The last year, 1976, in Table 3 gives the following energy indicators:

Person-miles per gallon	..	50
Btu. per person-mile ..	..	2,980

For bus travel raw estimates are not necessary because the CTB is one of the few organisations which publishes fairly useful and comprehensive performance data. These cover almost every aspect of its function except

For railway travel the approximate figures are far more difficult to obtain because fuel usage is not published separately for passenger and goods work. Hence, approximate figures of gallons used for passenger trains must be applied to published data as in Table 5, appearing on page 30.

As with buses, the inherent energy-thriftiness of mass transportation shows up in high passenger-mileage per gallon. But the inherent efficiency arising from the low rolling resistance of steel rail to steel-wheel does not show any advantage over bus here. This is due partly to greater tare weight of train per passenger carried, partly to peakier peaks and sparser off-speaks in urban rail traffic, and partly to the greater speed at which most rail passenger movement is achieved.

TABLE 4
CTB Performances 1964—1976

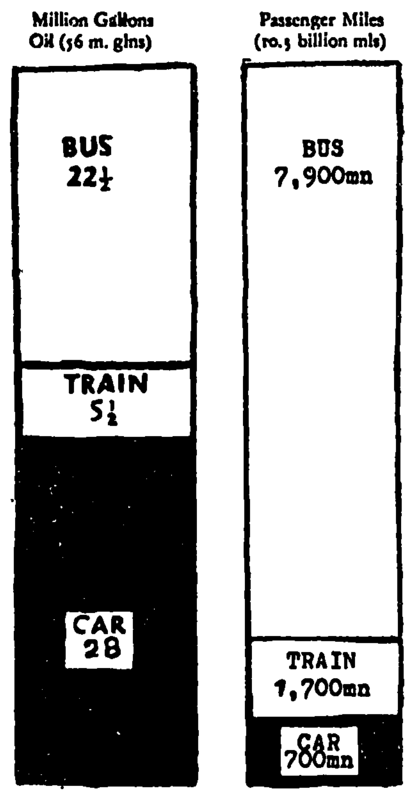
Year		*Mid year pop.*	*Million rides*	*Million pass. miles*	*Million vehi. miles*	*Million gallons diesel*	*Pass. miles per gal.*	*Buses operated*	*Miles per bus day*	**Per Capita** *Travel miles*	**Per Capita** *Rides*
1964	..	10.9	793	4,525	138	14	330	2,708	140	415	72
1965	..	11.2	930	4,898	161	17	291	2,931	143	437	80
1966	..	11.4	1,025	5,582	177	18	302	3,256	149	490	90
1967	..	11.7	1,145	6,184	206	21	284	3,599	157	529	98
1968	..	12.0	1,250	6,823	211	22	303	3,686	157	568	104
1969	..	12.3	1,314	7,156	217	23	307	3,787	157	582	107
1970	..	12.5	1,358	7,394	234	24	304	4,170	154	591	108
1971	..	12.7	1,337	7,377	236	24	301	4,409	147	581	105
1972	..	13.0	1,392	8,574	268	27	315	4,758	154	660	107
1973	..	13.2	1,405	9,212	251	26	396	4,590	150	698	106
1974	..	13.4	1,249	7,905	235	23	343	4,302	149	590	93
1975	..	13.6	1,336	8,315	246	25	338	4,469	151	611	98
1976	..	13.8	1,436	9,101	247	25	367	4,426	153	659	104

Source

Till 1973: CTB Annual Reports

1974 & 1975: N. Gananadha "Passenger Road Transport" at APO Seminar on Transport Management Dec. 76.

1976: Institute of Transport Management.



Energy for Personal Transport in Sri Lanka 1974

Source *"Transportation an Overview" Economic Review, Nov. 75.*

The last available year of data, 1974 gives the following indicators of rail energy thrift:

Person-miles per gallon	..	216
Btu. per person mile ..	..	768

A straight comparison of car, bus and train over a few selected years is shown in Table 6, based on aggregate data, also appearing on page 30.

It is clear from this table that once dieselisation of the railway was virtually completed and the coal-steam cycle relinquished, bus and train performance are in the same range, although rail is definitely more

TABLE 5

Travel by Rail in Sri Lanka 1964—1976

Year	Mid year pop.	Million rides	Million pass miles	Million train miles	Million gallons fuel	Pass miles per gal.	Per Capita Travel miles	Per Capita rides
1964	10.9	73	1,453	5.1			133	
1965	11.2	74	1,498	5.6	22.5	67	134	
1966	11.4	75	1,537	5.8	25.1	61	135	6
1967	11.7	78	1,585	5.8	24.6	64	135	7
1968	12.0	82	1,678	5.8	25.4	66	140	7
1969	12.3	88	1,781	5.6	18.5	96	145	7
1970	12.5	86	1,825	5.8	12.3	148	146	7
1971	12.7	83	1,734	4.7	8.0	217	137	6
1972	13.0	85	1,907	5.3	8.8	217	147	7
1973	13.2	89	2,051	5.4	8.7	236	155	7
1974	13.4	69	1,726	4.5	8.0	216	129	5
1975	13.6	69		6.6	7.4			
1976	13.8							

Source *Upto 1969-70 : CGR published reports*
After 1969-70 : CGR cyclostyled reports
1975 : G. P. S. Weerasooriya "Passenger Transported by Rail" at APO Seminar on Transport Management Dec. 76.

Assumed *Rail fuel for passenger and goods is proportionate to train miles.*

TABLE 6

Energy intensity of modes in Sri Lanka in selected years

Year	Passenger-miles per gallon Car	Bus	Train	Btu. per passenger-mile Car	Bus	Train
1965	50	291	67	2,980	570	2,478
1969	50	307	96	2,980	540	1,729
1970	50	304	148	2,980	546	1,122
1973	50	396	236	2,980	419	703
1974	50	343	216	2,980	484	768
1975	50	338		2,980	491	
1976	50	367		2,980	452	

Source *Estimated from prior tables.*

TABLE 7

Miles per capita travelled in Sri Lanka in selected years 1964—1976

Year	By Public Transport Bus	Train	Public	By Car	Total
1964	415	133	548	174	722
1969	582	145	727	163	890
1970	591	146	737	160	897
1973	698	155	853	129	982
1974	590	129	719	93	812
1975	611			92	
1976	659			98	

Source *Tables 4, 5 and 6*

Note: *Per capita car travel by each of the 200,000 people actually travelling by car would be in the order of 10,000 miles per annum in 1964 reducing to 5,000 miles per annum in 1976. The figures in this table are total car passenger miles divided by total population.*

expensive in energy. For this railway travel confers, as a rule, greater speed and comfort of journey. It is also seen that the year 1973 was one of exceptional bus and rail thrift, probably because of exceptional crowding.

Above all, it is obvious that travel by car is six to eight times more expensive in energy than is travel by public transport. This feature was illustrated in an earlier issue of the *Economic Review* as shown in Figure 1, on page 29.

It is also worth noting that most rail travel (measured in passenger or train-miles, not in track miles) can be electrified, and so can a lot of urban street transport either as trolley-buses, or as trams like the typical modern West German light rail lines. Once electrified, this portion of public passenger transport can be energised by hydro-power and thus taken off the demand area for imported fuel.

Private cars cannot be so electrified, and research into battery cars has not yet found a method which is free of resource limitation (lead, especially) or environmental problems.

Incidentally the US Congress in September 1976 passed a bill (over the head of President Ford's veto) supporting research into electric vehicles, in which the preamble states inter-alia:

"The Congress finds and declares that—

(1) The Nation's dependence on foreign sources of petroleum must be reduced, as such dependence jeopardizes national security, inhibits foreign policy, and undermines economic well-being;

(2) The Nation's balance of payments is threatened by the need to import oil for the production of liquid fuel for gasoline-powered vehicles;

(3) The single largest use of petroleum supplies is in the field of transportation, for gasoline and diesel powered motor vehicles.

Such proclamation of awareness ought to be even more apt for a less developed country like Sri Lanka. However, as against typical American travel of 8,000 miles per capita per annum by all modes (including air), and the consumption of 100 million btu. per capita (or 600 gals.) in the US, Sri Lanka's per capita travel for selected years is shown in Table 7.

Why did travel drop so sharply in 1974? Obviously the price increase in oil and the consequent bus and train fare increases were primary causes. But was there also a government social policy to repress travel by reference to miles travelled rather than by reference to energy consumed? The latter is set out in Table 8.

Whereas bus and train travel can be repressed by any government having the will to do so and lacking awareness of performance comparisons shown in Table 6, car travel cannot be so easily contained once cars have been imported and ownership of them secured to individual persons or institutions in the private and government sectors.

Only heavy restraint on the use of cars could significantly reduce car travel and petrol use. Such restraint could be by way of significant increase in petrol price (a seminar speaker last year suggested Rs. 50/- per gallon) or by savage parking taxes, or by road-use pricing, or by a series of physical restrictions on the use of cars in urban centres. Either way, if travel remained constant and was diverted to bus or train it is likely that for every 10 gallons of petrol saved, an additional one gallon of auto diesel would be used. Hence, theoretically, a complete ban on private motorised vehicles could save over 25 million gallons of petrol at the cost of 2½ million gallons of diesel fuel.

Theoretically private vehicles could be propelled by methanol gas, or batteries, or even hydrogen. But such possibilities have many inhibitions in practice.

For transport of goods, it is far more difficult to collect and assemble meaningful data simply because nobody publishes meaningful data. The energy (excluding human and animal muscle power) diffused in 1976 for goods transport was estimated in Table 2 in million gallons and in Table 9 as follows:

Lorry and Van	..	30
Train	..	3
Total	..	33

A tentative historical picture is obtained with a number of assumptions by taking one tenth of petrol sales together with the balance of auto diesel sales (after abstracting CTB, CGR and CEB usage) as being lorry and van consumption, and taking railway usage of all fuel for passenger and goods as being proportionate to train miles. The result is shown in Table 9.

Pre 1971 figures for the railway are clouded by coal content. However, Table 9 gives a picture that lorry consumption of fuel gradually increased from 21 m. gallons in 1965 to 28 m. gallons in 1970 and then remained more or less stagnant. This does not necessarily mean less transport growth because it is possible that gradual dieselisation of at least the heavy lorry fleet as well as gradual increase in lorry size has brought fuel economies.

How many tons of goods were moved for this expenditure of a scarce imported resource, and how many miles of transport were achieved? Available railway data is given in Table 10, on the next page.

After coal was virtually phased out the relevant energy indicators show up in Table 10 as:

Ton-miles per gallon	58
Btu. per ton-mile	2,862

This appears very very poor compared with US figures. Southern Pacific Railroad claims 238 ton-miles per US gallon, and most US aggregate studies show only 700-800 btu. per ton mile overall average. However, US trains are very much longer and run further with the following averages shown in the "Year Book of Railroad Facts" 1976 edition:

Average train load ..	1,938 tons
Average length of haul ..	515 miles

However, economies of scale are not a sufficient explanation for poor Sri Lanka railway performance. There may be excessive empty backhauls in Sri Lanka and there may be other inefficiencies. Moreover, the data (including the method of estimation) may be inadequate.

If it is difficult to evaluate energy used for goods transported by rail, it is impossible to do more than guess the energy indicators for road goods transport. The *Economic Review*, November 1975 complained thus:

"There is very little published data about work done by goods road vehicles in Sri Lanka .... There is no certainty as to how many registered vehicles were actually in use ..... The Report of the Transport Commission, Sessional Paper XIII of 1967 .... made no study at all of ton-miles which is essential to an understanding on the quantity of haulage and of the fleet requirements .... the 1965 (lorry) fleet worked an average of only 40 miles per lorry per working day .... buses which can only work during the traffic day run about 150 miles per day ..... lorries with less restrictions on useful working hours shows gross under-utilisation of scarce capital equipment .....".

TABLE 8

Energy used for Travel in Sri Lanka 1964—1976 (million gallons)

	Public			Private	
	Bus	*Train*	*Total*	*Car*	*Total*
1965	17	22	39	37	76
1969	23	18	41	40	81
1970	24	12	36	40	76
1973	26	9	35	34	69
1974	23	8	31	25	56
1975	25	7	32	25	57
1976	25			27	

Source ***Estimated on basis of prior tables.***

TABLE 9

Energy for Goods Transport in Sri Lanka 1964—1976 (million gallons)

	Lorry and Van			Railway	
	Diesel	*Petrol*	*Total*		*Total*
1964		4			
1965	17	4	21	9	30
1966	18	4	22	9	31
1967	21	4	25	9	34
1968	22	4	26	10	36
1969	24	4	28	7	35
1970	24	4	28	5	33
1971	25	4	29	4	33
1972	25	4	29	4	33
1973	26	4	30	4	34
1974	26	3	29	3	32
1975	25	3	28	4	32
1976	27	3	30	4	34

Source ***Estimated from prior tables.***

TABLE 10

Goods by Rail in Sri Lanka 1964—1975

Year			m. tons	m. ton miles	m. train miles	m. gal. oil	ton miles per gal.	ton miles per train mile	average haul miles
1964	..	..	1.9	218	2.1			104	115
1965	..	..	1.6	196	2.0	9.3	21	98	122
1966	..	..	1.8	212	2.1	8.9	24	101	118
1967	..	..	1.8	212	2.2	8.9	24	96	118
1968	..	..	1.8	221	2.3	9.7	23	101	123
1969	..	..	1.8	220	2.3	7.3	30	96	122
1970	..	..	1.7	228	2.6	5.0	46	88	134
1971	..	..	1.8	207	2.0	3.6	58	104	115
1972	..	..	1.8	211	2.3	3.7	57	106	117
1973	..	..	1.9	204	2.3	3.8	54	89	107
1974	..	..	2.0	197	2.2	3.4	58	90	98
1975	..	..	1.7	186		3.6			109
1976	..	..							

Source *CGR supplemented by estimates.*
Assumption *Goods energy proportionate to goods train miles.*

That issue of the *Economic Review* examined road goods transport from the point of view of overall economic utilization, but from the point of view of energy the assembly of data and serious analysis and evaluation is equally needed.

Nadaraja in "Goods Transport by Rail" at an APO Seminar on Transport Management in December 1976 indicated rail energy performance at 8.429 cts. per ton-mile, which works out at 57 ton-miles per gallon (see also Table 10) but Jilla, speaking at the same seminar on "Road Transport of Goods", while conceding only 40 to 50 miles per day per lorry average, could only say about energy:

"Unfortunately no proper Statistics are maintained by the road haulage industry to ascertain the net miles done per gallon of fuel consumed."

All that one can do is to take the 1967 Commission estimate that in 1965 there were 4.6 million tons to be carried, deduct the railway's 1.6 million tons, assume that the balance 3 million tons were carried an average 100 miles by lorry, giving a raw estimate for 1965 as follows:

$$\frac{300 \text{ m. tons}}{21 \text{ m. gals.}} = 14 \text{ ton-miles per gallon}$$

This is obviously unreasonably low because a typical 8 ton lorry (with 5 ton payload) at 10 miles per gallon and with a 50% average load will perform 25 ton-miles per gallon.

American aggregate studies reveal achievements of up to 72 ton-miles per US gallon (with 40-ton gross-weight rigs) and an average of 2800 btu. per ton mile which would convert to 57 ton-miles per imperial gallon.

However, although most American aggregate studies show a 4 to 1 ratio in favour of rail (and canal) as against lorry, what has really to be compared is lorry transport carrying loads suitable for rail, and, after taking account of circuity the ratio comes down to about 2 : 1 in favour of rail.

In this country what has to be compared is food and oil runs out of Colombo, cement runs towards the centre, and tea, rubber and copra runs towards the ports of Colombo, Galle and Trincomalee. An empirical test ought to be carried out, but here we can only postulate a possible comparison in our conditions of highway surface grades, curve and width, lorry size, maintenance standards etc.

			Ton-miles per gal.	Btu. per ton-mil
Rail	..	..	58	2,862
Lorry	..	..	25	6,640

Looking back to Table 8 it would seem that electric traction for public passenger transport (trains, trams, trolley buses) could save up to 10 m. gals. of diesel per annum (one third of bus and train energy). If goods were electrically hauled over the electrified section of the railway, we could at most save a further 1 million gallons (one quarter of rail fuel).

How much could be saved by "degrading" agricultural transport from trucks, vans, tractors and trailers to bullock carts? (Schumacher might call it "upgrading"). And how much by diverting goods transport to railway and canal transport where these modes are available?

On the cart question there may be secondary economic as well as environmental benefits except where the goods (such as fish) need quick transit. The need of the owner of the goods to get quick payment is an entirely different problem which has to be met by institutional, not transport, solutions.

On the modal transfer question, several international studies have placed a 4 to 1 ratio for fuel consumption by highway vehicles over rail and barge. But this ratio is hotly contested by trucking interests. Although little empirical research has been done there is no question but that lorries are, for the same goods, and given good loading with no circuity, at least twice as energy-profligate as trains and barges properly loaded. Hence, if one third of goods transport by lorries and vans was transferred to rail or canal, 11 m. gallons used on the highway might convert to 5½ m. gallons on rail, saving 5½ m. gallons.

The possibility of shifting tea and rubber from plantations upto 10 miles from rail facilities to rail transport ought to be easily achieved with government holding control of so much plantation land.

The above analyses tend to confirm, from the energy viewpoint, the transport conclusions in *Economic Review*, November 1975, that: "the future of transport in Sri Lanka should be based upon a policy with at least some of the following guidelines, wherever there are no compelling reasons to depart from them:

(1) The location of activities to minimise physical transport.

(2) The use where feasible of animal power, man-power and electric power as propulsive energy.

(3) The use where feasible (and where intensity of traffic volume justifies installation and maintenance) of canals and railways in preference to roads.

(4) The use of public carriers in preference to private carriers on roads.

(5) The allocation of highway development funds to rural roads, and to improving foundations for roads needed by heavy vehicles, in preference to widening roads and bridges needed to cope with private vehicles."