GOVERNMENT OF PAKISTAN
PLANNING AND DEVELOPMENT DIVISION
NATIONAL TRANSPORT RESEARCH CENTRE

- A CASE STUDY -

ECONOMICS OF ELECTRIFICATION

COMPARATIVE COSTS OF DIESEL AND ELECTRIC TRACTION ON KHANEWAL-SAMASATTA SECTION OF PAKISTAN RAILWAYS

NTRC-1

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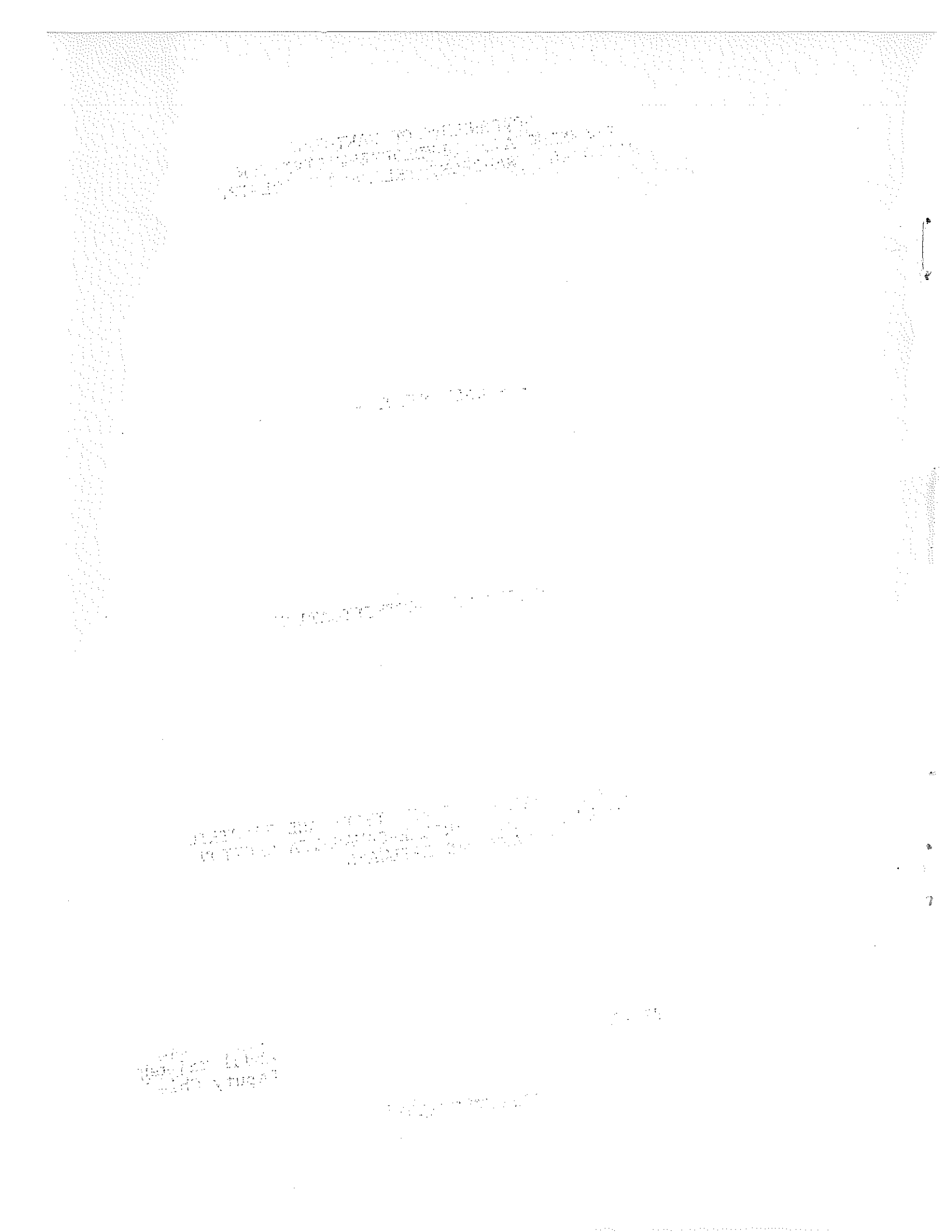

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F O R E W O R D

Electrification was introduced on Pakistan Railways over Khanewal-Samasatta section in 1970. The Economic Appraisal of the project then prepared by Mr. Hans Adler in the "Manual For Appraisal of Transport Projects" indicated that electric traction, as compared to diesel traction, would be justified in financial terms but not in economic terms. His analysis was based on shadow prices of Foreign Exchange and prices of HSD at Rs. 2.25 per gallon including tax and Rs. 0.90 excluding tax. Since then the currency has been devalued and shadow prices are not called for: the prices of fuel have increased many fold. At present the cost of HSD is Rs. 4.50 per gallon excluding tax and its retail price including tax is Rs. 5.50 per gallon. The price levels of other cost components have also undergone considerable changes and the balance of relative costs has markedly shifted in favour of Electrification. Accordingly a re-appraisal of relative economics of diesel versus electric traction was called for. This is provided by the present report, which is mainly an appraisal of the project for the Extension of Electric Traction to Khanewal-Samasatta section of the main line. The analysis shows that Electrification of this section would result in considerable savings in operating costs in both financial and economic terms but the project would be sensitive to capital costs of Electrification. Moreover, considerable volume of traffic is required on a given line to justify the large initial capital expenditure. Therefore, the results of this study cannot be applied elsewhere without considering traffic volumes and firm cost estimates for each section. However, the methodology used will it is hoped serve as a guide for the appraisal of similar other projects.

2. This is the first publication prepared by the National Transport Research Centre of the Planning and Development Division. The work done by Mr. Majeed in preparing this report is gratefully acknowledged.

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Director

S U M M A R Y

General

For the determination of relative economics of diesel and electeic traction, the cost components considered include capital works and capital maintenance, locomotives and locomotive maintenance, fuel and energy. All other cost items such as track maintenance, stations, staff and overheads which are common for the two alternatives, have been ignored as their equal weight on both sides would not affect the relative position of any. The terminal values of assets and, in the case of electric traction, savings on account of wagons, travel and transit times have been valued and accounted for as negative costs. Other indirect social costs, such as fume and pollution etc ; have not been touched upon as these are of academic interest in our country.

Traffic/Locomotives

It is estimated that for carrying the given amount of traffic, either 13 diesel of 10 electric locomotives would be required in the base year. For future increase in traffic projected at 6% per annum for passengers and 7.2% per annum for freight, 13 additional Diesel Locomotives or 8 electric locomotives would be required during the life of the project. These estimates presume some improvement in the performance of bothe diesel and electric locomotive and rolling stock. By the end of the project period, the train frequencies will be optimum and line capacity will be fully used up. Further increase in traffic has not been considered as the same would call for additional investment.

Cost/Benefits(Figures within brackets are excluding taxes and subsidies)

The electric traction would cost Rs.86.96 million (60.936 million) on capital works and Rs. 0.52 million on annual maintenance. This would result in savings in Locomotives and fuel costs are as below:-

TABLE I. Unit Costs of Locomotives and Fuel/Energy

		Diesel	Electric	Savings
1. Locomotives(Million Rs.per Unit)				
	Financial	6.5	5.2	1.3
	Economic	5.3	4.0	1.0
2. Fuel Energy Rs./1000 GTM:				
Passengers Traffic.	Financial	13.75	2.88	10.87
	Economic	10,95	2.88	8.07
Goods Traffic	Financial	8.00	2.88	5.12
	Economic	6.58	2.88	3.70

The overall operating cost of electric traction would be lower than diesel traction both in Financial and Economic Terms as below:

TABLE II. Overall Operating costs discounted at 12% per annum

(Million Rs.)

	Financial		Economic	
	Diesel	Electric	Diesel	Electric
Capital Works	-	86.95	-	60.936
Capital Maintenance	-	4.079	-	4.079
Locomotives	107.147	64.292	82.42	49.456
Locomotives Maintenance	13.979	5.923	13.979	5.923
Fuel/Energy	98.836	30.324	81.157	30.324
Total	219.962	191.568	177.556	150.718
Less Terminal Value	1.994	4.885	1.534	3.584
Savings in Wagons	-	-	-	1.876
Savings in Travel time	-	-	-	8.707
Saving in Transit Time	-	-	-	.503
Net cost	217.968	186.683	176.022	136.048

The Electrification would involve additional cost of Capital Works and Capital Maintenance of Rs. 91.029(Rs.65.015) Million and would result in savings of Rs. 122.314 (104.989) Million in operating costs. The net savings of Electric Traction would be Rs. 31.285 million in Financial Terms and 39.974 in Economic Terms as shown below.

TABLE III. Costs and Savings of Electric Traction discounted at 12% p.a.

(Million Rs.)

	Financial	Economic
Additional Costs :		
Capital Works	86.950	60.936
Capital Maintenance	4.079	4.079
Total	91.029	65.015
Savings :		
Locomotives :	42.855	32.964
Locomotive Maintenance	8.056	8.056
Fuel Energy	68.512	50.833
Sub-Total	119.423	91.853
Terminal values	2.891	2.050
Savings in wagons	-	1.876
Savings in Travel Time	-	8.707
Savings in Transit Time (Goods) ..	-	0.503
Sub-Total	2.891	13.136
Total Savings	122.314	104.989
Net Savings(Savings Costs) ..	31.285	39.974

The additional investment would have a rate of return on 16.7% in Financial terms and 21.5% p.a. in Economic terms.

The project would be sensitive to cost of capital works. A 36% increase on this item would eliminate the benifits.

In case there is no increase in traffic, the rate of return would be 8% p.a. in financial terms and 11% p.a. in economic terms excluding time savings. Including time savings, the rate of return would be 10% and 14% per annum in financial and economic terms respectively.

In view of the fact that Electric Engines are already available some risk of increase in costs is worth taking.

The above results are based on the basis of following assumptions which have been arrived at in this report.

(i) Volume of Traffic(Base Year) Passengers Traffic =221 Million GTM+Goods Traffic=561 Million GTM Total 782 Million GTM.

(ii) Growth Rate:Passengers Traffic 6% p.a. Goods Traffic 7.2% p.a.

(iii) Locomotive Requirements. Base Year 13 Diesel or 10 Elect.

End Year 25 Diesel or 18 Elec.

(iv) Fuel consumption passengers Traffic Lb. 12 per 1000 GTM

Goods Traffic Lb. 12 per 1000 GTM

Economic cost Rs. 4.50 per Gallon

Financial cost Rs. 5.50 per Gallon

(v) Energy consumption 24 KWH for 1000 GTM @ Rs. 0.12 per unit.

(vi) Project life 25 Years

(vii) Discount Rate 12% per annum.

INTRODUCTION

1. The Electrification of Railways, a well established technology to improve speed and efficiency which are so essential in the face of growing competition from road transport, has recently gained more attraction due to phenominal increase in the price of fuel over the last few years. Consequently, proposals are under consideration for the extension of electric traction from Lahore Khanewal to Samasatta bringing the total mileage of electrified section from 177 to 250 miles. An economic appraisal of the Khanewal Samasatta section has been attempted in this paper.

2. As an aid in making the decision objectively, comparison has been made between overall cost of electrification or continuation with diesel traction. The methodlogy used is based on marginal analysis and takes into account only those items where cost or savings of the two alternatives are different. These include Capital Works, Locomotives, Fuel/Energy, Maintenance of Capital Works and Locomotives. Additional benefits of Electrification on account of savings in Wagons, travel time and time for goods in transit have also been taken into account for economic analysis but not for financial analysis. All other items of cost common for both the alternatives have been ignored as their equal weight on both sides would not affect the relative position of any. Such items include maintenance of track, stations, staff and over heads. All costs are assumed to be incurred in the base year 'year 0' irrespective of the construction period. The period of project operation is numbered from year 1 to 25. A rate of discount of 12% has been suggested for comparing future costs and as a cut-off mark for Marginal Rate of Return. Variations have also been considered for sensitive items. The results are contained in the last section and tables 26 to 32 at the end.

Project Description

3. The electrification was started by P.R. in 1966 on Lahore-Khanewal Section which was completed in 1970. The project now under consideration is a proposal to extend electrification to Khanewal Samasatta Section via the Chord Line. The length of this Section is 73 miles of which 53 miles from Khanewal to Lodhran are singletrack while 17 miles from Lodhran to Samasatta are double track.

4. A main marshalling yard is located at Samasatta. The goods trains to and from Lahore have to change engines at Khanewal or the diesel engines will run over Lahore-Khanewal electrified portion as well. With the electrification of Samasatta-Khanewal Section, it would be possible to run through goods trains with electric engines.

5. It may be added that between Khanewal and Samasatta there are two lines - the loop and the Chord, the relative distances being 101 and 73 miles respectively. The large industrial city of Multan is located on the loop line. As will be indicated in subsequent paragraphs, a large proportion of passenger trains use the loop line whereas large proportion of goods trains run on the Chord line. Even after the electrification of the Chord line, it would not be possible to by-pass the city of Multan. A number of main passenger and goods trains will continue to use the loop line. Therefore, the problem of changing diesel engines at Khanewal for trains using the loop line will continue to exist and the Lahore Khanewal Section will remain mixed with diesel and electric engines, though the proportion of diesel engines would be less than before. This problem needs to be thoroughly examined before undertaking the project.

6. It has been indicated in the project proposal that in the case of electrification, no additional locomotives would be required as the surplus stock on Lahore Khanewal Section will be adequate to meet the requirements of extended length of electric traction. Therefore, while analysing the returns on electrification, the cost of electric engines has been ignored in the project proposal. This treatment gives undue advantage to electrification as against diesel traction. Although the availability of a number of electric engines would make a lot of difference to the Railways in financial terms, but for the purposes of project analysis, the cost of Locomotives to be employed on the line would be taken into account in this exercise for both the alternatives. Otherwise it would mean that electrification would be justified because of over investment in the past. This is not a reasonable assumption. Therefore, cost of Electric Locomotives that would be required for the proposed section, has been taken into account at current prices.

7. Only two alternatives have been considered, namely electrification of the existing line or continuation with diesel traction. The former involves high initial investment or no additional investment initially, but higher operating costs. The significant characteristics of the two alternatives are:-

(i) The electrification would require larger initial capital investment for power supply, immunization of communication lines and ancilliary engineering works whereas diesel locomotives require relatively simple and less expensive track facilities which are already existing.

(ii) The cost of electric locomotives is relatively lower and life longer than diesel electric locomotives.

(iii) The operating costs of electric locomotives are lower than diesel engines. The major difference is made by relative prices of fuel and power.

8. The higher initial investment would be justified if, at appropriate discount rate, the savings in operating costs out weigh the additional investment over the life of the project. The savings in operating costs will increase with the scale of operation i.e. the volume of traffic. At lower volume of traffic, the average costs would be higher for electrification but the relationship would be reversed at higher traffic volumes. The magnitude of additional investment, volume of traffic and savings in operating costs are important variable. Their inter-relations determine the economics of each.

Previous Study

9. The economics of electrification was earlier considered by Adler*in connection with the electrification of Lahore-Khanewal Section. The alternatives considered were electrification or dieselization of a line that was being operated with steam locomotives. The result of his study was that electrification was justified in terms of financial costs but not on the basis economic costs. There was no difinitive answer whether the Railway should electrify or not. It was suggested that if the Government insists Railways to dieselize, on the basis of economic costs, it should make a grant to the Railway equal to the extra financial costs of dieselization. The analysis was, however found sensitive to capital costs of electrification and relative prices of fuel and power. It was observed that a decrease of 25% in capital costs or electricity charges or similar increase in fuel costs would justify electrification on the basis of economic costs as well.

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*Planning Division, Manual for Economic Appraisal of Transport Projects, June, 1969.

10. Since then the costs and prices have changed in varying proportions. At that time the retail price of fuel (High Speed Diesel) was Rs. 2.25 per gallon and net of taxes and subsides, Rs. 0.90 per gallon only. However, taking shadow prices of foreign exchange, the economic cost of fuel amounted to Rs. 1.17 per gallon. The cost of electricity was taken at paisa 6.5 per unit. Now the price of fuel has increased to Rs. 5.50 per gallon all inclusive and Rs. 4.50 net of taxes and subsides.(1) The prices of materials and equipment, wages and salaries have also increased the costs considerably. The old analysis is, therefore, out dated and irrelevant.

11. The project has now been examined in the present set of costs and prices. The approach followed is similar as used by Adler, The overall costs for carrying a given amount of traffic have been estimated for the two alternatives for a period 25 years and discounted to their net present value. Only those factors have been considered where costs or saving of the two alternatives are different. Common elements have been ignored as their equal weight on both sides would not affect the relative position of any. Throughout the analysis, estimates have been made both in terms of financial and economic costs. The financial costs represent out of pocket expanses of the Railways. For the determination of economic costs, only direct taxes and subsides have been excluded. Some other benefits of electrification such as savings in Wagons, travel and transit times have also been quantified and treated as negative costs. However, direct costs like fume and polusion have not been touched upon for being of academic interest only. In view of the problems of definition and data involved in the estimation of true economic costs, only broad principles have been followed and much of the refinements have not been made. The economic costs may therefore not be wholly uncontroversial. These should therefore be strictly viewed in the light of assumptions made.

Traffic

12. There are at present 17 passengers(2) and 11.3 goods trains(3) each way between Khanewal and Samasatta. Of these, 13 passenger and 3 goods trains run on loop line and 8 goods and 4 passenger trains use the Chord line as shown below:

TABLE I

Daily No.of Trains(One Way) on loop and chord lines

	Loop	Chord	Total
Passenger	13	4	17
Through Goods	4	5.0	5.4
Other Goods	2.5	3.4	5.9
All Goods Trains	2.9	8.4	11.3

1. Details are contained in table 19 and 20.
2. Time and Fare Table Dec. 1973
3. PWR Operating Statistics Oct. 1971.

13. As is evident, the loop line is predominatly used for passenger traffic and chord line for goods traffic. However, the Pakistan Railways have indicated that the volume of traffic on the section under consideration would be 10 passenger and 8 goods trains each way daily. This means that nearly half the passenger trains on the loop line would be diverted to chord line. This should not be difficult as most of the trains on this line run through Peshawar and Karachi. Nevertheless, there will always remain the possibility of increasing or decreasing the volume of traffic by diverting trains to and from the loop. The full economies of electrification would be realized if the line is used to capacity. It would be in the interest of the Railways to divert the

largest possible amount of traffic to the low cost line to use the same to its capacity. Although, it is not possible to determine the exact amount of traffic that can be diverted to the chord line without further detailed studies, but it is expected that 2/3rd of passenger trains and a little more proportion of goods trains will use the chord line. Accordingly it is assumed that out of 17 passenger and 11 goods trains between Khanewal Samasatta, 11 passenger and 8 goods trains will go on Loop Line. On the basis of gross train loads observed on Lahore Division, the annual Volume of Traffic would be as follows:-

	No. of Trains	Gross Train Load	Annual Traffic Volume Million GTM
Passengers	11	375	221
Goods	8	1,227	561

This is about the same traffic as proposed by the Pakistan Railways. Future growth of traffic has been based on these figures.

Traffic Projections

14. The Rail Traffic has been stagnant over the last decade around 6 billion Passenger Miles and 5 billion ton miles of freight largely due to several bottlenecks, capacity constraints and declining efficiency which is evident from the declining use of rolling stock and locomotives. Consequently, almost all increase in traffic in the past has been absorbed by road transport. The Sofrail and TRACO consultants are of the view that capacity of the Railways can be increased by about 30 per cent by better control and management and without additional investment. The crash programme of the Railways

is expected to increase their capacity by the about 30 per cent. Besides, the investment during the Fifth Five Year Plan is intended to remove major bottlenecks and improve efficiency. The Rail traffic during the Fifth Plan period is estimated to increase at 9.2 per cent per annum for freight and 6 per cent per annum for passengers. For subsequent period upto 1994-95, the increase in traffic has been projected at an average rate of growth of 6 per cent per annum for passengers and 8 per-cent per annum for freight. This means that present trends would be reversed and much of the increased traffic which otherwise go to road transport would be diverted to Railways. These trates reflect the ideal distribution of traffic over rail and road. To achieve this objective, suitable measures including price and investment policies for Rail and Road would have to be devised and standard of rail service would be improved. Taking into account all such consideration, the same rate of growth as for perspective plan has been used for passenger traffic. However, for freight traffic slightly lower rate of growth has been used. Accordingly, the increase in traffic over a 25 years has been projected at 6 per cent per annum for passengers and 7.2 per cent per annum for freight as below:

Table 2

Traffic Projections(Gross Ton Miles)

	Ist Year	6th Year	11th Year	16th Year	21st Year
Passenger	221	296	396	530	708
Freight	561	794	1124	1592	2253
Total:	782	1090	1520	2122	2961

15. The electrification of Khanewal Samasatta Section is based on the same system as prevailing on Lahore Khanewal Section and would require, besides, overhead contact wire and ancillary engineering works, two feeder stations at Bahawalpur and

Dunyapur and one transformer at Khanewal Grid Station and immunization of overhead telegrph lines for which underground communication system is proposed. The initial cost of electrification has been estimated at Rs. 86.95 million, the details of which are given below:-

TABLE 3

Cost of Capital Works

(000 Rs.)

S.No.	Designation	Cost	Taxes	Total
1.	Detailed Feasibility Report and Project Design.	340	-	340
2.	Cost of Equipment installation, Testing and Commissioning.	48,000	26,000	74,000
3.	Establishment Charges	1,980	-	1,980
4.	Transport and Conveyance Charges	616	-	616
5.	Training of Staff	26	-	26
6.	Ancillery Engineering Works	3,720	14	3,734
7.	Incidential and at 50%	2,080	-	2,080
8.	Incidential and at 50%	4,174	-	4,174
	Total:	60,936	26,014	86,947

Financial Cost = Rs. 86,947

Economic Sot. = Rs. 60,936

The above costs are based on escalation or old prices. It would be appropriate to obtain fresh price quotations from suppliers for proper evaluation of the project.

16. In case of continuation of diesel traction, no capital works will be involved.

Locomotive Requirements

17. The P.W.R. have estimated that by extending the electric traction to Khanewal Samasatta Section, they will utilize 8 or 9 electric engines which are spare on the Lahore Khanewal Section and that by different composition of electric/diesel trains, 10 diesel engines will be released for utilization on other lines. Although the project should be considered with its relation to other lines, but it is also essential to know the number of diesel or electric engines that would be required to carry the given amount of traffic over the proposed line in order to determine capital requirement specific to the project as well as operating costs by different types of traction units.

18. The requirements of locomotives depend as much upon the characteristics of traction units as upon the track, traffic conditions and signalling system which equally determine their performance and efficiency. However, the track and traffic conditions remaining the same the number of locomotives would be determined by their relative performance. This is more important as it forms the basis of estimating relative costs.

19. Accordingly, the relative performance of diesel and electric engines, specifically the average daily/ mileage and load factors have been considered in detail.

Average Daily Mileage

Diesel Engines

20. The performance of both diesel and steam engines has gradually declined over the years as shown below:-

TABLE 4

Historical Trends of Average Daily Mileage by Diesel Engines

Year	Per Engine on line		Per Engine in use			
			All Engines		Goods Engines	
	Steam	Diesel	Steam	Diesel	Steam	Diesel
1955 - 60	80	201	110	235	87	184
1960 - 65	76	177	97	202	73	153
1965 - 70	69	168	83	110	60	128
1970 - 73	53	157	85	183	66	112

Source: - P.W.R. Statistical year Book 1973.

The decline in the performance of steam engines might be due to their continuous depreciation for virtual replacement and employment on less and less demanding operations. For the decline in the performance of diesel engines, various reasons that suggest include general decrease in efficiency, wearing out of locomotives, increase in less demanding operations in place of steam engines or increase in average wagon load. To the extent the decline is due to worn out stock, their performance would not be strictly comparable with relatively new electric engines. Nevertheless, the obvious conclusion is that contrary to historical trends, there is considerable scope for improvement in the performence of diesel engines. Thorough investigation of locomotive performance is, however, called for.

21. The problem of determining average daily mileage by locomotives is complicated by variation in their performance over different lines and also for various types of locomotives. The table below showing average daily mileage by diesel engines on various lines indicates the influence of other factors on performance.

TABLE 5

Average Daily Mileage by Diesel Engines in use on different lines during 1971

S.No.	P. W. R. Division		Type of Train		
			Passenger	Mixed	Goods
1.	Lahore	...	270.7	257.7	120.0
2.	Multan	...	-	-	121.6
3.	Sukkur	...	327.3	-	134.1
4.	Karachi	...	402	-	188.3
5.	Rawalpindi	...	301.9	103.4	132.3
6.	Quetta	...	243.1	151.1	109.1

Source:- Operating Statistics 1971-72, October 1971 P.W.R., Lahore. Data not available - Nil or not applicable.

The higher mileage on Karachi and Sukkur Divisions might be due to greater proportion of double track and through traffic than on Rawalpindi and Lahore Divisions. The mileage in Rawalpindi Division is higher than on Lahore Division inspite of high gradients and relatively poor track conditions. This might be either due to shorter trains or use of better types of engines on Rawalpindi Division but needs further examination. Taking these factors into consideration, the per mile cost of operation would be different on various lines and for different types of engines depending upon track and traffic conditions and type of the engine used.

Electric Engines

22. The electric engines are in use only on Lahore-Khanewal Section since 1970-71. Their performance, as shown in the following table, has increased over the short period. This might be due to overcoming of teathing problems and experience gained with electric traction.

Table 6

Average Daily Mileage by Electric Engines

Year	All Engines on line	All Engines in use	Goods Engines in use
1970-71	118	163	79
1971-72	144	226	151
1972-73	189	232	148

Source:- PWR Year Book of Statistics, 1973.

23. It is clearly evident from the foregoing, that relative performance of electric and diesel engines should be considered strictly in comparable track and traffic conditions and for comparable categories of both types of engines. It would, therefore, be more relevant to consider relative performance of diesel and electric engines on the basis of data for the Lahore Division of Pakistan Railways.

Table 7

Average Daily Mileage by Electric and Diesel Engines on Lahore Division

		Range	Maan
Electric Engines(July-Oct.1971):			
Passenger	...	292.9 - 339.4	322.9
Mixed	...	- -	-
Goods	...	159.5 - 206.4	176.9
All Engines	...	- -	240.5
Diesel Engines(Jan-Dec.1971):			
Passenger	...	241.7 - 313.5	309.1
Mixed	...	240.5 - 300.0	271.0
Goods	...	108.6 - 140.8	124.4
All Engines	...	- -	262.0

Source: Compiled from Pakistan Railways, Operating Statistics 1971-72 October, 1971.

24. With respect to the relative performance of diesel and electric engines on Lahore Division it may be noted that:

(i) the performance of electric engines is restricted due to short haul. The extension of electric traction will increase the length of haua and improve their performance.

(ii) the mileage of diesel engines also includes other than through goods trains and operations on lines with lower qualities of track and signalling system. Besides, the diesel engines are relatively worn out. Their performance on comparable track and traffic conditions might be expected somewhat better.

(iii) the factors responsible for the general decline in the performance of diesel engines as indicated in Table 5 above, exert their influence on electric engines as well. Therefore, it is expected that in better and comparable track and traffic conditions, the performance of both diesel and electric engines will increase but the present differential in their relative performance will continue particularly in view of the superiority of electric engines in acceleration, decelleration, over high gradients and for carrying heavier loads.

25. Taking into account all these factors, it is assumed that average daily mileage by electric and diesel engines would be near about the upper limits of the monthly range observed on Lahore Division. This should be possible in view of improvement in the performance of electric locomotives expected after electrification due to longer hauls. In the case of diesel engines, the higher performance may be taken to account for other than through goods trains and on branch lines to make track and traffic conditions comparable. The higher mileage for diesel engines is just about their past level of efficiency which, it is assumed, will be regained gradually. For future years, it is assumed that the average daily mileage would be about the highest observed on any division of the Railways.

26. On the basis of above assumptions, the average daily mileage of diesel and electric locomotives, estimated for the base year and projected for future years is as below:

TABLE 8

Performance of Locomotives for Estimating their Requirements

	Electric	Diesel
Average Daily Mileage 1970-71(Actual):		
Passenger ...	322	309
Goods ...	177	125
First year (Expected):		
Passenger ...	350	325
Goods ...	200	150
End year (Projected):		
Passenger ...	450	400
Goods ...	300	200

Load Factors

27. The average load factors for goods and passenger trains observed in the past as shown in table 9 below indicate that over the period 1955-60 to 1970-73 the average number of wagons per train has decreased from 60.2 to 53.6, the load per wagon has increased from 13.8 to 17.4 tons and net train load has increased from 450 tons to 557 tons per train. In the case of passengers, the train miles and passenger miles have both increased but the number of passengers per train has slightly decreased from 345 in 1955-60 to 320 in 1970-73. As in the case of average daily mileage, the problem of estimating average load factors is also complicated by variation over different lines as shown in table 9.

TABLE 9

Average Load for Diesel Trains on Various lines

(Gross Tons)

PWR Division	Pessenger	Goods
Lahore	383	1227
Multan	408	1271
Sukkur	395	1066
Karachi	408	1493
Rawalpindi	238	587
Quetta	363	521
All Divisions	392	1228

Source : PWR Operating Statistics 1971-72.

28. For the purpose of this exercise, it is expected that for diesel engines, average train loads for goods and passengers would be slightly higher than the loads observed on Lahore Division in the base year. For subsequent years, it is assumed that the highest load factors observed on any division would be achieved gradually before the end of the project period.

29. For electric trains detailed statistics regarding load fadtors are not available separately. However, for passenger traffic the difference in performance of diesel and electric engines would not be mueh as passenger trains are run on time tables. However, in the case of goods trains the difference on is considerable. The trains run with electric engines carried 16% more wagons. Therefore, proportionately higher load factors have been assumed for electric trains as shown below:-

TABLE 10

Average Load Factors

		Electric	Diesel
1970-71	Passenger	358	358
	Goods	1350	1227
Ist year	Passenger	375	375
	Goods	1400	1250
6th year	Passenger	400	400
	Goods	1450	1275
11th year	Passenger	425	425
	Goods	1500	1300
16th year	Passenger	450	450
	Goods	1550	1350
21st year	Passenger	450	500
	Goods	1600	1400

Locomotive requirements

30. On the basis of mileage and load factors given above, the requirements of electric and diesel locomotives for the traffic indicated before, have been worked out as below:-

TABLE 11

Requirements of Locomotives

		1970-71 Actual	1st year Estd.	6th year Proj.	11th year Proj.	16th year Proj.	21st year Proj.
Electric							
1. Traffic Volume Million GT Annual.	Pass.	191	221	296	396	530	708
	Goods	523	561	794	1124	1592	2253
2. Average Load Tons	Pass.	358	375	400	425	450	450
	Goods	1350	1400	1450	1500	1550	1600
3. Engine Miles Average.	Pass.	322	350	375	390	400	450
	Goods	176	200	225	250	275	300
4. Daily Train Miles	Pass.	1102	1614	2027	2552	3226	3879
	Goods	980	1098	1500	2053	2814	3858
5. No.of Trains Daily one way	Pass.	7.5	11	13.9	17.5	22.1	22.0
	Goods	5.6	8	10.3	14.1	-	26.4
6. Engines Rqd.	Pass.	3.4	4.6	5.4	6.5	8.0	8.6
	Goods	6.7	5.5	6.4	8.2	10.0	10.2
	Total:	10.1	10.1	12.0	14.0	18.0	18
Diesel							
1. Average Load	Pass.	358	375	400	425	450	500
	Goods	1227	1250	1275	1300	1350	1400
2. Av.Engine Miles	Pass.	309	325	350	370	358	400
	Goods	125	150	165	180	190	200
3. Daily Train Miles	Pass .	1460	1614	2027	2552	3226	3879
	Goods	1168	1230	1706	2369	3232	4409
4. Engines Reqd	Pass.	4.7	5.0	5.8	6.9	8.4	9.7
	Goods	9.3	8.2	10.3	13.2	17.0	22.0
	Total:	14.0	13.2	16.1	20.1	25.3	25.0

31. It will be seen from the above table that the number of trains will increase from 38 (both ways) in the first year to 80 in the 20th year and to about 100 in 25th year. The capacity of single line can be expected at the most at 80 trains per day (both ways). Thus, the capacity of the line under consideration would be used up by 20th year. For increase in traffic in subsequent year, either additional capacity would have to be created or load factors would have to be increased considerably. By that time, there will be 22 passenger trains and 19 goods trains daily. The frequency of passenger trains which would be about one train an hour, would be most reasonable. This frequency would not need expansion, However, in view of large amount of traffic it should be possible to increase the load factors. Therefore it is assumed that during the last five years all increase in traffic will be absorbed by higher load factors. Increase in traffic thereafter has not been taken into account as that would require additional investment.

Cost of Locomotives

32. The per unit cost of electric/diesel engine indicated by P.W.R. is as follows:-

TABLE 12

Cost of Electric/Diesel Engines

(Million Rupees)

Type of engine	F.E	Local	Total
Electric Engine ...	4.0	1.2	5.2
Diesel Engine 3000 HP. ...	5.0	1.5	6.5

33. The price of diesel engine is based on the latest quotation of General Motors of USA at which last orders were placed. The local currency component covers duties, taxes, etc. Therefore, for working out economic costs, local currency component will be excluded.

34. On the basis of number of Electric/Diesel Locomotives required and prices indicated above, the cost on account of locomotives would be as below:

TABLE 13

Cost of Electric/Diesel Locomotives

(Million Rupees)

	1st year	6th year	11th year	10th year
Electric Locomotives :				
Financial Cost	52.0	10.4	15.6	15.6
Economic	40.0	8.0	12.0	12.0
Diesel Locomotives :				
Financial	84.5	19.5	26.0	32.5
Economic	65.0	15.0	20.0	25.0

Maintenance Costs (Locomotives)

35. The P.W.R. have indicated per mile maintenance cost of diesel and electric engines at Rs. 1.138 and Rs. 0.523 respectively. The maintenance cost for Diesel engines is higher than the average for various Divisions as shown below:-

TABLE 14

Average Maintenance Cost of Diesel Engines (Per Mile)

	Rs.
Lahore Division	0.78
Multan Division	1.20
Sukkur Division	0.90
Karachi Division	1.02
Rawalpindi Division	2.28
Quetta Division	0.50
All Divisions (Un-weighted Average)	0.79

36. The above figures relate to the year 1970-71. Since then wages and prices of materials have increased manifold. Therefore, the maintenance cost of Rs.1.138 indicated by PWR seems to be reasonable.

37. At the above rates, the maintenance cost of electric and diesel locomotives will be as below:

TABLE 15

Maintenance Cost of Electric and Diesel Locomotives

		1st year	6th year	11th year	16th year	21st year
Electric Locomotives:						
Train/Engines ('000'Miles)	Pass.	589	740	932	1117	1180
	Goods	400	548	749	1027	1126
Cost @ Rs.0.523 '000'Rs.	Pass.	308	387	487	616	617
	Goods	209	287	392	537	589
	Total:	517	674	874	1153	1206
Diesel/Locomotives:						
Train/Engine Miles' 000'	Pass.	589	740	932	1177	1180
	Goods	449	623	864	1179	1609
Cost @ 1.138 '000' Rs.	Pass.	670	242	1061	1339	1343
	Goods	511	709	984	1342	1831
	Total:	1181	1551	2045	2681	3174

Maintenance of Capital Works

38. The cost of maintenance of capital works for electric traction has been estimated by PWR at Rs. 52,000 per annum. The same figure has been used for economic and financial costs. It is also assumed that this figure will remain constant over the life of the project.

Fuel Consumption

39. The rates of fuel consumption used by PWR in their project proposal slightly differ from the rates indicated by operating Statistics for 1970-71, as shown in the table below:

Table 16

Rates of Fuel Consumption

	Passenger	Goods
1. Lahore Division	19.0	13.3
2. Multan Division	21.2	12.7
3. Sukkur Division	20.4	16.8
4. Karachi Division	20.3	10.0
5. Rawalpindi Division	22.9	16.3
6. Quetta Division	28.8	32.4
7. All Division	19.6	12.3
8. Proposed by PWR	20.5	10.3

Source: Operating Statistics for 1970-71.

40. We have used round figures of average fuel consumption as below:

Passenger Traffic .. .. .. 20 Lbs.per 1000 GTM

Goods Traffic .. .. .. 12 Lbs.per 1000 GTM

Fuel Prices

41. The prices of petroleum products have increased manifold during the last few years. The present retail price of high speed diesel oil is Rs. 5.50 per gallon. Its composition-is complicated by subsidies and taxes as shown below.

TABLE 17

Price Composition of HSD

Imports Price	Rs. 10.76 00 per ton or Rs. 3.856 per gallon	
Subsidies to Refineries.. ..	Rs. 0.956	"
Ex-Refinery Price	Rs. 3.00	"
Duty	Rs. 1.35	"
Distribution Cost	Rs. 0.13	"
Freight	Rs. 0.38	"
Dealers Commission	Rs. 0.10	"
Development Surcharge	Rs. 0.54	"
Net Retail Price:	5.50	

42. For commercial analysis the retail price of Rs.5.50 per gallon at which purchases are made by the Railways would be applicable. For economic analysis the cost of fuel is to be taken net of taxes and subsidies. Import duty, development surcharge and dealers commission would be excluded. With regard to freight, it may be added that cost on this account was fixed at Rs. 0.38 long time before. The freight charges have since increased and are being subsidized out of development surcharge. Approximately, Rs. 18 crore are being paid as freight subsidies on all POL products. This amounts to Rs. 0.13 per gallon making the average freight cost equal to Rs. o.51 per gallon. This average includes expenses incurred for distant places and for transport by road. The overall average would not be applicable. Actual freight rates chargeable by Railways for HSD and Motor Spirit are shown below:

Distance	Freight Rate(Rs. per Maund)	
	H.S.D.	Motor Spirit
100 miles	1.43	2.38
300 miles	2.86	4.76
500 miles	3.89	6.48
600 miles	4.92	8.19

The distance from Karachi to Khanewal being 550 miles, a rate of 4.92 per maund would be applicable for the project analysis. This amounts to Rs. 0.506 per gallon. With regard to distribution charges, it may be added that these would not be applicable for the Railways as such but the cost of storage would be relevant. Assuming one months supplies is stock and 10% interest on capital thus blocked, the cost of storage would amount to Rs. 0.037 per gallon. Accordingly, the economic cost of HSD would amount to Rs. 4.50 per gallon as below:

Import price	Rs. 3.956
Freight Costs	Rs. 0.506
Storage Costs	Rs. 0.037
Total:	Rs. 4.499 or Rs. 4.50

Fuel Costs:

43. The financial and economic costs of fuel worked out on the basis of above prices are as below:

TABLE 18

Financial and Economic Cost of Fuel

	1st year	6th year	11th year	16th year	21st year
Fuel Consumption 000 lbs.					
Passenger Traffic	4,420	5.920	7,920	10,600	14,160
Goods Traffic	6,732	9.528	13,488	19,104	27,036
Total(000 ibs)	11,152	15,448	21,408	29,704	41,196
(000 Gallons)	1, 354	1,876	2,600	3,607	5,002
(Tons)	4,979	6,896	9,557	13,261	18,391
Cost (Mill Rs.)					
@ Rs. 5,50 p.g.	7,315	10,318	14,300	19,838	27,513
@ 4.50 p.g.	6.093	8.442	11.700	16.235	22.509

Energy Consumption

44. The energy consumption data is not given in the operating statistics. The P.W.R. proposal gives average energy consumption at the rate of 24 units (KWH) per 1000 GTM. The same rate has been used.

Energy Price

45. The cost of energy has been taken by P.W.R. at the rate of Rs. 0.10 per unit in the project proposal. In their other proposals, they have used a price of Rs. 065 per unit stating that before implementation of the project for electrification of Lahore-Khanewal Section, it was decided that the price to be charged by WAPDA to PWR for traction purposes would be Rs. 0.07 per unit upto 31st December 1970 and Rs. 0.065 per unit thereafter. The old costs do not hold in the present set of prices. The Railways are however,still insisting for a rate of 6.5 paisa per unit agreed to before Electrification of Lahore-Khanewal Section. Negotiations are at present going on between WAPDA and Pakistan Railways regarding the electricity rates. The work is being done to determine the cost of supplying electricity by WAPDA to Railways. Moreover, the rates have also been revised recently.

46. The Electricity tariff at Annexture II shows old and revised rates charged by WAPDA to different consumers. There is perfect monopoly price discrimination. The present rates vary from 37 paisa per unit for commercial users to 7.2 paisa per unit for Tube-Wells in Punjab and Sind and 3 paisa per unit for Tube-wells in NWFP and Baluchistan. The comparable rates for bulk supply to licencees having their own distribution system are 11.6 paisa per unit and to other consumers e.g. Railways, MES and PAF are 11.0 Paisa per unit plus Rs. 17.00 per KW/month. The effective rate for the

Railways would be 12 paisa per unit. These rates are applicable from 1st July 1974. Prior to this the applicable rates for the Railways were 10 paisa per unit plus Rs. 15.40 per KW/month.

47. The determination of economic cost of electric supply to Railways would require break down of WAPDA's cost for generation, transmission, distribution and revenue collection for different types of users etc. There are problems of joint cost/over-heads the allocation of which to different users is theoretically indeterminate. However, rough approximations can be made for practical purposes. There is a general thinking that WAPDA's electricity tariffs are highly subsidized. This might be true. But it is also possible that high costs are due to higher costs of distribution and revenue collection which are not involved in bulk supplies.

48. The cost of Electric Energy varies with the method of generation and plant size. As an example, the cost of generation in U.K. is shown below:-

Cost of Generation in U.K.(*)
Whole system costs

Coal	10.7	£/KW P.A.
Oil	10.1	$/KW P.A
Nuclear	9.1	£/KW P.A

Nuclear Generating Stations:

Berkeley..	1.23	d/KWH
Hinkley' A(Size well.. ..	1.03	d/KWH
'A'	0.70	d/KWH
Wylfa Dungeness	0.65	d/KWH
'B'	0.52	d/KWH
Hinkley 'B'	0.48	d/KWH

*Berrie, TW "The Economics of System Planning in Bulk Electricity supply" 1967 in Public Enterprised : Survey.

The inter country differences should not be much as the technology and international prices of input material are similar.

Moreover, the hydroelectric generation which is the major source of WAPDA's energy is the cheapest of all methods. Therefore, WAPDA generation costs should not be more than a few paisa per unit. Therefore, unless the break down of costs, for generation and transmission for different users are analysed, it cannot be said with certainty that the bulk supplies for Railways are also subsidized. Even if it is admitted that bulk supplies are subsidized the extent of subsidy cannot be determined.

49. In the circumstances, it is better to avoid any distortion or personal bias due to incomplete information. Accordingly, the cost of electric energy has also been taken at the published tariff of Rs. 0.12 per unit both for financial and economic analysis. 100% increase in the cost of Electric Energy would bring Diesel and Electric traction at par. Small variations in the cost of Electric Energy would not affect relative position of electrification.

Energy Costs

TABLE 19

Financial and Economic Cost of Electric Energy

	Unit	1st year	6th year	11th year	16th year	21st year
Traffic (Pass: & Goods)	Million GTM	782	1090	1520	2122	2961
Energy consumption 000 units @ 24 KHW/1000 GTM		18.768	26.160	36.480	28	71.064
Cost @ Rs.0.12 per unit (Million Rs.)		2.251	3.139	4.378	6.111	8.527

Savings in Wagons

50. By electrification, there will be savings in the number of wagons which would otherwise be required for transportation of fuel. For commercial analysis, cost or savings on this account are not to be taken into account as these are implicity covered in the price of fuel. The Railways would have less traffic in POL and will require less capital and earn less freight. However, for economic analysis, the savings in number of wagons is a net gain as the same amount of goods and services would be produced by relatively less capital stock. These savings have been valued at the rate of interest on capital saved for having less number of wagons as below:

TABLE 20

Value of Savings in No. of Wagons for the Transportation of Fuel.

	1974-75	1979-80	1984-85	1989-90	1994-95
1. Fuel consumption tons	4,979	6,896	9,557	13,261	18,391
2. Ton Miles with lead 550 miles	2,738	3,793	5,256	7,294	10,115
3. Wagon-days saved @ 440 ton miles per wagon per day.	6,846	9,482	13,140	18,235	25,288
4. No. of wagon saved per year	18.8	26.0	36.0	50.0	69.3
5. Cost of wagons @ Rs. 75,000 per wagon (thousand Rs.)	1,406	1,950	2,700	3,750	5,198
6. Value Savings @ 10% per annum (000 Rs.)	140	195	270	375	520

Travel Time Savings

51. The improvement in speed and performance would result in some savings in travel time for passengers and less time for goods in transit. The travel time is differently valued by different persons depending up whether it is working time or liesure time or whether the time saved can be used productively or not. The value of time also depends upon the amount of time saved as well as its relation to overall time required. A 30 minutes saving may be signification for a journey of an hour and a half but not for a journey of 30 to 36 hours. For the Khanewal Samasatta Section, a saving of 15 - 30 minutes could be expected at the most. This may not be significant for the through traffic but would be important for traffic of 200 to 300 miles lead. Although the time savings of individual sections of the line may not be important if taken separately, but may become significant if taken together. Thus the samall savings of Khanewal-Samasatta Section will become important in continuation with Lahore-Khanewal Section.

52. The value of time can be estimated in two ways, viz.: at the wage rate or by the amount which an individual would be willing to pay in order to travel by a faster mode. In the absence of any such information about the choice of the travelling public, the savings in travel time have been valued at the rate of Rs.1.00 per hour. This implies an average income of a rail traveller between Rs. 250 and Rs.300 per month. This is about the minimum wage in the public, private, commercial and industrial employments.

53. On the basis of above assumptions, the value of time saved has been estimated as in the table below:-

TABLE 21

Value of Travel Time Saved

	1st year	6th year	11th year	16th year	21st year
1. No.of Trains	11	14	18	22	22
2. No.of Passengers per train	350	375	400	425	500
3. Value of time saved at the rate of 15 minutes per journey and Rs.1/- per hour (000 Rs.)	703	958	1314	1706	2007

Transit Time Savings

54. The savings in transit time for goods traffic can be valued at the appropriate rate of interest on capital in transit for the time saved. Such savings can only be realised if the amount of time saved is significant and if reduction in transit time does not lead to increase in waiting time elsewhere. In view of time involved in the transit of goods by rail, it is doubtful if savings of 30 minutes or an hour would be of any significance importance. Nevertheless, in order to account for improvement in service, the value of transit time saved has been estimated in the table below for academic interest.

TABLE 22

Value of Savings in Time for Goods in Transport

	1st year	6th year	11th year	16th year	21st year
1. No. of Trains	8	10	14	19	20
2. Average Train load (Tons)	600	625	650	700	750
3. Value of Goods in Transit @ Rs.2000 per ton (Million Rs.)	7.008	9.125	13.286	19.418	21.900
4. Value of Time saved @ 30 Minutes per ton (000 Rs.)	40	52	75	111	125

Terminal Values

55. The costs/savings of the Project have been estimated for a period 25 years for the reasons that:

(a) estimates for distant periods are uncertain.

(b) The traffic growth beyond stipulated period would call for additional facilities the inclusion of which would complicate the analysis.

(c) The discounted values for distant periods become insignificant and have little effect on project viability.

Therefore, the terminal values of assets lasting longer have been accounted for as negative costs as in the table below

TABLE 23

Terminal Values of Durable Assets

Type of Asset	Ba.Life	No.of Unit.	Terminal Values	
			Financial	Economic
1. Diesel Locomotives ...	5/25	3	3.900	3.00
	10/25	4	10.400	8.00
	15/25	5	19.500	15.00
	Total:		33.800	26.00
2. Electric Locomotives	10/35	10	14.857	11.428
	15/35	2	4.457	3.428
	20/35	3	8.914	6.857
	25/35	3	11.142	8.571
			39.320	30.284
3. Capital Works(Electrification)	25/50	-	43.475	30.468
			82.795	60.752

56. The above estimates have been prepared on the basis of straight line depreciation and assuming the life of assests as:

Diesel Locomotives	25 years
Electric Locomotives	35 years
Capital Works	50 years

The economic life of Diesel and Electric Locomotives have been indicated at 20 and 35 years respectively. However, the age distribution of existing diesel fleet indicates that one third of the fleet is over 20 years of age. Therefore, the age of Diesel Electric Locomotives has been taken at 25 years. This also facilitates analysis by avoiding replacement costs near the end of project life. The life of Electric Locomotive has been assumed at 35 years as indicated by the Railways.

Discount Rate

57. The two most widely used methods for comparing the future streams of costs and benefits are the Net Present Worth and Rate of Return. For both the methods, the choice of an appropriate discount rate is essential either for discounting the future costs/benefits to their Net Present Worth or for determining the cut off point of Rate of Return.

58. The appropriate discount rate depends upon the cost of capital which is determined by the interest rate at which capital can be obtained in the market and service charges etc. However, the determination of appropriate discount rate for public enterprises not dependent upon capital market and drawing their resources out of public funds is complicated by a number of factors including variations over different types of loans, short term fluctuations, requirements of foreign exchange, floating exchange rates, inflationary tendencies and the world monetary crisis. For commercial analysis, the rate at which a loan is actually obtained may be used. But for economic analysis a Social Discount Rate is recommended by Economists. The opinions however differ as to what should be the Social Discount Rate and how it should be determined. One school of thought is of the view that social discount rate should be lower than the Bank Rate particularly for projects having long gestation periods. Their arguments are based on the reasons that society's view of future is short sighted. Others suggest a discount factor higher than the Bank Rate

when capital is not freely available. Their arguments are based on opportunity cost or scarcity value of capital.

59. The various interest rates prevailing at the moment are shown below:-

1. Bank Rate	9.0%
2. Call Money Rate	11.0%
3. 'A' Class Bank Advance Rate	12.0%

60. The Railways might be able to get loan/credit from international lending Agencies at lower rates. But this would be a privilege. The use of A class Bank Advance Rate of 12 per cent would be more relevent for equality of treatment in competition with other industries/sectors. Alder has also suggested a 12 per cent rate of discount for the evaluation of projects in the Transport sector for countries like Pakistan*. Accordingly, this rate may be used for determining the Net Present Worth of relative costs of two alternatives and as a cut off mark for Marginal Rate of Return.

61. In addition, it may also be noted that the use of a uniform discount rate for public sector enterprises is also essential for allocative efficiency. It is therefore better to use the discount rate suggested in the Manual for the Appraisal of Transport Projects for uniformity of treatment and allocative efficiency.

Comparative of costs of Diesel and Electric Traction

62. The foregoing costs of diesel and electric traction in financial and economic terms have been added over the life of the project of 25 years and discounted to their net present value at 12 per cent per annum. The computations are contained in Tables 24 to 31 that follow.

*Planning Division, A Manual of Economic Appraisal of Transport Projects, June, 1969.

Main Features

63. The main features of foregoing results are given below:-

TABLE 24

Financisl Cost of Operation-Diesel Traction

Year	Capital	Locomotives	Locomotives Maintenance	Fuel	Total
1.	2.	3.	4.	5.	6.
0	-	84,500	-	-	84,500
1	-	-	1,181	7,315	8,496
2	-	-	1,247	7,834	9,081
3	-	-	1,317	8,390	9,707
4	-	-	1,990	8,986	10,376
5	-	-	1,468	9,624	11,092
6	-	19,500	1,551	10,418	31,396
7	-	-	1,639	10,014	12,653
8	-	-	1,732	11,760	13,492
9	-	-	1,830	12,555	14,385
10	-	-	1,334	13,398	15,332
11	-	26,000	2,045	14,300	43,345
12	-	-	2,158	15,266	17,424
13	-	-	2,278	16,297	18,575
14	-	-	2,408	17,398	19,806
15	-	-	2,538	18,672	21,210
16	-	32,500	2,681	19,838	55,019
17	-	-	2,773	21,117	23,890
18	-	-	2,868	22,606	25,474
19	-	-	2,967	24,132	27,099
20	-	-	3,069	25,761	28,830
21	-	-	3,174	27,513	30,687
22	-	-	3,284	29,370	32,654
23	-	-	3,397	31,392	34,749
24	-	-	3,514	33,468	36,982
25	-	-	3,635	35,728	63,363
Total:		162,500	58,078	454,012	674,590
Terminal Value		(33,800)	-	-	(33,800)
Discounted at 12%		107,147	13,979	98,836	219,962
Less Terminal Value			1,994		
Net costs		107,147	11,985	98,836	217,968

TABLE 25

Financial Cost of Operation of Electric Traction

Year	Capital Cost	Locomotive.	Loco. Maint.	Capital Maint.	Electricity	Total	N.P.V.
0	86,950	52,000	-	-	-	138,950	138,950
1			517	420	2251	3,288	2,989
2			545	520	2405	3,470	2,866
3			575	520	2570	3,665	2,792
4			606	520	2746	3,872	2,644
5			640	520	2934	4,094	2,542
6		10,400	674	520	3139	14,733	8,309
7			710	520	3345	4,584	2,352
8			747	520	3384	4,851	2,265
9			787	520	3830	5,137	2,178
10			829	520	4093	5,443	2,101
11		15,600	874	520	4378	21,772	7,480
12			924	520	4678	6,112	1,953
13			976	520	5000	6,496	1,884
14			1032	520	5342	6,894	1,813
15			1090	520	5708	7,318	1,749
16		15,600	1153	520	6111	23,384	5,098
17			1163	520	6530	8,213	1,626
18			1174	520	6979	8,673	1,561
19			1184	520	7459	9,163	1,503
20			1195	520	7971	9,686	1,443
21			1206	520	8527	10,253	1,384
22			1217	520	9106	10,843	1,333
23			1228	520	9726	11,474	1,285
24			1239	520	10387	12,146	1,239
25			1250	520	11094	12,864	1,183
Total :	86,950	93,600	23,535	13,000	139,902	356,987	63,532
Terminal Value:	39,320	43,475	-	-	-	82,795	7,617
Discount at 12%	86,950	64,292	5,923	4,079	30,324	191,568	-
Less NPV of Terminal Value.	-	-	-	-	-	-	4885
Net Present Value	-	-	-	-	-	-	186,683

TABLE 26

Economic Cost of Operation Diesel

Year	Capital	Loco	Loco. Maint.	Fuel	Total
0		65,000	-	-	-
1			1181	6093	7,274
2			1247	6504	7,751
3			1317	6943	8,260
4			1390	7412	8,802
5			1468	7912	9,380
6		15,000	1551	8442	9,993
7			1639	9017	10,656
8			1732	9625	11,357
9			1830	10274	12,104
10			1934	10968	12,902
11		20,000	2045	11700	13,745
12			2158	12499	14,657
13			2278	13343	15,621
14			2408	14243	16,651
15			2538	15204	17,742
16		25,000	2681	16232	18,913
17			2773	17327	20,100
18			2868	18496	21,364
19			2967	19745	22,712
20			3069	21078	24,147
21			3174	22509	25,683
22			3284	24019	27,303
23			3397	25640	29,037
24			3514	27371	30,885
25			3635	29219	32,854
	Total	65,000	58078	371,815	429,893
					(26,000)
Descount at 12%		82,420	13,979	81,157	177,556
Less NPV of TerminalValue		1,534	-	-	-
Net Present Value		80,886	13,979	81,157	176,022

Table 27

Economic Cost of Operation - Electric Tractions

Year	Capital Cost	Locomotives	Loco. Maint.	Capital Maint.	Electricity	Wagon Savings	Transit Time Savings	Transit Time Savings	Net Cost	Present Value
1	2	3	4	5	6	7	8	9	10	11
0	60,936	40,000								100,936
1	-	-	517	520	2,251	141	703	40	2,404	2,185
2	-	-	545	520	2,405	150	748	42	2,530	2,090
3	-	-	575	520	2,570	160	795	44	2,666	2,002
4	-	-	606	520	2,746	171	847	46	2,808	1,918
5	-	-	640	520	2,934	183	900	49	2,962	1,839
6	-	8,000	674	520	3,139	195	958	52	11,128	6,276
7	-	-	710	520	3,354	208	1,020	56	3,200	1,693
8	-	-	747	520	3,584	223	1,086	60	3,482	1,626
9	-	-	787	520	3,830	238	1,156	64	3,679	1,560
10	-	-	829	520	4,093	254	1,231	69	3,888	1,501
11	-	12,000	874	520	4,378	270	1,314	75	16,113	5,640
12	-	-	924	520	4,678	288	1,384	81	4,369	1,394
13	-	-	976	520	5,000	308	1,460	87	4,641	1,346
14	-	-	1,032	520	5,342	329	1,538	95	4,932	1,297
15	-	-	1,090	520	5,708	351	1,621	102	5,244	1,253
16	-	12,000	1,153	520	6,111	375	1,706	111	17,592	3,835
17	-	-	1,163	520	6,530	400	1,672	113	5,938	1,175
18	-	-	1,174	520	6,976	427	1,821	116	6,309	1,136
19	-	-	1,184	520	7,459	456	1,881	119	6,707	1,100
20	-	-	1,195	520	7,971	487	1,943	122	7,134	1,063
21	-	-	1,206	520	8,527	520	2,007	125	7,601	10,026
22	-	-	1,217	520	9,106	555	2,074	128	8,086	995
23	-	-	1,228	520	9,726	593	2,142	131	8,608	964
24	-	-	1,239	520	10,387	633	2,213	134	9,166	935
25	-	-	1,250	520	11,094	676	2,287	137	9,764	989
NPV	60,936	51,328	7,082	4,720	37,005	2,285	10,489	611	147,686	147,686
Terminal Value	2,786	2,786	-	-	-	-	-	-	5,589	-
Net Cost	58,133	48,542	7,082	4,720	37,005	2,285	10,489	611	142,097	142,097
Total:	60,936	72,000	23,535	13,000	139,902	8,591	36,597	2,198	261,987	
Terminal Value	(30,284)	(30,488)							(60,752)	
Discounted at 12%	60,936	49,456	5,923	4,079	30,324	1,876	8,707	503	139,632	- 3,584 - 136,048

TABLE 28

Comparative Costs of Operation for Diesel and Electric Traction Discounted at 12% p.a.

Financial Analysis	Gross Values		Discounted Value		
	Diesel	Electric	Diesel	Electric	Difference
1.	2.	3.	4.	5.	6.
Capital Works	-	86,950	-	86,950	+ 86,950
Locomotives	162,500	93,600	107,147	64,292	- 42,855
Locomotives Mainterance	58,078	23,532	13,979	5,923	- 8,056
Capital Maintenance	-	13,000	-	4,079	+ 4,079
Fuel/Energy	454,012	139,902	98,836	30,324	- 68,512
Total:	674,590	356,987	220,065	191,568	- 28,497
Less Terminal Value	33,800	82,795	2,094	4,885	- 2,790
Net Cost	640,790	374,192	217,968	186,683	- 31,285
Economic Analysis					
Capital Works	-	60,936	-	60,936	+ 60,936
Locomotives	1,25,000	72,000	82,420	49,456	- 32,964
Locomotives Maintenance	58,078	23,535	13,979	5,923	- 8,056
Capital Maintenance	-	13,000	-	4,079	+ 4,079
Fuel/Energy	371,815	139,902	81,157	30,324	- 58,689
Total	429,893	309,373	177,556	150,718	- 26,838
Less Terminal Value	26,000	60,752	1,534	3,584	- 2,050
Net Cost	403,893	248,621	176,022	147,134	- 28,888
Savings in Wagons	-	8,591	-	1,876	- 1,876
Savings in Travel Time	-	36,597	-	8,707	- 8,707
Savings in Transite Time	-	2,198	-	503	- 503
Total Net Costs	403,893	201,235	176,022	136,048	39,974

Table 29

Rates of Return in Financial and Economic Terms

Year	Overall Operating Costs			
	Financial		Economic	
	Diesel	Electric	Diesel	Electric
0	84.500	138.950	65.000	100.936
1	8.496	3.288	7.274	2.404
2	9.081	3.470	7.751	2.530
3	9.707	3.665	8.260	2.666
4	10.375	3.872	8.872	2.808
5	11.092	4.094	9.380	2.962
6	31.369	14.733	24.993	11.128
7	12.653	4.584	10.654	3.300
8	13.492	4.851	11.357	3.482
9	14.358	5.137	12.104	3.679
10	15.332	5.442	12.902	3.888
11	42.345	21.372	33.745	16.113
12	17.424	6.122	14.657	4.369
13	18.575	6.496	15.621	4.641
14	19.806	6.894	16.651	4.932
15	21.210	7.318	17.742	5.244
16	55.019	23.384	43.913	17.592
17	23.890	8.213	20.100	5.938
18	25.474	8.673	21.364	6.303
19	27.099	9.163	22.712	6.707
20	28.830	9.686	24.147	7.134
21	30.687	10.253	25.683	7.601
22	32.654	10.843	27.303	8.086
23	34.749	11.474	29.037	8.608
24	36.982	12.146	30.885	9.166
25	39.363	12.864	32.854	9.764
25 TV	33.800	82.795	26.000	60.752
N.P.V.				
at 16%	181.569	178.668	-	-
17%	174.477	175.644	-	-
21%	-	-	121.931	121.170
22%	-	-	118.560	119.893
I.R.R.		16.7		21.5

TABLE 30

Foreign Exchange Costs Diesel Electric Traction

Year	Diesel			Electric		
	Locomotives	Fuel	Total	Capt. Work	Locomotive	Total
1.	2.	3.	4.	5.	6.	7.
0 ...	65.000	-	65.000	-	40.000	91.000
1 ...		5.356	5.356	-	-	-
2 ...		5.717	5.717	-	-	-
3 ...		6.103	6.103	-	51.000	-
4 ...		6.515	6.515	-	-	-
5 ...		6.955	6.955	-	-	-
6 ...	15.000	7.425	22.475	-	8.000	8.000
7 ...		7.926	7.926	-	-	-
8 ...		8.461	8.461	-	-	-
9 ...		9.032	9.032	-	-	-
10 ...		9.642	9.642	-	-	-
11 ...	20.000	10.292	30.292	-	12.000	12.000
12 ...		10.987	10.987	-	-	-
13 ...		11.729	11.729	-	-	-
14 ...		12.520	12.520	-	-	-
15 ...		13.365	13.365	-	-	-
16 ...	25.000	14.268	32.298	-	12.000	12.000
17 ...		15.231	15.231	-	-	-
18 ...		16.259	16.259	-	-	-
19 ...		17.356	17.356	-	-	-
20 ...		18.528	18.528	-	-	-
21 ...		19.778	19.778	-	-	-
22 ...		21.114	21.114	-	-	-
23 ...		22.539	22.539	-	-	-
24 ...		24.060	24.060	-	-	-
25 ...		25.684	25.684	-	-	-
	125.000	326.842	451.842	51.000	72.000	123.000
Discounted value at 12 % p.a.	82.420	71.053	153.473	51.000	49.456	100.456

TABLE 31

Relative Costs of Diesel and Electric Traction in Case of No. Increase in Traffic.

Financial Analysis			Discounted Value 8%	10%	12%
Diesel Traction					
Locomotives	Base year	84,500	84,500	84,500	84,500
Locomotive Maint	Annual	1,181	12,605	10,721	9,266
Fuel	Annual	7,315	78,080	66,406	57,393
			175,185	161,627	151,159
Electric Traction					
Capital Works	Base year	80,950	80,950	86,950	86,950
Locomotives	Base year	52,000	52,000	52,000	52,000
Locomotive Maint	Annual	517	5,518	4,693	4,056
Capital Maint	Annual	520	5,550	4,720	4,080
Electricity	Annual	2,251	24,027	20,425	17,661
	Total		174,045	168,788	164,747
Less Terminal Value	End Year	82,795	12,088	7,617	4,885
Net Costs			161,957	161,171	159,862
Economic Analysis					
Diesel Traction			12%	14%	16%
Locomotives	Base year	65,000	65,000	65,000	65,000
Locomotives	Annual	1,187	9,266	8,116	6,733
Fuel	Annual	6,093	47,805	41,876	37,119
Total			122,071	114,992	108,852
Electric Traction					
Capital Works	Base year	60,936	60,936	60,936	60,936
Locomotives	Base year	40,000	40,000	40,000	40,000
Locomotive Maint	Annual	517	4,056	3,553	2,947
Capital Maint	Annual	530	4,080	3,574	2,964
Electricity	Annual	2,251	17,661	15,470	12,833
Total			126,773	123,533	119,680
Less Terminal Value	End Year	60,752	3,584	2,308	1,458
Other Savings		884	6,935	6,076	5,040
			116,214	115,149	113,155

(i) Table 24-27. The operating costs of electric traction are lower than diesel traction in both financial and economic terms as shown below:-

Overall Operating Costs

(Million Rs.)

	Diesel	Electric	Difference
Financial costs ...	270.908	186.683	84.285
Economic costs ...	170.022	130.080	39.942

(ii) Table 28. - The savings in Operating costs of Electric Traction over the project life would exceed the extra costs of Capital Works by Rs. 31.185 and Rs. 39.974 in financial and economic terms respectively, as shown below:-

Additional Cost and Savings of Electric Traction 12% Discount Rate.

(Million Rs.)

	Financial	Economic
(a)Capital Works and Maint ...	91.029	65.015
(b)Savings on Operating Costs ...	122.214	104.989
(c)Net Savings (a-c) ...	31.185	39.974

(iii) Table 29.- The overall financial operating costs of diesel and electric traction would be at par at 16.7 per cent discount rate whereas the economic costs would be at par 21.5 per cent discount rate. These are the Internal Rates of Return at which the additional cost of Electric Traction would equal savings. At lower discount rates, the Electric Traction would cost less and at higher discount rates, diesel traction would costs less.

(vi) Table 30. - The Foreign Exchange component of Capital and Operating Costs of Diesel and Electric Traction discounted at 12 per cent p.a. over the life of the Project are:-

	(Rs.in Million)
Diesel Traction	153.475
Electric Traction	100.458
Difference	53.017

Thus the Electric Traction would result in savings of Rs. 53.017 million in Foreign Exchange.

(v) Table 31. - In case of no increase in traffic over the base year, the overall financial operating costs of Diesel and Electric Traction would be at par with at the following discount rates:-

Rates of Return

	Financial costs	Economic costs
Excluding Time Savings	8%	11%
Including Time Savings	10%	14%

That is, the additional capital costs of Electric Traction would be paid off at the above rates even if there is no increase in traffic.

Sensitivity Analysis

64. A simple manipulation of Tables 26 to 29 would indicate that the following variations in costs/prices or a combination of these will bring the costs of the two alternatives to the point of indifference:-

	Financial	Economic
1. Increase in cost of Capital Works for Electrification.	36%	47%
2. Increase in the cost of Electricity	100%	97%
3. Decrease on the cost of Fuel	32%	64%

65. It would appear from the above that the Project is sensitive to increase in the cost of capital works and decrease in the fuel prices. The chances of decrease in fuel prices are less. However, the cost of capital works is uncertain in the present trend of increasing prices. The Project would be justified if the cost of capital works do not increase or increased by less than 36 per cent in financial terms or 47 per cent in economic terms.

Conclusion

66. In the present set of costs and prices, the electrification of Khanewal Samasatta Section would result in net savings of Rs. 31.185 million in financial terms and 39.974 million in economic terms. The Project is, however, sensitive to increase in the cost of capital works. 36 per cent increase on this account would obviate the savings of electrification. However, in view of the fact that electric locomotives are already available, and the savings in foreign exchange are even more significant, the risk of some increase in costs is worth taking.

Annexure I

REVISED SCHEDULE OF ELECTRICITY TARIFF(EFFECTIVE 1ST JULY,1974)

1. DOMESTIC TARIFF A-I

(For A.C. General Supply)

For supply to residences, hospitals and dispensaries places of workshop and approved religious, educational and charitable institutions, etc.

Consumption during the month	Existing Tariff	New Tariff
(i)First 20 units	25.0 paisa per unit	No Change
(ii)21 to 250 units	16.0 paisa per unit	No
(iii)For the balance	15.0 per unit	
Minimum charges per month/point supply	Rs. 2-00	No Change

II. COMMERCIAL TARIFF A-2

(For A.C. General Supply)

For supply to all Government and Semi-Government Offices and Institutions, Commercial offices and Commercial Establishment such as shops, hotels restaurants and places of entertainment like cinemas theaters, and clubs, etc.

Consumption during the month	Existing Tariff	New Tariff
(i)First 100 units	30.0 paisa per unit	33.0 ps.p.unit
(ii)For the balance	33.5 paisa per unit	37.0 ps.p.unit
Minimum charges per month per point of supply.	Rs.2.50	Rs. 3.00

III. INDUSTRIAL SUPPLY TARIFFS

(a) Table B-1

(For single phase 230 Volts A.C. or three phase 400 Volts A.C. Ind:Supply)

Connected load	Existing Tariff	New Tariff
Upto & including 70 KW Minimum charges	20.5 Paisa	22.6 paisa
(i)For connected bads upto & including 20 KW	Rs.4.20 per KW	Rs. 4.62
(ii)For connected load exceeding 20KW & upto and including 70 KW	Rs.6.00 per KW	Rs.6.60

(b) TARIFF B-2

(For three phase 400 Volts A.C.Industrial Supply)

Connected load	Existing Traiff	New Tariff
Above 70 KW and upto & including 500 KW	Rs.19.80 per KW per month of declared load + 1.5 Paisa per unit.	Rs.21.80 per KW month of declared load + 12.7 paisa per month.

(c) TARIEF B-3

(For Industrial Supply at 11 KV)

Declared load	Existing Traiff	New Tariff
All loads	Rs.18.00 per KW per month + 11.0 paisa per unit.	Rs.21.80 per KW per month + 12.1 paisa per unit.

(d) TARIEF B-4

(For Industrial Supply at 33 KV, 66 KV or 132 KV)

Declared load	Existing Traiff	New Tariff
All loads in excess of 5000-KW	Rs.16.80 per KW per month + 11.0 paisa per unit.	Rs.18.50 P. KW per month + 11.0 paisa per units.

IV. BULK SUPPLY TARIFFS FOR

(i) Licences (Lincensed under part II of the Electricity Act. 1910 to supply energy within their area of supply) and Non-Licences(Permitted under part II of the Electricity Act, 1910 to supply energy within their area of supply).

(ii) Other consumers e.g., Railways, MES; PAF, Cantonment Boards & other Government and Semi-Government and approved institution having their own distribution facilities within their respective jurisdiction.

(a) TARIFF C-1

(For Buld supply 400 Volts A.C.)

Particulars	Existing Tariff	New Tariff
(i) For Licences & Non-Licences	13.0 paisa per unit	14.3 paisa per unit
(ii)For other consumers e.g. Railways, MES.	Rs.18.20 per KW per month + 11.0 paisa per unit.	Rs.20.pp per KW month + 12.1 paisa per unit.

(b) TARIFF C-2

(For Buld supply at 11 KV)

Particulars	Existing Tariff	New Tariff
(i) For Licences & Non-Licences	11.0 paisa per unit	12 paisa p. unit
(ii)For other consumers e.g., Railways, MES, PAF etc.	Rs.16.50 per KW per month + 10.5 paisa per unit.	month + 11.6 paisa per unit.

(c) TARIFF C-3

(For Bulk supply at 33 KW, 66 KV & 132 KV)

Particulars	Existing Tariff	New Tariff
(i) For Licences & Non-Licences	10.5 paisa per unit	11.6 paisa per unit
(ii)For other consumers e.g., Railways, MES, PAF etc.	Rs.15.40 per KW per month per unit.	Rs.17.00 per KW month + 11.0 paisa per unit.

V. TUBEWELLS TARIFF D-I

(For supply to agricultura T/wells & lift irrigation pumps)

Particulars	Existing Tariff	New Tariff
1. For Reclamation & Drainage scheme T/Wells (Under Salinity Control and Reclaming Project).	10.0 paisa per unit	11.6 paisa per unit
2. For bona fide agricultural T/ Wells & lift irrigation pumps for the irrigation & Agricultural land.	Rs. 5.00 per KW	Rs. 5.50 per KW
(i)For all T/Wells lift irrigation pumps except NWFP and Quetta Grid area.	month + 6.5 paisa per unit.	month + 7.2 paisa per unit.
(ii)For T/Wells, & lift irrigation pumps,in NWFP & Grid area.	Rs. 4.00 per KW per month + 2.5 paisa per unit.	Rs. 4.50 per KW/ month + 3.0 paisa per unit.

VI. TEMPORARY SUPPLY TARIFF

(a) TARIFF E-I

(For Domestic and commercial supply consumers)

Particulars	Existing Tariff	New Tariff
Domestic	38.0 paisa per unit	38.0 paisa per unit
Commercial	45.5 paisa per unit	50.0 paisa per unit
Minimum bill	Rs. 5.00 per day but not less than 20.00 for the period of temporary supply.	Rs. 5.00 per day but not less than Rs. 22/- for the period of temporary supply.

(b) TARIFF E-2

(For Industrial & bulk supply consumers)

Particulars	Existing Tariff	New Tariff
1. Temporary Industrial supply	27.5 paisa per unit.	30.3 paisa per unit
2. For supply to Licences & Non-Licences:		
(a) 400 Volts	17.0 paisa per unit	19.0 paisa per unit
(b) 11 KV	15.5 paisa per unit.	17.0 paisa per unit.
(c) For Bulk supply to other consumers e.g.	24.0 paisa per unit.	26.5 paisa per unit.

VII. SEASONAL INDUSTRIAL SUPPLY TARIFF

TARIFF - F

Existing Tariff	New Tariff
125% of the charges for a corresponding supply to a regular industry, except that the fixed charges per KW per month shall be recovered on the basis of the declared load for the period seasonal industry actually runs, subject to a minimum per of six consecutive months during any twelves consecutive months.	No change

VIII. PUBLIC LIGHTING TARIFF

TARIFF - G

Particulars	Existing Tariff	New Tariff
1. Supply charges for the Electric Energy consumed.	23.0 paisa per unit.	26.6 paisa per unit.
2. Fixed line charges per month per mile:		
(i) Where the entire capital cost in laying S/Lighting Supply line which is exclusively meant for S/Lighting is borne by the Authority.	Rs. 44.00	Rs. 48.40
(ii) Where the entire capital cost in laying S/Lighting Supply line which is exclusively meant for S/Lighting is borne by the Local body.	Rs. 3.90	Rs. 4.30
(iii) Where the capital cost in laying S/Lighting supply live over the existing distribution system is borne by the authority.	Rs. 27.50	Rs. 30.25
(iv) Where the capital cost in laying S/Lighting supply live over the existing distribution system is borne by the local body	Rs. 5.50	Rs. 6.10
(v) For S/Lighting supply through U/G cables.	Rates to be negotiated	Rates to be negotiated.
3. Fix lamps & fixture charges per lamp of capacity:		
(i) Ordinary lamps provided installed by the authority:		
(a) Upto & including 60 watts.	0.87	Rs. 1.00
(b) Above 60 watts upto including 100 watts	1.06	Rs. 1.20
(c) Above 100-200 watts	2.37	Rs. 2.60
(d) Above 200-300 watts	3.00	Rs. 3.30
(e) Above 300 watts.	-	-

(ii) Flourescent tubes provided by local body but installed by the Authority For all Wattages.	Rs. 2. 00	Rs. 2.20
(iii) Special Mercurry Vapour Lamp provided by local body but installed by the authority. For all Wattages	Rs. 3.00	Rs. 3.30

IX. TARIFF FOR SUPPLY TO RESIDENTIAL COLONIES ATTACHED TO THE PREMISES OF INDUSTRIAL SUPPLY CONSUMERS HAVING THEIR OWN DISTRIBUTION FACILITIES WITH THEIR COLONIES.

TARIFF - H

Particulars	Existing Tariff	New Tariff
1. For consumer who provide their own transf: receiving and controlling the supply.	20.5 paisa per unit	No change.
2. For consumer who do not provide their own Transf: receiving and controlling the supply.	21.0 paisa per unit.	No change.