Paper No. 535

ENERGY CONSERVATION BY IMPROVING LOCOMOTIVE UTILIZATION

Muhammad Aurangzeb Khan
Dy. Chief Mechanical Engineer, Pakistan Railways, Lahore.

ENERGY CONSERVATION BY IMPROVING LOCOMOTIVE UTILIZATION

Muhammad Aurangzab Kahn*

1. INTRODUCTION

The subject of this paper "energy conversation by improving locomotive utilization", is one that concerns all of us and it deserves our full attention. Energy is one of the most important resources the man has on this earth for his existance and comfert. Today if we educate every one in the economic use of energy, we can solve most of our problems. To avoid wastage of energy is in accordance with the spirit of Islam. The Holy Quran says.

لَا تُسْرِفُوا إِنَّهُ لَا يُحِبُّ الْمُسْرِفِينَ

"Do not waste; Indeed Allah loveth not the wasters."

Energy conservation does not require the curtailment of vital services, it merely requires the curtailment of energy waste. Few know that energy has a qualitative dimension that " the quality of energy declines as it is used " is just as absolute as the Law which states that the quantity of energy in the universe is constant.

2. TRANSPORTATION

Transportation plays an important role in the growth and development of a nation. It is a versatile and powerful tool for shaping the micro and macro structure of the urban, rural and regional environment. Owen describes it as under :-

In the complex process of development, transport plays a special role in facilitating other objectives; getting land into production, marketing agricultural commodities; making forest and mineral wealth accessible, developing industry, expanding trade, conducting health and education programmes and exchanging ideas.

2.1 ENERGY CONSUMPTION BY DIFFERENT MODES OF TRANSPORT

* Dy Chief Mechnical Engineer, Pakistan Railways, Lahore.

The energy requirement by different modes of transport is indicated as under:-

(A) PASSENGER MODE ENERGY INTENSITIES

Automobile	2750 BTU per passenger K.M.
Scooter	850 -do-
Bus	320 -do-
Rail	170 -do-

(B) FREIGHT MODE ENERGY INTENSITIES

Truck	1600 BTU per tonne K.M.
Rail	250 -do-

An air traveller consumes 2 to 10 times more fuel than a passenger travelling in an express train. In fact the railroad can suply the needs of transportation on the basis of true costs if it is permitted to operate as a business concern without regulating it to the nth degree.

One way to reduce energy consumption is to shift traffic from less to more efficient carriers. Exhibit I lists the energy intensities of different modes of transport. Exhibit 2 shows the historical trend of freight haulage in Pakistan. The Railway's share in absolute terms has more or less remained steady whereas the road sector has absorbed a large share of the increased tonnage in goods transport. Likewise when we examine the development of respective capacities of these two modes of transport, we find that over the years there has been a decline in the rolling stock of the Railways while the truck census has risen by 38% over the last six years. The position has been elaborated in Exhibit 3.

The historical trend is for greater growth to occur on the less effcient highway mode and less growth on more effcient rail mode. Consequently, if road sector continues to share more traffic it will result in faster rate of energy demand and consumption.

It has been assessed that if Railway were to improve its services and increase its market share of freight haulage by 5% in 1988-89 than the consequent saving to the national petroleum procurement would be equivalent to approximately 2,666 billion Btu's or in other words the country's energy will be reduced by Rs.273 million.

3. TRACTION UNITS ON PAKISTAN RAILWAYS

The Railway started after Independence in 1947 with the follwing traction equipment :-

	B.G.	M.G.	N.G.	TOTAL
Steam Locomotives	732	25	50	807
Diesel Electric Locomotives	14	-	-	14
Diesel Mechanical Railcars	11	-	-	11
TOTAL	757	25	50	832

During last 41 years, there have been radical changes in the forms of Railway traction in Pakistan and the present position is as follows:-

	B.G.	M.G.	N.G.	TOTAL
Steam Locomotives	135	25	29	189
Diesel Electric Locomotives	566	-	-	566
Diesel Hydraulic Railcars	11	-	-	11
Electric Locomotives	29	-	-	29
TOTAL	741	25	29	795

3.1 Steam Traction

Pakistan Railway has 135 B.G. steam locomitives which constitute 18.2% of the broad gauge traction fleet. These locomitives are overage and un-economical and are being retained in service after heavy repairs. These locomotives carried 3.08 percent of the gross tonne kilometer in 1986-87.

3.2 Diesel Electric Locomotives

The diesel electric traction was introduced in 1952. 547 diesel electric locomotives were in service on 30-6-87. These locomotives constituted76.38% of total fleet and hauled 90.72% of the total gross ton-kilometers on the Railway during 1986-87.

3.3 Electric Traction

With the construction of Mangla and Tarbela Dams, it was thought that abundant electric supply would be available in the country and based upon this assumption, electric traction on Lahore-Khanewal section came into operation in 1970. At that time there was unprecedented shortage of electricity from Hydro stations in the country. This resulted in an adverse public reaction against this form of traction and thereby electrification on Lahore-Rawalpindi section was defered.

29 electric locomotives work on a limited section of Lahore-Khanewal. These locomotives constitute 3.91% of the total fleet and hauled 6.20% of the total gross tonne-kilometres during 1986-87.

3.4 Railcar Train Sets

Railcar and trailers are in use in different combinations and have been found a very good substitute for locomotives hauled passenger cars on branch lines. The main advantage with railcar train sets is that owing to light axle loading and high power weight ratio these can run at higher speeds on the existing track. This way, heavy expenditure on upgrading of branch line tracks having low density of traffic could be avoided.

3.5 Mixed Operation

The mixed operation f different types of motive power suited the Railway in the beginning as only such services, were run by diesel electric locomotives on which utilization was very intensive. This led to very efficient utilization of new diesel locomotives. As the fleet of diesel locomotives increased, it was observed that mixed operation was adversely affecting locomotive utilization. Further, the maintenance facilities for steam traction on sections where these are not fully utilized, are a burden on Railway finance.

With the increase in the number of diesel locomotives, diesel maintenance facilities have also been increased and lift shop at Quetta and Rwalpindi have been established recently. The stage has now come when complete elimination ofsteam traction can be considered. This, in turn, will permit better utilization of diesel locomotives unhampered by mixed operation with steam and will also result into economy due to closure of steam facilities on broad gauge system.

3.6 Average Life of Locomotives

177 d.e. locos comprising 31.27% of total diesel fleet, have completed 20 years service and are due replacement. Similarly 84 steam locomotives, comprising 61.31% of

steam fleet have completed 45 years life and are due replacement being uneconomical for retention in service. Number of diesel and steam locomotives of each class alongwith their age have been shown in Exhibit 4&5 respectively.

4. UTILIZATION OF MOTIVE POWER

We, are fully aware of the tremendous savings that can be achieved through complete dieselization by eliminating some of the intermediate servicing stations and repair facilities and other expenses solely related to steam locomotives. One railroad President once expressed himself to the effect that dieselization produced greater saving to the department than any other single change made in a hundred years.

We are not going to obtain the utilization savings through discussions and seminars regardless of how modern our ideas of motive power utilization are. The only way we are going to achieve this goal is, to implement these modern concepts, notwithstanding the attendant expenses. Maximum utilization is dependent on availability and availability in turn is dependent on good maintenance. The out of service time can be reduced if a railroad is able to maintain spare engines, main generators, traction motors, trucks, air compressors, turbo superchargers, diesel engine governors, auxiliary generators, water pumps, lube oil pumps etc. The maintenance aspect being a separate study, this paper would be restricted to the utilization of locomotives only.

Diesel locmotives work passenger, goods and shunting services on the entire system. These have been discussed as follows:-

4.1 Passenger Services

There is an improvement in the utilization of diesel electric locomotives as indicated below:-

S. No.	YEAR	KMs earned per engine per day by Diesel Locos	Steam Locos	Elec. Locos
1.	1984	442	182	437
2.	1985	448	192	399
3.	1986	447	174	423
4.	1987	457	188	363
5.	1988	457	198	361

Extra/less KMs earned per engine per day in 1988.

Total KMs (extra) earned in 1988	15x199x365 = 1,089,525	16x22x365* = 128,480	76x7x365 = 194,180
No. of locomotives saved	1,089,525 / 457 x 365	1,28,480 / 198 x 365	194,180 / 437 x 365
Or used in excess	= 6.53	= 1.777 (say 2)	* = 1.217 Locos

* Less K.Ms means extra locos

4.1.1. Load Variation and Fuel Consumption

The diesel electric locomotives utilized on passenger services during June-August 1988 shown in Exhibit '6' are analysed as under:-

(A) Average Load

The average load of the passenger trains worked by heavy diesel electric locomotives varied from 165 tonnes for HPU-20 locomotives to 754 tonnes by HGMU-30 locomotives.

The average loads of passenger trains worked by light diesel electric locomotives varied from 80 tonnes for Hitachi Railcars to 344 tonnes for GEU-15 locomotives.

(B) Fuel Consumption

The fuel consumption varied from 5.18 litres/1000 GTKM for average load = 754 tonnes worked by HGMU-30 locomotives to 10.61 litres/1000 GTKM for average load of 165 tonnes worked by HPU-20 locomotives. The fuel consumption varied on light diesel electric locomotives from 4.97 litres/1000 GTKM for average load of 344 tonnes (worked by GEU-15 locomotives) to 8.90 litres/1000 GTKM for average load 199 tonnes worked by ALU-12 locomotives. The minimum consumption was, however, achieved with Hitachi Railcars viz. 1.28 litres per kilometer.

4.1.2. Passenger Trains worked by same Class of Locomotives

Passenger trains fitted with air brake system worked by same class of locomotive on the same section, vary in fuel consumption (as shown in Exhibit 7) due to the following:-

(i) The fuel consumption has been worked out 5.31 litres per 1000 GTKM on 15 Up with load = 844 tonnes on Karachi-Robri section. It increased to 5.35 litres per 1000GTKM when 13 Up was worked with load = 750 tonnes on the same section and 7.58 litres per 1000 GTKM when 45 Up was worked with load = 344 tonnes.

(ii) RUNNING TIME/STOPPAGE ENROUTE

103 Up covers KC-ROH section in 6 hours - 8 minutes as compared to 6 hours - 35 minutes taken by 13 Up. Both trains when worked with the same load (750 tonnes) consumed 5.26 litres and 5.35 litres per 1000 GTKM respectively due to the variation in the running timings and stoppages enroute. There are only 3 stoppages for 103 Up whereas the number of stoppages are 6 in case of 13 Up.

(iii) SPEED OF THE TRAINS

The fuel consumption has ben noticed as minimum in case of Shalimar Express which has only two stoppages betwen KC-ROH as compared to 3 stoppages for 103 Up and 6 stoppages for 13 Up. Due to increased speed, there is considerable reduction in the running time and consequently reduction in fuel consumption.

4.1.3. CONCLUSION

(i) For lighter loads particularly on branch lines, trailers hauled by Railcars are most economical from energy conservation fuel consumption point of view.

The usage of railcars consisting of one tractive coach and one trailer on Railway Lines with limited passing capacity (especially on single track lines like Lahore-Rawalpindi and Lahore-Multan) should have been discontinued immediately after the Seminar held at Islamabad on "Railway problems and policies" in 1973. The proposal was implemented in 1983.

(ii) On main line where sufficient traffic offering is available, 3000 H.P. locomotive is the best choice.

(iii) Utilization of heavy locomotives on loads ranging165 to 360 tonnes results into excessive fuel consumption and may be avoided in consultation with the Mechanical Branch as it involves the transfer of locomotives from one base shed to the other.

(iv) Increasing the number of coaches per train upto the maximum depending on length of passenger platforms and capacity of locomotives used.

(v) Routing mail and parcels by special "parcel Express" trains. This proposal, if implemented, will not only result in improving the punctuality but will also increase the passenger carrying capacity by conversion of postal vans into passenger carriages.

(vi) Restructuring the mail and express services by grouping trains in "batteries" according to passenger needs gives free time spaces for the goods services.

(vii) Reducing way side stops of mail and express trains, both in number and duration is another good measure.

4.2. FREIGHT SERVICE

The diesel electric locomotives utilized on goods services during June-August, 1988, shown in Exhibit 8, are analysed as under:-

4.2.1. AVERAGE LOADS

The average loads of goods trains worked by heavy d. e. locomotives varied from 617 tonnes by ALU-18 locomotives to 1465 tonnes by HGMU-30 locomotives.

The average loads of goods trains worked by light d. e. locomotives varied from 430 tonnes to 901 tonnes.

4.2.2. FUEL CONSUMPTION PER 1000 GTKM

The fuel consumption forthe above loads varied from 3.25 litres per 1000 GTKM with average load = 1465 tonnes worked by HGMU-30 locomotives, to 5.21 litres per 1000 GTKM with average load = 617 tonnes worked by ALU-18 d. e. locomotives.

The fuel consumption on light d. e. locomotives varied from 2.83 litres per 1000 GTKM with average load = 901 tonnes worked by GEU-15 locomotives to 6.73 litres per 1000 GTKM with average load = 430 tonnes worked by GMCU-15 d. e. locomotives.

4.2.3 GOODS TRAINS WORKED BY KARACHI BASED LOCOMOTIVES.

The average loads of the trains worked by KC based diesel electric locomotives during June-August 1988, shown in Exhibit-9 are summarized as under:-

(i) 488 trains were worked on KC-SMA with average load = 1942 tonnes by 3000 H.P. GMU/HGMU-30 locos. The number of trains could have been reduced to

421, resulting into saving of 67 trains or 67 x 85 ÷ 24 = 237 locomotives in 3 months or 79 locomotives a month for clearance of same load between KC-SMA by increasing the average load to 2250 tonnes.

(ii) Similarly, 451 trains were worked on Karachi Samasta by 2000 H.P. locomotives with average load = 1866 tonnes. The number of trains could have been reduced to 421, resulting into saving of 30 trains = 106 locomotives during 3 months or 35 locomotives a month for clearance of same load between KC-SMA by increasing the average load to 2000 tonnes.

4.2.4. CONCLUSIONS

(i) The allocation of locomotives between locomotive home sheds should be done in such a manner that routes with the heaviest density of passenger and goods traffic should be served by the most powerful and fast locomotives on Pakistan Railways.

On main line (Lahore-Karachi section) 3000H.P. locomotive is best choice because of extra hauling capacity and lower fuel consumption per 1000 GTKM.

(ii) It is uneconomical to work light loads with heavy locomotives due to excessive fuel consumption per 1000GTKM.

(iii) Increase the loads of goods trains to improve/save fuel energy per 1000 GTKM.

Under-load trains are uneconomical because of higher fuel consumption per 1000 GTKM and more number of locomotives are required to clear the same load.

(iv) Draw up transport plan taking into account the actual capacity of the facilities with concentration of traffic in "primary marshalling yards". Steps have already been taken by rerouting Peshawar, Nowshera, Daud Khel bound trains via Samasatta-Mahmood Kot-Kundian instead of via main line. Some of the up loads for Lahore have also been rerouted via Lodhran-Pakpattan to reduce the load on main line.

(v) Raise the speed limit of goods trains to narrow down the difference in speeds of passenger and goods trains.

(vi) Handle most of the traffic by regular trains with convenient paths and a minumum of intermediate stops.

4.3. SHUNTING/DEPARTMENTAL SERVICES

Fuel consumption on shunting locomotives shown in Annexure-10 reveals as follows:-

Heavy DE Locomotives - The fuel consumption varies from 1.87 litres per kilometer with HAU-10 DE Locos to 3.91 litres per kilometre with HAU-20 locos.

Light DE Locomotives - The fuel consumption varies from 1.63 litres per kilometre with FRU-75 d.e. locomotives to 2.24 litres per kilometre with GMU-15 DE locomotives.

4.3.1. CONCLUSION

HAU-10 class locomotives amongst the locomotive fleet available on Pakistan Railways, has proved to be the best choice as shunting/shuttling locos as far as fuel consumption is concerned. It negates our existing policy to utilize overage/obsolete passenger/freight locomotives on shunting services.

5. ENERGY CONSERVATION DUE TO ELECTRIFICATION

Electricity from hydel projects such as Mangla Dam and Tarbela Dam is much more economical than the imported fuel which involves handling transportation and storage expenses as additional burden on Railways. The economy affected during 1979-80 to 1983-84 and during July 1988 has been shown in Exhibit-11.

The saving effected during 1974-80 to 1983-84 varies from Rs. 20.365 million per annum to Rs.34.02 million i.e. Rs. 1.697 million per month to Rs. 2.959 million. Due to imposition of fuel adjustment charges on electric supply, the saving has reduced to Rs. 0.581 million per month during 1988.

6. SCOPE OF ENERGY CONSERVATION ON DIESEL LOCOMOTIVES.

There are four well demarcated areas of diesel locomotive operations where considerable scope exists for achieving energy conservation. These areas are:-

6.1. Idling of diesel locomotives in traffic yards, terminals and in locomotive sheds. Light running of locomotives (without load) is an added factor in this area.

6.1.1. IDLING OF DIESEL LOCOMOTIVES IN TRAFFIC YARDS AND TERMINALS.

The detentions to locomotives yards at terminals and short of interchange points, are considerably on high side. Similarly, the idling of locomotives in maintenance sheds needs special attention of all concerned. The idling time is termed as unproductive use.

Yard detention to the locomotives during June to August, 1988, are attached as Exhibit 12.

The fuel consumption while idling in sheds is attached as Exhibit 13. It, however, includes fuel consumed on load box.

6.1.2. LIGHT ENGINE RUNNING

Due to imbalanced traffic and return of failure locomotives as dead attached to their base sheds, light engines were supplied to Samasata from Karachi, Rohri, Kundian to clear the traffic on Multan Division. The locomotive supplied as light to Samasata and Rohri during June-August 1988 alongwith fuel consumption are as follows:-

Section	No of Locos Supplied As Light	Distance in KMs	Fuel Consumption per KM	Total Fuel Consumption in Litres
KC-SMA	64	827	1.5	64x827x1.5 = 79392
KC-ROH	16	472	1.5	16x472x1.5 = 11328
ROH-SMA	16	355	1.5	16X355X1.5 = 8520
KDA-SMA	36	402	1.8	36X402X1.8 = 21708
	132 Locos			1,20,948 Litres

6.1.3. Detentions at Interchange Points

The detentions to trains at interchange points is a sign of sick operation and need to be curbed.

For this purpose we checked the detentions to up trains short of Lalamusa and down trains short of Sahiwal. Exhibit 14 indicates that 155 Up trains suffered 476 hours detention short of Lalamusa and 156 down trains suffered 260 hours detention short of Sahiwal. The average detention to the up train works out 3 hours - 4 minutes and to down trains 1 hour-40 minutes during June-August, 1988.

6.1.4. Recommendations

(i) Whenever a train is likely to be detained for more than one hour at a station/yard, the diesel engine must be switched off by the driver. The Station Mster and Control Office staff be made responsible to convey a messae to the driver for shutting down the diesel engine.

(ii) The following provisions may be considered for inclusion in the "Trip Rations" for the out of course stops as indicated below:-

Passenger Trains	-	10	litres
Goods Trains	-	12	litres

6.2. Timely application of brakes, coasting and proper handling of locomotives, proper training of locomotive crews can make a significant contribution in this area.

6.2.1. ENERGY CONSERVATION BY THE USE OF BETTER DRIVING TECHNIQUES.

Provision of Dynamic Braking on main line locomotives would result into fuel savings because of the following advents:-

(i) The speed restrictions can be observed without loss of extra time.

(ii) After application of dynamic brakes, momentum can be gained more swiftly and with considerable less consumption of energy.

(iii) It reduces the unpowered movement of diesel locomotives, which is also termed "coasting".

6.2.2. OPERATIONAL EFFECT

The fuel consumption varies from driver to driver depending upon operating skill. To study this effect two drivers were selected to gauge their working in respect of fuel consumption while working same load = 686 tonnes to 688 tonnes, same train (106Dn) on the same section (Lahore-Khanewal), at the same speed (105 KMPH) and following were observed.

S.No.	DE Loco No.	Driver's Name	Fuel consumption per 1000 GTKM
1.	8208	A	4.42
		B	4.69
2.	8224	A	4.31
		B	4.57
3.	8227	A	4.44
		B	4.50

6.3. Proper maintenance and updating the fleet of diesel locomotives will go a long way in achieving our main objectives.

6.3.1. SAVING IN FUEL CONSUMPTION BY UPDATING DIESEL FLEET.

Due to the research made by the Manufacturers of locomotives, it has been possible to develop matching turbo chargers, improved piston bowl shape and camshft design, which may result into reduction of Specific Fuel Consumption which amounts neary 10%. Saving in fuel consumption would pay for the investments made in this field in a very short time.

6.3.2. IMPROVED MAINTENANCE EFFECT

To study the behaviour of locomotives from fuel consumption point of view, different locomotives but of the same class when worked by same crew, on the same section (Lahore-Khanewal) at the same speed (105 KMPH) with almost uniform load (686 to 688 tonnes) and without variation in the running time (train being same i.e. 106 Dn) were studied and observed as under:-

DE Locomotive NOs.	8208	8224	&	8227
Fuel consumption in litres per 1000 GTKM	4.69	4.57		4.50

6.4. TRAILING LOADS HAULED BY DIESEL ELECTRIC LOCOMOTIVE

A diesel engine gives best fuel efficiency while working on 80% load factor.

6.5. ORGANIZATIONAL SET UP

The last but not the least, is a proposal for input in terms of more Officers and Senior Supervisors to achieve objective of effcient use of fuel. To begin with, it will be necessary to have atleast one Officer on each Division exclusively for fuel economy work. The present size of the Organization responsible for efficient use of energy bears little relation to the size of expenditure, involved.

* * * * *

Exhibit - 4

Average Life of Diesel Electric Locomotives

S.No.	Class of DE Locos	No. of Locos	Year put in service	Average Life (1988)
1.	GE - 61	3	1954	34
2.	ALU - 95	25	1958	30
3.	ALU - 18	27	1961	27
4.	ALU - 20	52	1962	26
5.	ALU - 12	49	1962	26
6.	ALU - 24	21	1967	21
7.	GEU - 15	23	1970	18
8.	GEU - 20	40	1971	17
9.	GMU - 15	32	1975	13
10.	GMU - 30	36	1975	13
11.	ARU - 20	26	1976	13
12.	ARP - 20	23	1977	12
13.	GMCU - 15	30	1979	9
14.	FRAU - 75	2	1979	9
15.	HAU - 10	4	1980	8
16.	HAU - 20	28	1982	6
17.	HPU - 20	10	1982	6
18.	ARPW - 20	42	1982	6
19.	ALU - 20 R	3	1985	3
20.	HGMU - 30	30	1986	2
21.	HBU - 20	60	1986	2

Percentage over-age locomotives - 31.27

Exhibit - 5

Age group of Broad gauge steam Locomotives

Sr. No.	Class of Locos.	41 to 45	61 to 65	66 to 60	71 & above	Total
1.	CWD	53	--	--	--	53
2.	SP/S	--	--	1	20	21
3.	SG/S	--	--	15	4	19
4.	SG/C	--	--	--	19	19
5.	HG/S	--	9	6	10	25
	Total-	53	9	22	53	137

Total number of over-age locomotives - 84

Percentage of over-age locomotives 61.31

Exhibit - 6

Fuel Average month/consumption on passenger Services during 1-6-1988 to 31-8-1988

S.No.	Class of Locos	Engine KMS	GTKM	Average Load Tonnes	Fuel Consumption Total	Per 100 GTKM	Per K.M.
	Heavy D.E. Locomotives						
1.	HGMU - 30	492229	431300032	754	2234810	5.18	5.54
2.	GMU - 30	262744	192806112	617	1100774	5.71	4.19
3.	ALU - 20	13644	6445525	369	37413	5.80	2.74
4.	GEU - 20	126757	54444668	332	327592	6.02	2.58
5.	ARP - 20	7129	3670954	405	22192	6.05	3.11
6.	HBU - 20	143344	65143060	348	450188	6.91	3.14
7.	HAU - 20	323936	157084812	381	1167703	7.43	3.60
8.	ALU - 18	153067	50902538	235	427946	8.41	2.79
9.	ARU - 20	43324	21024891	372	201238	9.57	5.64
10.	HPU - 20	55827	14998496	165	159181	10.61	2.85
	Light D.E. Locomotives						
1.	GEU - 15	79523	34082118	344	169568	4.97	2.13
2.	GMU - 15	6221	23710669	294	141649	5.97	2.28
3.	GMCU - 15	54119	19468188	271	134561	6.91	2.49
4.	ALU - 95	76163	21312840	205	179731	8.43	2.36
5.	ALU - 12	79757	21946663	199	195364	8.90	2.45
6.	Hitachi Railcar	94674	9336779	80	121532	13.02	1.28

ბ ב

Exhibit - 7

Fuel consumption comparison of 15 up, 13 up, 103 up, 105 up & 45 up on Karachi Cantt - Rohri Section

1.	Type of Loco motive.	HGMU - 30	HGMU - 30	GMU - 30	HGMU - 30	GMU - 30
2.	Engine Weight (Tons)	122	122	116.8	122	116.8
3.	Trians	15 Up	13 Up	103 Up	105 Up	45 Up
4.	Load (Tonnes)	20=40=844	17=34=750	17=34=750	15=30=688	8=16=344
5.	Speed (KMH)	105	105	110	120	95
6.	Running Time	6' - 35"	6' - 35"	6' 08"	5' - 24"	9' - 05"
7.	Stoppages	6	6	3	2	26
8.	Distance (KMs)	472	472	472	472	481
10.	Total Kilo-meters Earned.	13688	14160	14160	14160	13941
11.	Total GTKMs.	13223893	12346464	12277773	11465918	6427940
12.	Fuel Consumed (Litres).	70286	66099	64682	60231	48610
13.	Consumption Per KM (Litres)	5.13	4.66	4.56	4.25	3.48
14.	Consumption per 100 GTKM (Litres)	5.31	5.35	5.26	5.25	7.56

Exhibit - 8

Average Fuel Montly consumption on goods Services during 1-6-1988 to 31-8-1988

S.No.	Class of Locos	Engine KMS	GTKM	Average Load Tonnes	Fuel Consumption Total	Per 100 GTKM	Per K.M.
			Heavy D.E. Locomotives				
1.	HGMU - 30	102784	163158644	1465	529781	3.25	5.15
2.	GMU - 30	181881	286467127	1458	936707	3.27	5.15
3.	ARP - 20	171968	251664416	1353	827534	3.29	4.81
4.	ALU - 20	19802	24491235	1133	92455	3.77	4.67
5.	ARU - 20	13074	1742535	1220	69364	3.98	5.30
6.	HBU - 20	239208	304758507	1167	1222512	4.01	5.11
7.	HPU - 20	6029	7856762	1200	32432	4.13	5.38
8.	GEU - 20	20175	21023261	944	91175	4.34	4.52
9.	HAU - 20	5896	7960571	1247	35176	4.42	5.97
10.	ALU - 18	2820	2015471	617	10497	5.21	3.72
			Light D.E. Locomotive				
1.	GEU - 15	3090	3044254	901	8626	2.83	2.79
2.	GMU - 15	3556	2677626	668	13039	4.87	3.67
3.	ALU - 12	1173	637448	467	3358	5.27	2.86
4.	ALU - 95	374	197424	453	1257	6.37	3.36
5.	GMCU - 15	10458	5419941	430	34462	6.73	3.49

Exhibit - 9

Average Loads Hauled by KC Based D.E. Locos during June - August, 1988

S.No.	Period	Trains run with		Total Trains	Total Loads Hauled by		Average Loads Hauled per Loco by	
		3000 HP Locos	2000 HP Locos	Run	3000 HP Locos	2000 HP Locos	3000 HP Locos	2000 HP Locos
1.	6 - 88	162	188	350	322705	358963	1992	1909
2.	7 - 88	164	133	297	318074	247749	1940	1863
3.	8 - 88	162	140	302	306722	255443	1893	1825
	Total	488	451	949	947501	862155	5825	5597
	Average	162.66	150.33	316.33	315833.66	287385	1942	1866

Exhibit - 10

Average Monthly Fuel Consumption of Shunting/ Departmental Services During 1-6-1988 to 31-8-1988

S.No.	Class of Locos	Eninge Kolometers	Fuel Consumption Total	Fuel Consumption Per Kilometer
	Heavy D.E. Locomotives			
1.	HPU - 20	6376	15956	2.50
2.	GMU - 30	2283	5947	2.60
3.	ALU - 20	1653	4688	2.84
4.	HBU - 20	3317	9465	2.85
5.	GEU - 20	14104	40669	2.88
6.	ARP - 20	9312	28087	3.01
7.	ARU - 20	59027	184801	3.13
8.	ALU - 18	7811	25422	3.25
9.	HAU - 20	1845	7222	3.91
	Total	105727	322217	3.04
	Average	11748	35802	3.04
	Light D.E. Locomotives			
1.	FRU - 75	524	854	1.63
2.	ALU - 95	64958	110106	1.69
3.	GEU - 61	5032	9015	1.79
4.	HAU - 10	22154	41435	1.87
5.	ALU - 12	42317	83966	1.98
6.	GEU - 15	13755	28114	2.04
7.	GMCU - 15	2471	5347	2.16
8.	GMU - 15	8600	19230	2.24
	Total	159811	298067	1.86
	Average	19976	37258	1.86

Exhibit - 11

Economy Effected due to Electrification on Lahore - Khanewal Section

Year	*G.T.K.M. (E.T)		HSD Oil Consumption in KG per 1000 GTKM		Total Fuel Consumption in K.Gs		Expenditure in Million Rupees HSD. Electrical		Saving in Million Rupees	
	Passanger	Goods	Passanger	Goods	Passanger	Goods	Oil	Energy	Per Annum	Per Month
1979-80	844	1662	6.32	3.51	5342	5844	28.614	8.248	20.366	1.697
1980-81	983	1548	6.44	3.77	6336	5837	42.108	11.440	30.663	2.555
1981-82	1099	1381	6.65	4.08	7316	5638	47.137	13.178	33.957	2.829
1983-84 (July-83/ May-84, 11 months)	749	1409	6.64	3.97	4977	5593	48.634	16.082	32.552	2.959
1988-89 (July-88)	54	117	7.05	3.81	381	449	03.032	02.451	**	0.581

* GTKM earned by Elct. Locos (Figures in Millions)

** (Figures in Thousands)

Exhibit - 12

Yard Detentions to Goods Trains During June, July & August, 1988

Sr. No.	Description	LLM	LHR	KWL	SMA	MHK	ROH	KOT	MYP	KPT	Total
	June, 1988										
1.	Total number of trains.	77	69	115	145	69	82	85	21	126	789
2.	Total Detention.	308.15	288.30	495.40	714.50	617.20	353.50	376.10	106.05	655.10	3916
3.	Detention per train.	4.00	4.12	4.19	4.56	8.57	4.19	4.26	5.01	5.12	4.58
	July, 1988										
1.	Total number of trains.	106	91	126	152	73	85	83	24	121	861
2.	Total Detention.	490.00	398.30	614.30	698.10	495.55	351.35	403.55	110.25	595.50	4258.50
3.	Detention per train.	4.37	4.23	4.55	5.07	6.48	4.08	4.52	4.36	4.55	4.57
	August, 1988										
1.	Total number of trains.	89	87	127	133	71	79	66	20	137	709
2.	Total Detention.	414.40	378.55	604.00	660.20	577.25	346.10	271.20	93.40	742.25	4088.55
3.	Detention per train.	4.39	4.21	4.45	4.58	8.08	4.23	4.07	4.41	5.34	5.46

Exhibit - 13

Fuel Oil Consumption During idling in Sheds

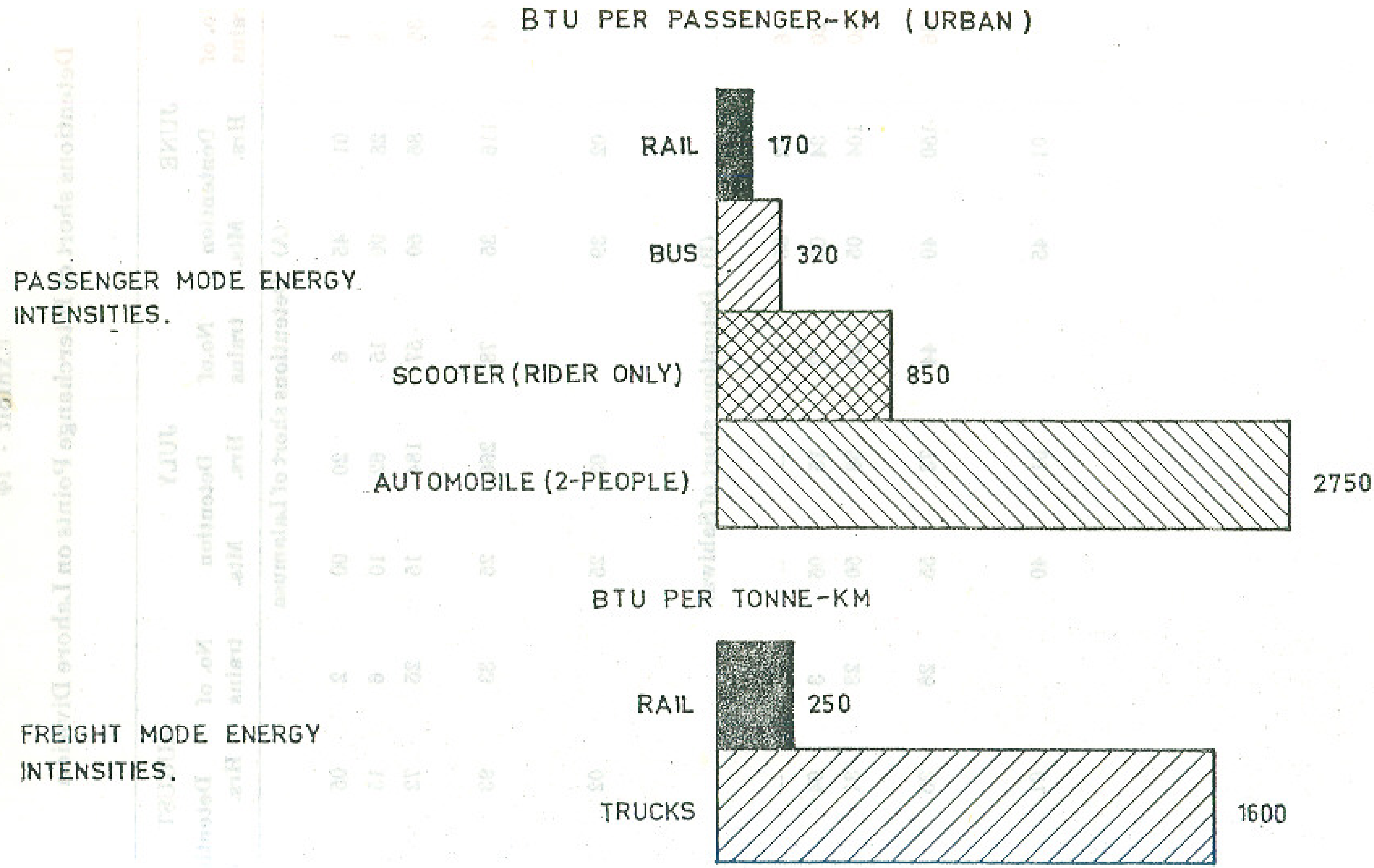
Base Shed	Fuel Oil Consumption in litres during June	July	August
KC	46566	73434	77725
ROH	68585	53568	52580
SIB	22682	11812	13008
QTA	14235	18085	22959
SMA	12158	12726	12919
LHR	57822	50878	39693
FSLD	8605	7884	9811
RWP	31365	3914	38547
KDA	24171	27574	28567
Total	286189	287875	295809

Exhibit - 14

Detentions short of Interchange Points on Lahore Division

Station	JUNE			JULY			AUGUST		
	No. of trains	Dentention Hrs.	Mts.	No.of trains	Detention Hrs.	Mts.	No. of trains	Detention Hrs.	Mts.
(A) Detentions short of Lalamusa									
KTL	1	01	45	6	20	00	2	05	50
GRT	8	28	00	15	62	10	6	15	20
DEN	35	86	50	57	184	15	25	72	35
Total	44	116	35	78	266	25	33	93	45
Average per train		02	39		03	25		02	50
(B) Detentions short of Sahiwal									
QDB	6	12	35	--	--	--	--	--	--
YSW	20	34	00	9	15	05	3	04	25
NMML	60	104	05	35	58	50	23	31	05
Total	86	150	40	44	73	55	26	35	30
Average per train		01	45		01	40		01	22

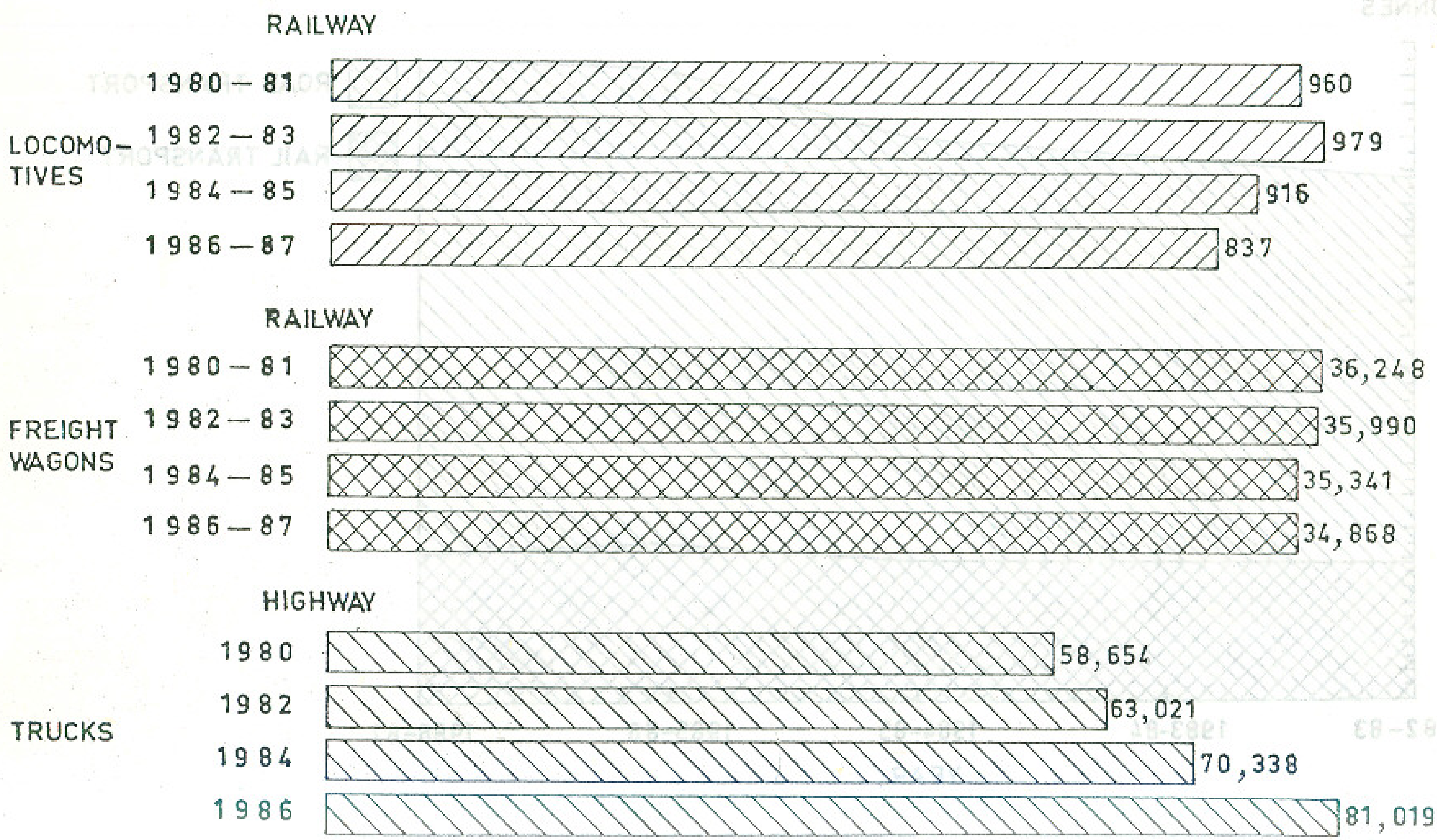
ENERGY INTENSITIES OF DIFFERENT MODES OF TRANSPORT



NOTE: PASSENGER MODE ENERGY INTENSITIES REPRESENT URBAN TRANSPORTATION.

EXHIBIT 1

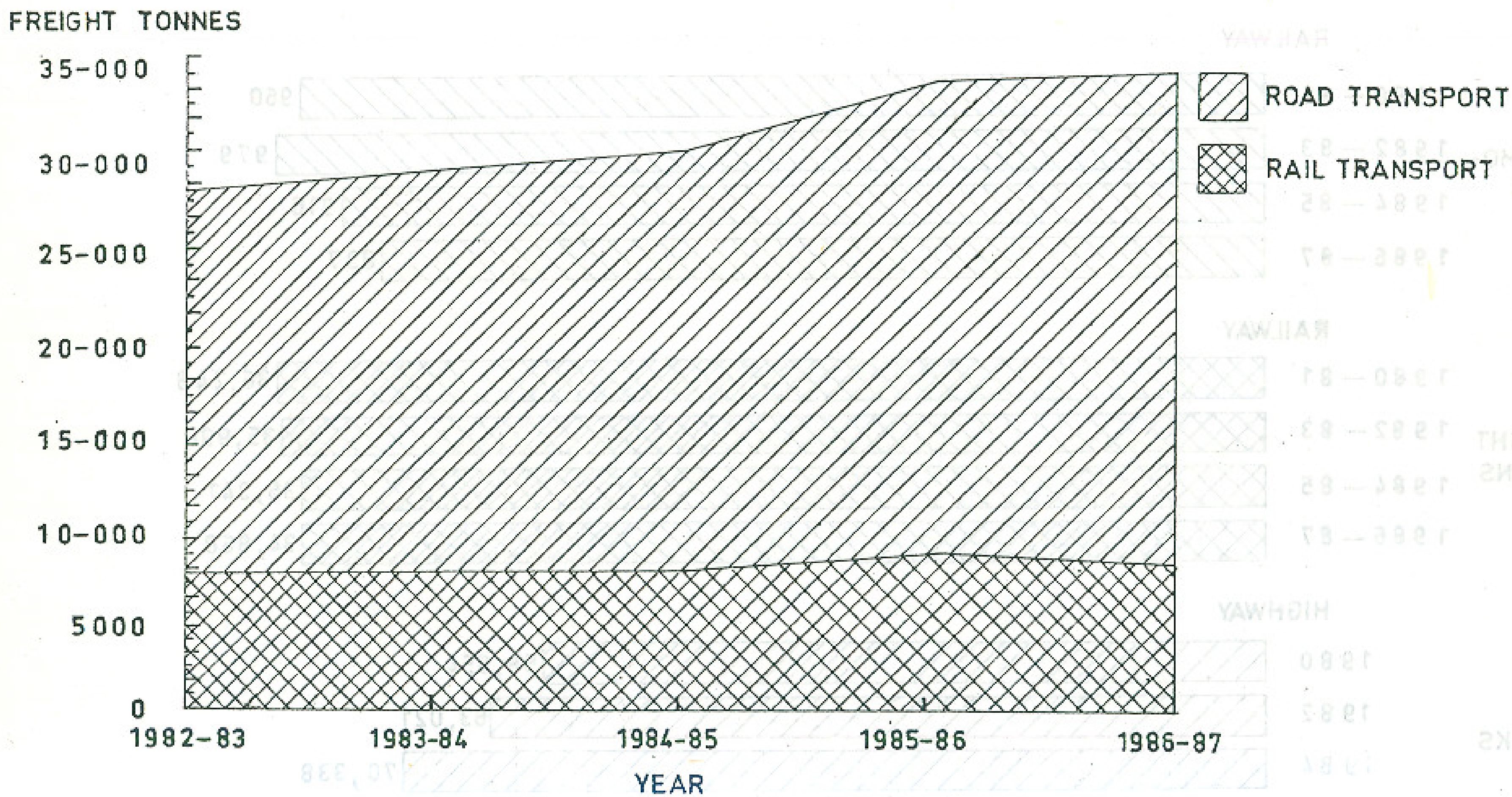
COMPARISION OF FREIGHT HAULAGE CAPACITY BETWEEN RAIL AND ROAD TRANSPORT



SOURCE: ECONOMIC SURVEY OF PAKISTAN, 1987–88

EXHIBIT 3

HISTORICAL TREND OF FREIGHT TRANSPORT
IN PAKISTAN
1982 – 83 TO 1986 – 87



SOURCE : ECONOMIC SURVEY OF PAKISTAN 1987-88
PAKISTAN STATISTICAL YEAR BOOK 1988

UNITS : MILLION TONNES

EXHIBIT 2