

Study of
Relative Economics
of
Diesel & Electric Traction
on
Indian Railways



मह्यमत्र जपने

GOVT. OF INDIA
MINISTRY OF RAILWAYS

June, 1978

GOVERNMENT OF INDIA (BHARAT SARKAR)
MINISTRY OF RAILWAYS (RAIL MANTRALAYA)
(RAILWAY BOARD)

No.77/RE/138/6

New Delhi, dated 23 -2-1979.

1. The General Managers,
All Indian Railways.
2. The Director General,
R.D.S.O., Lucknow.
3. The Principal,
Railway Staff College,
Baroda.
4. The General Manager,
M.T.P., Calcutta.
5. C.A.O. (R),
M.T.P., Bombay.
6. C.P.O.,
M.T.P., Delhi.

Re: Study of Relative Economics of
Diesel & Electric Traction on
Indian Railways (June'78).

The Railway Board appointed a Committee in December, 1977 to study the relative economics of Diesel & Electric Traction. The Committee submitted its Report titled "Study of Relative Economics of Diesel & Electric Traction on Indian Railways in June 1978 (Raj Committee Report)". The report was examined by the concerned Directorates of the Railway Board.

2. On receipt of the comments of the Directorates the Board constituted a High Level Committee to go into the details of the Report and the comments received from the Directorates. After carefully examining the Raj Committee Report and the Reports of the High Level Committee, the Board have taken the following decision:-

- "(i) The original Report made by Shri J.A. Raj on the relative economics is accepted in principle. As the relative economics comparison between Diesel and Electric Traction will continue to vary from time to time, it would be necessary to examine each and every proposal for electrification on its own merit. The following broad

contd..../

principles have to be followed:-

- (a) The break-even level for taking up sections for electrification could vary between 30.00 and 35.00 million GTKM per route km. per annum.
 - (b) It should be on a route basis, for example, our next step should be to concentrate on the route from Bombay to Delhi, with Delhi-Mathura, and Vadodara-Ratlam already included for electrification. The Board felt that the high density main trunk routes between the four metropolitan cities of Delhi, Calcutta, Bombay and Madras and the routes from Delhi to Madras and Bombay to Calcutta would have to be eventually electrified depending on the availability of resources.
 - (c) While preparing electrification schemes, it should be our objective to eliminate steam for the smaller services, suitably replacing them by Diesel Shunters (WDS6) or wiring the lines as required. It is accepted that over a long period, which would be required to provide electric traction (being capital intensive), both Diesel and Electric Traction have to be developed and can be sustained.
- (ii) On the subject of Colour Light Signalling being included in electrification project estimates, the Committee's Report that the cost of electrification for purpose of comparison with dieselisation, should not include the cost of Colour Light Signalling, is accepted. However, Colour Light Signalling should form part and parcel of electrification, in as much as electrification projects are being taken up on high density routes and there is no question of not providing Colour Light Signalling.

contd.../

-: 3 :-

(iii) In the Corporate Plan for the development of Railways, both Electric & Diesel Locomotives have to be provided for in ample measure, duly phasing out steam traction in a gradual manner."

3. Copies of Raj Committee Report are available with CE/RE, Northern Railway, Allahabad, who is being instructed to distribute the necessary number of copies as available to the Zonal Railways.

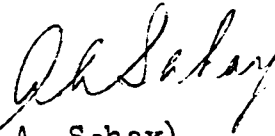
4. Railway Electrification proposals may be prepared keeping in view the details worked out by the Raj Committee Report and the decision of the Board thereon.



(A.A. Sahay)
Joint Director, Rly. Electrification(E),
Railway Board.

No.77/RE/138/6 New Delhi, dated 23-2-1979.

Copy to CE/RE, Northern Railway, Allahabad.
He may arrange to distribute copies of Raj Committee Report to the Railways.



(A.A. Sahay)
Joint Director, Rly. Electrification(E),
Railway Board.

Copy for information to:-

PS/CRB, FC, ME, MM, MT, Adv. Finance, Adv. Elec.
DRP, DEB, DEE, DST, EA, DF(B), DIT,
DS&C & DME.

FOREWORD

Economic haulage of trains has been under constant study on the Indian Railways for a very considerable period. With the introduction of diesel and electric traction in 1950s, the subject gained more importance and caught the attention of traction Engineers of different disciplines to go deeper into the problems.

The quest led to a "Study of electrification and dieselisation on Indian Railways" in 1963 commonly known as the Sahai Committee Report. Subsequently in 1970 the National Council of Applied Economic Research conducted a similar study.

The oil crisis in 1973 aggravated the situation and the need for a fresh study on the relative economics of diesel and electric traction attracted attention. The present study is a sequel to this keenly felt necessity.

This Committee was constituted with men with specialised talents, drawn from the Indian Railways and Planning Commission. The Committee held 12 sittings between January and June, 1978. The discussions during these meetings were very meaningful and the exchange of knowledge and ideas was of a high order. The Convener is thankful to all the Members of the Committee for the unstinted co-operation extended to him in completing the report in such a short time.

The detailed back-up calculations are in a separate supplement to this Report.

The active assistance given by Mr. A.A. Sahay in framing this report is gratefully acknowledged.

New Delhi
17-6-1978

J.A.Raj
CONVENER

ACKNOWLEDGEMENT

Assistance, suggestions and cooperation given, in collecting data and working out details, by the various Directorates of the Railway Board and the Research, Designs & Standards Organisation of the Railways, Planning Commission, Central, Western, Northern, Eastern & South Eastern Railways, Diesel Locomotive Works and Chittaranjan Locomotive Works, is gratefully acknowledged.

The Committee also thank Officers and Staff of the Railway Electrification, Northern Railway, Allahabad, who have spent considerable time and energy in collecting field data, in working out various calculations and for willingly lending their experience of executing an electrification project.

The work done by the Sahai Committee and the NCAER has been a great help to the Committee.

C O N T E N T S

				Pages.
CHAPTER	-	I	Introduction	... 1 - 9
CHAPTER	-	II	Scope & Methodology of Study	... 10 - 25
CHAPTER	-	III	Study of Selected Section: Delhi - Jhansi and Mathura - Gangapur City	... 26 - 34
CHAPTER	-	IV	Conclusions and Recommendations	... 35 - 46

Contd.....

C O N T E N T S

ANNEXURES:

		Pages
1.	Director's Committee Report - Electrification Programme in the Sixth Five Year Plan (1979-84) ...	47 - 63 47 - 63
2.	Extract of Para 19 of Minutes of Meeting held between Rly. Board & Planning Commission on 5.12.77 ...	64
3.	Cost of Electrification ...	65 - 71
4.	Views of Kunzroo & Wanchoo Accident Enquiry Committees on provision of colour light signalling ...	72 & 73
5.	Requirement of Electric Locomotives vis-a-vis Diesel Locomotives ...	74 - 78
6.	Fuel & Energy consumption norms and their costs ...	79 - 87
7.	Cost of Repair & Maintenance of Diesel & Electric Locomotives ...	88 - 92
8.	Energy Policy of Govt. of India and extract of Chapter 10 'Energy' from Draft Five Year Plan 1978-83 ...	93 - 96
9.	Traffic Projection on Delhi-Jhansi & Mathura-Gangapur City sections ...	97 - 100

GRAPHS:

G-1	Freight traffic hauled under different modes of Traction (B.G.) ...	101
G-2	Passenger traffic hauled under different modes of Traction (B.G.) ...	102
G-3	Availability of Crude Oil ...	103
G-4	Market price of Persian Gulf oil ...	104
G-5	Consumption of Petroleum Products ...	105
G-6	Consumption pattern of H.S.D. Oil ...	106
G-7	Trends of specific fuel/energy consumption of total traffic hauled on Indian Railways ...	107

MAPS:

Map - 1	Railway Map of India showing Electrification ...	108
Map - 2	Route Map of Delhi-Jhansi & Mathura- Gangapur City Sections ...	109
	Abbreviations ...	110
	References ...	111

CHAPTER - I

INTRODUCTION

- 1.1 Background - In ^{the} past due to increasing traffic - both passenger and goods - Indian Railways have had to carry more and more traffic on their network. Steam engines which hauled almost the entire traffic in 1950-51 were found unequal to the task of hauling heavier trains at faster speeds. Accordingly, Indian Railways decided to progressively switch over to diesel or electric traction and to finally abandon manufacture of steam engines altogether from 1971, and to retire the steam engines already running on their system at the end of their economic lives, replacing them by diesel and electric locomotives. Diesel and AC traction started almost at the same time in 1959-60 on Indian Railways. A Diesel Locomotive Works was set up at Varanasi, which today has a capacity to manufacture 120 Broad Gauge and 30 Metre Gauge locomotives per annum. The Chittaranjan Locomotive Works which had commenced with manufacture of steam engines in 1951, have changed over to manufacture of electric locomotives and diesel shunters and have a capacity of manufacture of 66 Broad Gauge Electric locomotives and 50 Diesel Shunters. In 1977, diesel traction carried 56% goods and 25% passenger traffic, while electric traction hauled 26% goods and 22% passenger traffic, the rest being on steam traction. The changing share of workload amongst

steam, diesel and electric motive powers on Broad Gauge since 1959-60 for freight and passenger traffic is shown at Graphs G-1 and G-2. 4553 route kilometres (15%) out of 30,873 route kilometres on Broad Gauge over Eastern, South Eastern, Northern, Central and Western Railways are electrified and work of electrification is in progress over 948 route kilometres on South Eastern, South Central and Southern Railways (see Map-1). The growth of A.C. electrification from its inception is given in the table below:

TABLE - 1.1:

<u>Progress of Electrification</u>					
Plan period	Year	Route km electrified.	Total actual expenditure (Crores of Rs.)	Route km electrified per annum (Average)	Average expenditure per annum (Crores of Rs.)
Second	1956-61	216	52.89	Work commenced in 1958	21.293
Third	1961-66	1755	80.71	351	16.14
Annual	1966-69	905	36.14	302	12.05
Fourth	1969-74	956	70.04	191	14.00
Fifth	1974-78	531	78	133	19.5

Works in progress

<u>Section</u>	<u>Likely to be completed in</u>
i) Vijayawada - Madras	1979-80
ii) Madras - Trivellore	1979-80
iii) Waltair - Kirandul	1980-81

1.2 Choice between Diesel and Electric Traction

1.2.1 The diesel traction needs comparatively lower capital cost, has flexibility in operation and can be introduced at short notice on new sections. Sections with heavy fluctuations in traffic can be best served by it. However, repairs, maintenance and fuel cost per unit of traffic are higher in diesel traction as compared to the electric traction. Thus, while fixed cost is higher in the case of electric traction, variable cost is higher in diesel traction and, therefore, electric traction becomes economical only above a certain level of traffic termed as 'Break Even Level'. The indirect advantage of electric traction is compulsory improvement in the communication system which results in greater efficiency in operation. In addition, provision of colour light signals which can be introduced on electrified routes at only a slightly additional expenditure, reliable power supply having been ensured from the overhead equipment, results in greater safety.

1.2.2 Selection of Routes for Electrification - Although a number of high density trunk routes may merit electrification, their priorities are fixed on the following guidelines:

- (1) High density trunk routes carrying both Goods and passenger traffic, with an attempt to cover terminal electrification, eliminating multiplicity in modes of traction.
- (2) Other high density routes carrying coal or iron ore but not on trunk routes.

- (3) Routes contiguous to already electrified territory and required to be electrified for continuity to avoid change of traction for short distances, resulting in savings in working expenses.

1.3 Proposals for Railway Electrification according to Corporate Plan of Indian Railways.

The Corporate Plan of Indian Railways has envisaged approximately 4800 route kilometres to be electrified in the 15 years (1974-89) on routes which would have traffic densities of above 12 to 13 million nett tonne kilometres (NTKM) per annum per route kilometre (33.6 to 36.4 million gross tonne kilometres per route kilometre based on the ratio of GTKM to NTKM of Indian Railways in 1976-77). These routes have been indicated in Map-1.

Priorities and phasing of electrification schemes were considered by a Directors' Committee of the Railway Board Annexure-1. For period 1979-84, they recommended an energisation of 1980 route kilometres and suggested commencement of work on about 1000 route kilometres to be completed in the following Plan. The Draft Plan 1978-83 provides for Rs.120 crores for electrification in a total outlay of Rs.3350 crores for the Railways.

1.4 Sahai Committee.

- 1.4.1 In 1963, a Committee with Shri P. Sahai as Convener, was set up to assist the Railway Board in formulating the traction policy. The Committee made a systematic study of the relative costs of electric and diesel

modes of traction and submitted its report the same year¹. The report was based on imported cost of both diesel and electric locomotives and the other relevant costs existing then.

- 1.4.2 The train services provided in the study were based on Amsler Train Schedule computer studies made by the Research Designs and Standards Organisation, Indian Railways, Lucknow, and were simulated for comparable services for haulage by WDM-2 Diesel Electric Locomotives for all traffic, WAM-1 Electric Locomotives for Passenger services and WAG-1 Electric Locomotives for Goods services. These locomotives had just then been imported and adequate statistical data on their operation, repairs and maintenance had not yet been built up. The approach to costs was mainly financial.
- 1.4.3 On the basis of comparative financial cost, the Shah Committee established a break-even level between diesel and electric traction of 6 to 7 million gross tonne kilometres (trailing) i.e. excluding weight of engine or approximately 10% higher, if weight of engine is included) per route kilometre per annum on level and 1:100 graded sections. On heavily graded sections (1:60) like Waltair-Kirandul, the corresponding break-even level was found to be only 1.91 million trailing tonne kilometres per route kilometre per annum. Excluding the duty on diesel oil, the break-even level was estimated between 20 to 30 million trailing tonne kilometres per route kilometre per annum.

¹ Study of Electrification and Dieselisation on Indian Railways, Government of India, 1963.

- 1.5 NCAER Report 1970 - The next methodical study was carried out by the National Council of Applied Economic Research in August 1968-69². This study based on statistical data collected from the Railways attempted both financial and economic costs. According to this study, for the three sections examined, the financial and economic break-even level based on prices of 1968-69, were found as below:

TABLE 1.2

Break-even level of traffic density between Diesel & Electric traction (Million GTKM* per route kilometre per annum).

	<u>At Financial cost</u>	<u>At Economic cost</u>	<u>Maximum</u>	<u>Minimum</u>
1. Durgapur-Mughalsarai	18	93	63	
2. Ratlam-Vadodra	13	58	42	
3. Durg-Ehusaval	17	87	68	

Based on economic cost consideration, no section could have been justified for electrification.

² Economics of Diesel and Electric Traction, NCAER August, 1970.

* Includes weight of engine. All further exercises have been done including the weight of engine.

1.6 The wide disparity between the break-even levels of financial and economic cost was mainly due to high taxes on fuel oil. While the cost of fuel oil with taxes was around Rs.800/- per kilo litre, the cost without taxes was found to be less than Rs.300/- per kilo litre. The break-even level on the financial cost basis as compared to Sahai Committee rose almost three times mainly due to general increase in cost of electrification, inclusion of cost of Railways' tele-communication cables as a part of electrification and difference in assumption regarding train weights. While the Sahai Committee assumed the weight of trains as 2680 tonnes, the NCAER based its calculations on actual weights of trains running on electrified route between Durgapur and Mughalsarai. The average weight of trains was worked out to be only 1855 tonnes.

1.7 Present day situation & formation of the Committee -

The oil crisis of 1973-74 highlighted the monopoly situation of the oil producing countries in the world market. The prices of crude and its distillates have been continuing to rise. On the other hand, the cost of electrification in the wake of general price rise has also risen sharply in the period 1972-74. It was considered necessary to review the situation afresh (see Annexure 2) and, therefore, the Railway Board in consultation with the Planning Commission vide their letter No.77/PL/9/2 dated 28.12.77 constituted a Committee to go into the

question of relative economics of electrification
vis-a-vis dieselisation as below:

1.7.1 Composition

Railways

- | | |
|---|-----------|
| 1. J.A. Raj
Chief Engineer
Railway Elect-
rification,
Northern Railway,
Allahabad. | Convener |
| 2. Mahesh Kapoor
Joint Director
Corporate Planning
Railway Board,
New Delhi. | Member |
| 3. Pratap Narayan
Joint Director
Planning-I,
Railway Board,
New Delhi. | Member |
| 4. Murali Pande
Joint Director
Mech.Engg.(Fuel)
Railway Board,
New Delhi. | Member |
| 5. K. B. Verma
Deputy Director
Stat.Cost Analysis
Railway Board,
New Delhi. | Member |
| 6. A. A. Sahay
Joint Director
Rly.Electrification
(Electrical)
Railway Board,
New Delhi. | Secretary |

Planning Commission

- | | |
|---|--------|
| 1. Dr.M.Q.Dalvi
U.N.D.P.
Adviser. | Member |
| 2. Dr.P.C.Sah
Consultant
Project Appraisal
Division. | Member |

1.7.2 Terms of Reference

- 1) Collection of field data for updating the past studies on remunerativeness of electrification schemes, picking out representative sections.
- ii) Furnish guidelines for principles involved in selection of routes.
- iii) Make recommendations based on the latest field data, on the priorities which should be adopted for electrification commenting on the recommendations of the Directors' Committee Report recently approved by the Board.

SCOPE AND METHODOLOGY OF STUDY

2.1 Scope of study

The Committee, following the terms of reference have divided the study in three parts:

- i) Updating the norms and cost.
- ii) Estimate the break-even levels afresh.
- iii) Suggest future plan for electrification in context of the energy policy, operational and organisational considerations.

One representative section has been selected to compare the relative costs of hauling the projected level of traffic through the two alternative modes of traction. Although results of this study made on one section cannot be directly applied to other sections, the results arrived at could assist selection of likely sections for electrification, which can then be surveyed and the projects examined with greater accuracy.

2.2 Method of study

In this study, both financial and economic costs have been worked out. While financial cost is important from the point of view of Railways as they are a separate Undertaking, a decision on electrification should be taken from national angle and from that aspect economic costs are important. In the study, the comparative cost

of hauling the projected traffic as well as the internal rate of return for additional investment required for electrification have been worked out. In calculating the comparative costs as well as internal rate of return, DCF technique has been adopted. The assumptions made regarding norms, social wage rate, shadow exchange rate, scarcity value of oil and pricing for different inputs are spelt out in detail in subsequent paras. As the conclusions in the study are based on comparative costs, such costs which are common to both modes of traction have been excluded. While a 10% discount factor has been used for financial costs, a 12% discount factor has been used for economic costs to arrive at the break-even levels.

2.3 Choice of Section

- 2.3.1 Map 1 indicates the heaviest density, routes proposed for electrification in the Railways Corporate Plan. Most of the non-electrified heavy density routes lie in Central India. These routes are either on level or are lightly graded 1 in 150 or 1 in 200 only with some short stretches of 1 in 100.
- 2.3.2 With the limited time at the disposal of the Committee, it was essential to choose a section for which details of work and costs were available, which lay on a trunk route having a heavy density and with an assured growth of traffic, and which could be accurately projected for DCF calculations. Also the route so selected should have light grades. In view of its characteristics, the Delhi-Jhansi Section has been selected for study by the Committee.

The cost-cum-feasibility survey of this section was available in the Ministry of Railways and the section is on the main trunk route to South and West. It also connects north with Central India Coal-fields via Bina and has a high proportion of mail and express trains. The Committee also observed that the Western Railway stream of traffic merges at Mathura and to ascertain the benefit of running the entire traffic under electric traction, decided to examine the simultaneous electrification of Mathura-Gangapur City section of the Western Railway also.*

- 2.3.3 Although for Delhi-Jhansi section, cost-cum-feasibility survey is completed and the Project report is available, Mathura-Gangapur City section is yet to be surveyed. However, as the section is almost level, and contiguous to Delhi-Agra and does not pass through heavily built up areas affecting the cost of modification to fixed structures, the Committee considered that a prorata cost per kilometre of Delhi-Jhansi electrification would be accurate enough for the study. The costs used in the study are the updated costs and not the original survey estimates.

* The necessity to electrify Mathura-Gangapur City simultaneously with Delhi-Jhansi was also expressed by the Directors's Committee.

2.4 Norms and Costs

The norms and costs which affect the relative economics of diesel and electric traction, are as under :

Capital Cost

Electric Traction

- 1) Fixed Installations (includes Traction Distribution, Signalling and Telecommunication).

- ii) Locomotive Shed
- iii) Locomotives

Diesel Traction

- 1) Locomotive Shed
- ii) Locomotives.

Operating Costs

- | | |
|---|---|
| 1) Energy consumption. | 1) Fuel consumption. |
| ii) Running & Maintenance costs of locomotives. | ii) Running & Maintenance costs of locomotives. |
| iii) Maintenance of fixed installations. | iii) Maintenance of locomotive sheds. |

2.5 Costs estimates for fixed installations for electrification

- 2.5.1 The cost of electrification varied between Rs.1.00 and Rs. 1.3 lakh per track kilometre in the initial schemes. Subsequently colour light signals, Railway's own communication cables in place of hiring P & T channels, and Substations were also included as part of the total work. The inflation partly due to oil crisis led to a further increase in the cost of electrification. Consequently, the latest works under progress are expected to cost about Rs.5 lakhs per track kilometre.

2.5.2 In view of the increasing cost of electrification, the Railway Board appointed a Working Group³ to examine and recommend areas where economies could be achieved. The report of the Working Group was received in 1976 and the Railway Board have accepted most of the recommendations made. The measures include aluminium catenary in place of copper, tramway equipment in yards and secondary lines, reduction in number of spare power transformers, use of solid state equipment in telecommunication equipment and use of unscreened signalling cables in certain locations. In addition, savings are also possible in establishment costs. These measures would reduce the present day costs from Rs.5.09 lakhs to Rs.4.30 lakhs per track kilometre.* In the study the latter costs with economies have been adopted (see annexure 3 for details).

2.5.3 Colour Light Signals (CLS)

Both Kunzru and Wanchoo Committees have recommended use of colour light signals on heavy density routes as a safety measure irrespective of the fact whether the route is electrified or

3. Report & Recommendations of the Working Group for Reduction of costs of Electrification, Ministry of Railways, September, 1976.

* British Railways have reported a saving of - 29% on their latest Weaver Jn to Glasgow Electrification due to economy measures adopted by them. Railway Engineer, November/December 1977.

dieselised. (see Annexure 4). Earlier electrification schemes did not include cost of colour light signals. If this situation is accepted, the cost of colour light signals should not be included as part of electrification. However, in the recent past, in view of the visibility of semaphore signals being affected by erection of electrification masts, colour light signals have been included as part of electrification schemes. The latest policy of the Railway Board, however, on the subject is not to include the colour light signalling as a compulsory item for electrification. In view of the fact that the policy with regard to provision of colour light signalling on safety considerations as part of electrification projects has been changing from time to time, the Committee have adopted two alternatives for this analysis :

- i) including cost of colour light signalling,
 - ii) excluding cost of colour light signalling,
- to arrive at the rate of return and break-even levels.

2.6 Locomotives

2.6.1 The costs of locomotives have been obtained from the locomotive production units. Cost of diesel power pack has been obtained from Kharagpur Workshops.

2.6.2 A ratio of 1.2 diesel electric locomotive to 1 electric locomotive for Goods, Mail & Express trains and 1:1 for stopping passenger services have been taken in the study. In arriving at the

above ratio, the Committee have taken into account the higher horsepower and the better usage of the electric locomotives (Annexure 5).

2.7 Operation & Maintenance

- 2.7.1 Fuel, lubricants and electric energy consumption norms have been averaged from the 3 years (74-77) actual data of consumption and performance of diesel and electric locomotives on the Northern, Central and Western Railways. In arriving at these norms, the consumption and performance of electric DC, diesel bankers and diesel hydraulic locomotives have not been taken into account (Annexure 6).
- 2.7.2 Norms for repairs & maintenance costs of locomotives have been based on actual expenditure in the year 1976-77. In regard to running repairs, these are based on the costs of Ratlam Shed (for diesels) and of Vadodra Shed (for electric). For periodic overhauls, the estimates are based on the expenditure of Kharagpur Workshop (for diesels) and Bhusaval (for electrics) (Annexure 7).
- 2.7.3 The norms for repairs and maintenance of fixed installations have been based on Central Railway's figures of 1976-77 for traction distribution. For signalling and telecommunication, the costs are based on the latest section electrified - Tundla-Delhi (in January, 1977).
- 2.8 Based on a study of Tundla-Ghaziabad section, after cabling but before energisation, saving in wagon - days due to improved telecommunication has been

taken into consideration, for the sections taken up for study on a prorata basis*. Saving in locomotive time is already considered in establishing the ratio of diesel to electric locomotives.

- 2.9 Since 1974, staff quarters are being constructed under Capital. Earlier these were charged to Development Fund. Credit for rent deducted and non-payment of house rent allowance has been taken for financial evaluation. In economic evaluation, this does not apply.

2.10 Economic Costs

The following basic approach has been adopted for estimating the economic cost of different important items:

- 2.10.1 Taxes and duties have been eliminated from capital and operating costs.
- 2.10.2 Shadow exchange rate - The Project Appraisal Division of the Planning Commission have roughly calculated a premium on foreign exchange at around 25%. This rate has been adopted in working out viability of Public Sector Projects. However, the situation has changed and an exercise in the Planning Commission is being carried out to ascertain the new rate. The Committee felt that a 15% premium will be very reasonable in the current situation which has been

* This comes to Rs.12.55 lakhs per annum for Delhi-Jhansi Section and Rs. 3.05 lakh per annum for Mathura-Gangapur City section for the year 1983-84.

adopted by the Committee. It may be emphasised that this change is not mainly due to improvement in the foreign exchange situation but due to change in the world prices versus Indian prices.

- 2.10.3 Shadow wage rate - The shadow wage rate of semi-skilled and unskilled labour has been taken as 60% of the market wage rate in view of large reserve of unemployed or under-employed in the country. This is again based on a study made by the Project Appraisal Division of the Planning Commission. For this exercise, all Class III and Class IV staff have been treated as semi-skilled or unskilled staff.
- 2.10.4 Imported commodities have been valued on the basis of their C.I.F prices after making adjustments for internal transport cost and handling charges.
- 2.10.5 Tradeable commodities, for which the country is a net importer, have been valued on the basis of their C.I.F. prices.
- 2.10.6 Electric and diesel locomotives and electricity have been valued on the basis of their real cost of production.
- 2.10.7 The capital cost of residential houses has not been included because housing has to be provided as a part of the social obligation.
- 2.10.8 High Speed Diesel Oil - The country would continue to import crude oil and in addition HSD oil, inspite of important oil strikes including Bombay High* (see Graph G3). Therefore, diesel oil

* This is also confirmed by Kumar Committee, constituted in 1977.

has been valued on the basis of its C.I.F. price which is currently Rs. 898 per kilo litre at official exchange rate. Shortage of crude oil in the whole world is likely to be felt in a couple of decades. The price of crude oil per barrel which increased from \$ 2.7 in 1973 to \$ 13.60 in December 1977 is expected to rise further (see Graph G-4). Amongst the various distillate of crude oil, the growth in demand of HSD oil is about the highest at 8% per annum (see Graphs G-5 & G-6). The imports in 1976 and in 1977 were 0.577 and 0.666 million tonnes of HSD oil in addition to an indigenous production of 6.21 and 6.989 million tonnes respectively⁴. These represent about 9.5% of country's demand of HSD oil^{*}. The present energy policy has emphasised the need for substituting oil wherever technically and economically feasible by other forms of energy. This has also found a place in the Draft Plan 1978-83 which indicates that use of oil products would have to be retained within the manageable limits and oil production policy would be weighted in favour of conservation of our limited resources (Annexure 8).

4. Annual Reports, Ministry of Petroleum.

* The Railways' consumption of HSD oil in 1976-77 was 0.702 million tonnes.

- 2.10.9 The Committee feel that in view of the expected world-wide shortage of oil, there should be a premium reflecting this scarcity, although an objective calculation for this purpose is difficult. The Committee have, however, felt that a 10% premium will be a reasonable assumption to reflect such a scarcity and one exercise has been carried out under economic analysis with this assumption. It may be mentioned that this scarcity value does not reflect the supply and demand position of oil in the country.
- 2.10.10 Copper - According to the demand and supply projections made by the Planning Commission, the country will continue to be a net importer of copper and hence copper has been valued on its expected C.I.F. price which is currently Rs. 11,870/- per tonne at official exchange rate, or Rs. 13,650.50 at shadow exchange rate. Adding the transport cost and handling charges, the value of copper is estimated at Rs.14,539.50 per tonne.
- 2.10.11 Zinc - Like copper, the total domestic demand of zinc is expected to be higher than its domestic production. Hence, zinc has also been valued on the basis of its C.I.F. price, which is currently Rs.5,420/- per tonne at official exchange rate, or Rs.6,233/- per tonne at shadow exchange rate. Adding the freight and handling charges, the value is taken at Rs.6,664/- per tonne.

2.10.12 Locomotives - The break-up of the cost of production of diesel and electric locos is given in the Table 2.1 below. The basis of calculation of economic cost is self evident.

TABLE 2.1

COST PER DIESEL LOCO	(Figures in lakhs of Rs.)				
	:Cost :without :duties :& taxes :but with :other :charges:	:Duty :and :tax- :es.	:Financi- :al :cost	:Economic Cost :Without :premium :on for- :eign :exchange :	:With :15% :premium :on for- :eign :exchange
Imported Parts (c.i.f. price)	6.22	2.85	9.07	6.22	7.03
Indigenous Parts	21.53	0.81	22.34	21.53	21.53
Labour	0.48	-	0.48	0.29	0.29
Overhead charges	7.41	-	7.41	7.41	7.41
Proforma charges	2.70	-	2.70	2.70	2.70
Total	38.34	3.66	42.00	38.15	38.96
COST PER ELECTRIC LOCO					
Imported Parts- (c.i.f. price)	3.68	1.58	5.26	3.68	4.15
Indigenous Parts	28.34	1.37	29.71	28.34	28.34
Labour charges	1.25	-	1.25	0.75	0.75
Overhead charges	5.91	-	5.91	5.91	5.91
Proforma charges	2.87	-	2.87	2.87	2.87
Total	42.05	2.95	45.00	41.55	42.02

2.10.13 There has been a chronic shortage of electric energy despite a significant increase in installed generating capacity from 2300 MW in 1950 to 24,000 MW in 1976-77. The Draft Plan 1978-83 has proposed 18,500 MW addition to the generating capacity in the country and envisages another 20,000 to 25,000 MW in the period 1983-88. The investment for power in 1978-83 plan is expected to be Rs.15,750/- crores against Rs. 7016 crores in the V Plan. With this investment, the country expects to overcome the chronic shortage of power by 1982-83*. The economic cost of production of electricity has been roughly estimated at 20 paise per KWH for the new power schemes by the Project Appraisal Division of the Planning Commission, which has been adopted though the Pooled Cost of Production of energy by Electricity Authorities is lower (Annexure 6).

2.11 Norms and Unit Costs of various inputs of diesel and electric traction, are given in Tables 2.2 & 2.3.

* Indian Railways consumed 1945 million KWH in 1976-77 against a total generation in the country of 89200 million units.

TABLE 2.2N O R M S

Sl. No.	Item	Unit	Rate	
			Diesel	Electric
1.	Estimated gross cost of fixed installations			
	a) With colour light signals.	Track Km.	-	Rs.4.30 lakhs
	b) Without colour light signals	"	-	Rs.4.12 lakhs
2.	Fuel/Energy Consumption			
	(a) Goods	Per 1000 GTKM	3.60 ltrs.	11.08 KWE
	(b) Mail & Express	"	4.77 "	19.81 "
	(c) Stopping Passenger	"	5.52 "	25.10 "
3.	Consumption of Lubricants		1.83% of H.S.D oil.	0.73 litres per 100 Engine Km.

.....

TABLE 2.3
UNIT COSTS

I T E M	Unit	FINANCIAL COST	ECONOMIC COST	
			Without premium on Foreign Exchange	With 15% premium on Foreign Exchange (Shadow Price)
(1)	(2)	Rs. (3)	Rs. (4)	Rs. (5)
1. Copper	Tonne	23,750.00	12,759.00	14,539.50
2. Zinc	Tonne	11,000.00	5,851.00	6,664.00
3. H.S.D.Oil@	Kilo	1,292.60*	968.00 *	1,102.70 *
	Litre	1,258.60**	950.90 **	1,085.60 **
4. Electricity	KWH	24 paise	20 Paise	20 Paise
5. Electric Locomotive (WAM 4)	Each	45 lakhs	41.55 Lakhs	42.02 Lakhs
6. Diesel Locomotive (WDM 2)	Each	42 Lakhs	38.15 Lakhs	38.96 Lakhs
7. Power Pack for Diesel Locomotive	Each	17.4 Lakhs	16.04 Lakhs	16.04 Lakhs
8. Diesel Loco Shed	One Loco	3.66 Lakhs	2.375 Lakhs	2.40 Lakhs
9. Running Repair of Diesel Locomotive	Engine Km.	1.417	1.313	1.313
10. Running Repair of Electric Locomotive	Engine Km	1.062	0.94	0.94
11. Periodic Overhaul (POH) Electric Locomotive.	One Loco	2.26 Lakhs	2.07 Lakhs	2.07 Lakhs
12. Periodic Overhaul (POH) of Diesel Locomotive.	One Loco	3.19 Lakhs	2.88 Lakhs	2.88 Lakhs

(1)	(2)	(3)	(4)	(5)
13. Lubricating Oil	Kilo	7,899.20 *	7,595.38 *	7,595.38 *
	Litre	7,863.33 **	7,560.89 **	7,560.89 **
14. Repair & Maintenance of fixed installations:				
(a) Traction distribution	TKM	3,540	2,336	2,336
(b) Signalling	RKM	2,092	1,381	1,381
(c) Telecommunication	RKM	3,856	2,545	2,545
(d) Civil & Electrical assets	%age of cost of works	3% for Civil & 5% for Electrical general works	3% for Civil & 5% for Electrical general works	3% for Civil & 5% for Electrical general works.

* Delhi - Jhansi Section

** Mathura-Gangapur City Section

@ For H.S.D. Oil :

Note - 1 Economic cost of transport of HSD: Rs.60 per K.Litre for Delhi-Jhansi Section
(Included in economic costs) Rs.42.90 per K.Litre for Mathura-Gangapur City
Section.

2 Economic cost of H.S.D. with 15% premium on Foreign Exchange and
additional 10% premium as scarcity value is Rs.1,192.50 for Delhi-Jhansi Section
Rs.1,175.40 for Mathura-Gangapur City
Section.

C H A P T E R - III

STUDY OF THE SELECTED SECTION: DELHI-JHANSI
AND MATHURA - GANGAPUR CITY.

- 3.1 Delhi-Jhansi section (414 Route Kilometres) forms part of main trunk route connecting North-South and North to West (Map-2). The sections being considered are entirely double track except a length of 39 km between Tughlakabad and Palwal which has three lines. Apart from the heavy foodgrains traffic that flows from North to South, there is substantial traffic of general goods flowing towards Delhi, both from Bombay and from other regions. A sizeable amount of P.O.L. traffic flows from Western Railway on Mathura-Delhi section. Against a density of 13.7 million GTKM in 1967-68 the densities have increased to 26.4 million GTKM in 1976-77 recording a growth of 10.3%^{per annu}. Apart from the freight traffic, the section has a very large number of important mail and express trains connecting metropolitan cities. The anticipated traffic on the section is likely to be influenced by the movement of coal from C.I.C., linked to the Power Stations of Northern India. There will, however, be a decline in the P.O.L. traffic from Western Railway with commissioning of Mathura Refinery. This drop in traffic has been taken in account while projecting the demand.
- 3.2 Traffic over the Section:
- 3.2.1 In the event of only Delhi-Jhansi section being electrified without electrifying Mathura-Gangapur City section, the Western Railway stream of traffic is assumed to flow under Diesel Traction on Delhi-Mathura section,

as change of traction after 153 kms at Mathura will not be operationally desirable. With electrification of Mathura-Gangapur City, the entire traffic on Mathura-Delhi would work under electric traction. The cost benefit analysis, therefore, has been separately done for electrification of:

a) Delhi-Jhansi

b) Delhi-Jhansi & Mathura-Gangapur City.

3.3 The details of the freight traffic sectionwise for both Up and Down direction are given in table below:

TABLE 3.1

Daily Goods Throughput in terms of 4 Wheelers as in 1976-77 (actual and projected in 1983-84).

Section	1976-77			1983-84			
		Loaded	Empty	Total	Loaded	Empty	Total
Agra-Jhansi							
	UP	414	219	633	530	380	910
	DN	733	18	751	1095	25	1120
Mathura-Agra							
	UP	359	215	574	550	400	950
	DN	649	15	664	990	160	1150
Tughlakabad-Mathura (CR)							
	UP	379	103	482	425	670	1095
	DN	586	27	613	1255	-	1255
Tughlakabad-Mathura (WR)							
	UP	368	360	728	425	300	725
	DN	640	21	661	690	60	750
Bayana-Gangapur City							
	UP	509	423	932	585	360	945
	DN	768	64	832	830	80	910
Mathura-Bayana							
	UP	368	360	728	425	300	725
	DN	640	21	661	690	30	720

Note:

- 1) Against a past rate of growth of 8.7% on the Agra-Jhansi section and 6.4% in the Mathura-Agra section, a growth of 4% of traffic other than coal & POL has been taken in the period 1976-77 to 1983-84.

- 2) 145 wagons of coal on the Jhansi-Delhi section linked from Central India Coal fields to Power Houses in Western India in the period upto 1983-84 has been taken.
- 3) With commissioning of Mathura Refinery a pipe line for the flow of light distillates in the Mathura-Delhi section has been assumed. 300 wagons of heavy distillates is assumed to move on the Mathura-Delhi section by rail. In the event of the pipe line not materialising the projected volume of traffic on Mathura-Tughalakabad section would increase further by about 300/250 wagons.
- 4) 125 wagons of POL is assumed to move on the Mathura-Agra section on commissioning of the Mathura Refinery.
- 5) A growth of 4% per annum in the Dn direction i.e. towards Delhi and 3% per annum in the Up direction has been assumed beyond 1983-84. No increase in coal and POL traffic has been included in the projections beyond 1983-84. Further details of traffic beyond 1983-84 are given in the Annexure 9.

3.4 Passenger traffic:

The growth of mail and express traffic on Indian Railways has been of the order of 7 to 8% per annum in the past. An annual growth rate of 4.7% has been assumed in the projections and the number of coaches required at this rate over the base year of 1977-78 in terms of coaches has been worked out. As important mail and express

trains are to run with 20/22 coaches, this composition is assumed commencing from 3 pairs of trains in 1983-84 to 8 pairs in 1993-94. No increase in stopping passenger services are assumed. Details of passenger traffic are also at Annexure 9.

3.5 The total number of trains, Up and Down, goods and coaching in different sections are as below:

TABLE 3.2

(Delhi-Jhansi traffic only)

	<u>1976-77</u> <u>(Actuals)</u>	<u>1983-84</u>	<u>1988-89</u>	<u>1993-94</u>
a) Jhansi-Agra Cantt.	46.3	56.6	66.1	72.3
b) Agra Cantt.- Mathura	53.9	67.8	76.6	82.2
c) Mathura- Tughlakabad	51.7	71.8	80.0	84.9

With electrification for Gangapur City-Mathura section the traffic on items (c) above increase and the number of trains are:

c) Mathura- Tughlakabad	84.0	105.6	115.2	125.3
d) Mathura- Bayana	32.3	33.3	38.9	43.2
e) Bayana- Gangapur City	38.11	39.8	46.6	52.3

With automatic colour light signals it would be possible to cater to traffic of 125 UP and DN trains expected in 1993-94 on Tughlakabad-Mathura section.

3.6 Gradients on the Section:

About 20% of the Delhi-Jhansi section is graded while Mathura-Gangapur City is generally flat except for a short stretch of 1 in 200. On the Delhi-Jhansi section, Delhi-Mathura is flat and ruling gradient on Mathura-Agra and Gwalior-Jhansi is 1 in 200 and on Agra-Gwalior 1 in 150.

3.7 Cost of Project:

Based on the norms and costs discussed in Chapter II, the gross cost of electrification works* including cost of CLS (including cost of a standard Locoshed for 100 locos) chargeable to capital, depreciation reserve funds and revenue is estimated as Rs.4366.20 lakhs. The net cost chargeable to capital only (excluding Loco Shed) both for financial and economic study has been estimated as below:

TABLE 3.3 (Cost in lakhs of rupees)

		<u>Without colour light signals</u>	<u>With colour light signals</u>
Delhi-Jhansi	Financial	3565.59	3729.29
	Economic [⊗]	2772.08	2917.70
Delhi-Jhansi	Financial	4800.93	5021.33
and			
Mathura-Gangapur City.	Economic [⊗]	3732.47	3913.83

* The cost of equipment for the 3rd line between Tughlakabad to Palwal has also been included in the cost of works.

⊗ Includes shadow price of 15% on Foreign Exchange.

The cost of locomotive sheds for both diesel and electric traction facilities being dependent upon the number of locomotives required, is estimated as below:

(Cost in lakhs of Rupees)

		<u>Diesel</u>	<u>Electric</u>
Delhi-Jhansi	Financial	333.06	264.88
Total Locomotives:	Economic@	218.40	211.47
Diesel	91		
Electric	77		
<hr/>			
Delhi-Jhansi	Financial	479.46	378.40
and			
Mathura-Gangapur	Economic@	314.40	302.10
City			
Total Locomotives:			
Diesel	131		
Electric	110		

(See also aAnnexure 3)

3.8 Return on D.C.F. Calculations on Financial and Economic Costs:

- 3.8.1 The results of the return on Electric traction over Diesel traction based on financial and economic study under both the cases of (a) electrification of Delhi-Jhansi section alone and (b) combined

@ Includes shadow price of 15% on Foreign Exchange.

project including Mathura-Gangapur City are as below. In the former case Western Railway traffic on Mathura-Delhi is assumed to flow under diesel traction.

TABLE 3.4

		<u>Internal rate of return in %</u>			
		<u>Finan- cial</u>	<u>Economic</u>		
			<u>Without premium on for- eign exchange</u>	<u>With 15% premium on foreign exchange</u>	<u>With addl. 10% scarcity value of HSD oil</u>
Delhi- Jhansi section	Incl.cost of CLS	9.90	10.18	12.40	13.82
	Excl.-do-	10.42	10.79	13.12	14.42
Delhi- Jhansi & Mathura- Gangapur City as combined project.	Incl.cost & of CLS	10.63	10.66	13.21	14.52
	Excl.-do-	11.14	11.38	13.80	15.01

- 3.8.2 The study assumes a growth of traffic of 2.7% on the base year 1983-84 upto 1993-94, after which period the traffic is assumed to be constant.
- 3.9 The results indicate that electrification of Mathura-Gangapur City as part of the project improves the rate of return by 0.7 to 0.8% for the total investment and GTKM per route km increases from 31.5 million to 32.37 million. In view of better financial and economic return and flexibility in operation, the Committee feel that Delhi-Jhansi and Mathura-Gangapur City sections should be taken as one project.

- 3.10 The break-even level between diesel and electric traction, based on the study of Delhi-Jhansi, Mathura-Gangapur City at 10% internal rate of return on D.C.F. calculations on financial cost and at 12%* on economic cost, is as below:

TABLE 3.5

Figures in million GTKM per route Km per annum.

Costs	Including cost of CLS.	Excluding cost of CLS
Financial at 10% I.R.R.	31.25	29.5
Economic at 12% I.R.R.		
(a) with 15% premium on Foreign Exchange	30.25	28.0
(b) with 15% premium on Foreign Exchange and additional 10% as scarcity value of diesel oil	27.00	24.75

- 3.11 The above exercise is based on the assumption that the economies in the cost of electrification mentioned in para 2.5.2 will be implemented. These have yet to be implemented in future projects. Although the Committee are not in doubt that these can be implemented, an exercise with the existing costs has also been done to ascertain the rate of return on D.C.F. calculations at the gross capital cost of Rs.5.09 lakhs per track

* For economic evaluation in Planning Commission, this is considered as the minimum value of I.R.R. for national investments.

kilometre against Rs.4.30 lakhs with economies. The results are:-

TABLE 3.6

Cost	Internal rate of return in %	
	Delhi-Jhansi	Delhi-Jhansi-Mathura-Gangapur City
I. Financial (a) with CLS	7.92	8.56
(b) Without CLS	8.31	8.96
II. Economic with 15% premium on Foreign Exchange		
With CLS	10.24	10.79
Without CLS	10.69	11.24
III. Economic with 15% premium on Foreign Exchange and addl.10% on scarcity value of HSD oil.		
(a) With CLS	11.28	11.94
(b) Without CLS	11.84	12.52

The corresponding break-even levels on Delhi-Jhansi and Mathura-Gangapur City are as below:

TABLE 3.7

Costs	Break-even level in million GTKM per route KM per annum	
	Including cost of CLS	Excluding cost of CLS
Financial at 10% I.R.R.	37.50	36.50
Economic at 12% I.R.R.		
(a) with 15% premium on Foreign Exchange only.	36.25	35.00
(b) With 15% premium on Foreign Exchange and 10% scarcity value of oil.	32.75	32.00

3.12 Based on the study of Delhi-Jhansi, Mathura-Gangapur City, the Committee find that the break-even level with various alternatives at the time of introduction of electric traction vary between 24.75 and 37.50 Gross million tonne kilometres per route kilometre per annum. It, however, narrows down when the scarcity value of oil is ignored and the cost of electrification assumes economies, when it falls within a range of 28 to 31.25 million.

C H A P T E R - I V

CONCLUSIONS AND RECOMMENDATIONS

- 4.1 Break-Even Level - The break-even levels established vary from 28.0 to 31.25 million GTKMs per route kilometre per annum. ~~While~~ The break-even level established above cannot be considered as the point at which electrification could be introduced on any section because different sections present peculiarities in the volume of work resulting in variations in the cost of work as well as in other inputs like cost of electric energy, fuel and nature of traffic etc. However, this break-even level could be used as a broad guidelines by the Indian Railways to identify routes which should be taken up for electrification. It is necessary to study the remunerativeness of a particular section and to use the above guidelines to carry out cost-cum-feasibility surveys around break-even levels of about 30 million GTKMs per annum (10-11 nett tonne kilometres per annum) in the projected year of energisation with a growth rate of 2.7% per annum for the next 10 years. The study also shows that when the traffic densities are about 50 million GTKMs per annum at the time of energisation, the economic return on the investment is as high as 20%.
- 4.2 High Density Sections - As the lead time from survey to energisation of a section takes about 5 to 7 years, it is necessary to have a long term perspective plan

for electrification. The Railways' Corporate Plan gives perspective for electrification on the Railways. The Corporate Plan envisages growth of freight traffic on the Indian Railways from 240 million tonnes to around 310 million tonnes in the period 1979-84 and to around 370 million tonnes in 1988-89. The Draft Plan issued by the Planning Commission envisages freight traffic on the Indian Railways to reach 310 million tonnes by 1983. The growth of traffic on the high density routes has been higher than the average rates of growth on Indian Railways. Taking this factor into account, the sections which are currently in the traffic density range between 25 and 30 gross million tonnes would be reaching densities well above the break-even levels in the next 5 years. Sections identified for electrification in the Corporate Plan (1974-89) detailing the present and projected levels of traffic are given in Table 4.1.

- 4.3 Recommendations of the Directors' Committee.- The Directors' Committee which was appointed to fix the priorities for electrification for the Plan 1979-84 noted that the existing works in progress of about 950 route kilometres would be energised in the period 1979-84 as throw-forward of the Fifth Plan. The Directors' Committee considered the traffic densities, contiguity with electrified routes, operational advantages and flexibility, dispersal of schemes and availability of teams, to arrive at a phased programme. They recommended commencement of work on about 2000 route kilometres in period 1979-84 of which it was anticipated that 1000 kilometres would be energised in the Plan itself while the other 1000 kilometres would be a throw-forward for energisation in the next Plan.

TABLE - 4.1

TRAFFIC FORECASTS OF SECTIONS PROPOSED FOR ELECTRIFICATION

Sl. No.	Section	Route Km.	Traffic Density in million GTKM per RKM per annum 1976-77.	Past growth rate per annum 1967-68 to 1976-77	Anticipated Traffic Density in million GTKM per RKM per annum in 1980-89 (as per Corporate Plan)	Projected rate of traffic growth per annum.
1.	Delhi-Jhansi & Mathura-Gangapur City	567	25.5	10.3%	42	6.2%
2.	Vadodra-Ratlam & Godra-Anand	340	31.7	7.8%	58.0	5.9%
3.	Sitarampur-Mughalsarai(*)	557	21.4	1.2 %	43.5	3.6%
4.	Bhusaval-Nagpur	395	24.6	7.2%	41.0	5.5%
5.	Jhansi-Bina	151	28.9	12%	42.0	3.8%
6.	Eina-Katni-Anuppur	429	30.2	10%	47.0	4.6%
7.	Bina-Bhopal-Ratlam	421	25.2	7%	36.0	3.6%
8.	Bhopal-Itarsi	91	23.6	7%	49.5	9.1%
9.	Sonenagar-Barkakhana(*)	301	16.5	(-) 0.66%	54.5	19.2%
10.	Durg-Nagpur (**) (@)	265	15.9	3.8%	29.5	7.1%
	<u>Alternative:</u>					
	(a) Bhusaval-Itarsi or	301	27.8	6.2%	45.5	5.2%
	(b) Anuppur-Bilaspur(@)	151	11.6	7.3%	25.0	9.6%

(*) Traffic growth anticipated heavy on this route due to saturation of the Ground Chord on Eastern Railway.

(**) Alternative sections could be selected based on the trends in the growth of traffic in the next five years.

(@) For continuity with other electrified sections.

4.4 Pace of Electrification - The Indian Railways in the past achieved an energisation rate of 350 route kilometres per year during the III Plan period. At present the rate is around 150 route kilometres per year. Looking at the large number of sections that would be well above the break-even levels, the Committee feel that the pace of electrification needs to be stepped up from what has been in the immediate past. The Committee is conscious of the fact that to increase it suddenly may not be possible and an attempt has, therefore, been made to try and cover the sections which are around 40 million GTKMs, projected traffic density in the year 1988-89 as the first priority. In dealing with the sections to be taken up for electrification, the Committee has not only taken into account the traffic density but have also considered operational factors, continuity with contiguous electrified sections and problems of change of traction in heavy density isolated electrified sections. Keeping all these factors in view, the Committee have made phased programme of electrification to cover upto year 1988-89. In making out the phased programme, the Committee have gone through the recommendations of the Directors' Committee and the phasing suggested by them in the next 5 years and are in general agreement with the programme suggested by the Directors' Committee.

4.5 Programme of Electrification

4.5.1 The proposed programme of electrification is shown in the chart at pages 43 & 44. This programme envisages work to be commenced in about 2150 route kilometres in the period 1978-83, taking into account

the throw-forward works from the period 1974-78 and energisation of sections taken up in the current Plan and energisation of 1500 kilometres approximately. This will involve an outlay of approximately Rs.150 crores as against a provision of Rs.120 crores in the draft 5 year plan 1978-83. The proposal for the Plan 1983-88 is to energise approximately 2000 route kilometres in that period with outlay of approximately 230 crores. At the end of 1987-88, there would be works in progress on sections which would have been initiated in the period 1983-88, about 1100 kms. The phased programme suggested by the Committee envisages energisation of about 350 kilometres per annum on an average for the next 10 years.

- 4.5.2 In recommending the pace of electrification, the Committee have considered availability of teams, technical expertise, indigenous equipment and electric energy and other relevant factors. With the existing teams available on the Indian Railways with slight modification, it should be possible to achieve the pace suggested by the Committee. While most of the equipment is now indigenously available and there is likelihood of no shortage of any of the equipment of electrification, augmentation of manufacturing capacity of solid core insulators would have to be ensured.
- 4.5.3 The programme would require an additional demand of about 260 million KWH in 1983-84 and about 1750 million KWH in 1988-89. This will be adequately covered by the extra generating capacity of 41000 MW expected by that period (present level 24000 MW).

4.5.4 The proposed programme suggested by the Committee can be executed by deploying 4 teams which are available currently. These 4 teams will be kept engaged over the indicated projects over the next 10 years. Nearly 1/4th of the outlay on electrification work is spent on wages of men engaged in the activity. With this suggested pace of electrification, it would be possible to sustain employment of about 20,000 persons on an average for about 10 to 12 years. These include Railways' and Contractors' staff and provide employment locally on the section. In addition to the employment during the construction period, regular employment for maintenance of fixed assets created for electrification would absorb about 2 persons per route kilometre.

4.5.5 After having reached a pace of electrification of about 350 kilometres per annum the Railways will not face curtailment of electrification activity in the year 1988-89, as a few works initiated in the period 1983-88 would be completed in the next Plan. Besides, other sections of the Indian Railways would have qualified for being considered for electrification in the nineties. Some of the sections which could be considered would include Ratlam-Gangapur City of Delhi-Bombay route, Bhusaval-Itarsi, Anuppur-Bilaspur, Belampalli-Vijayawada, Trivellore-Shoranur, Lucknow-Amritsar etc. These routes would account for more than 3000 kilometres. It would thus be possible to sustain the same pace of electrification in the period beyond 1989.

4.5.6 No new schemes have been sanctioned in the last 4 to 5 years and unless some works are taken up immediately, there is likelihood of no energisation in the period 1981-83. The Committee recommend that decision on sections which have already been surveyed and which are likely to have traffic above the break-even levels at the time of energisation, should be taken on priority basis.

4.6 Requirement of Locomotives:

4.6.1 735 AC electric locomotives now running on 4360 route kilometres, give a norm of 0.168 locomotive per route kilometre. For Delhi-Jhansi & Mathura-Gangapur City section, the corresponding norm works out to 0.15 locomotives per route km. Considering that the routes proposed for electrification now would have a density lower than the routes already electrified, a figure of 0.15 locomotive per route kilometre appears reasonable and is adopted for assessing the needs for the proposed electrification programme. Therefore energisation programme of 1515 route kilometres till 1983 will require 227 locomotives besides another 135 needed on additional account on existing electrified routes. Against the requirements of 362 locomotives, a manufacturing programme of about 330* would be necessary. In view of the fact that the energisation of the section proposed would take place in gradual phases completing in 1983-84, the locomotive production in the year 1983-84 can take care of this gap in the overall requirements. The number of locomotives needed in the Plan period 1983-88 would be around 460.

* The draft plan 1978-83 envisages a production of 320 electric locomotives.

4.6.2 The present capacity to produce electric locomotives at Chittaranjan Locomotive Works is 66 locos and with marginal inputs, the capacity could be increased to 72. In order to meet the requirements of electric locomotives for the pace of electrification suggested, it would be necessary to immediately plan the marginal inputs to bring the production capacity to 72 in the year 1981-82 and simultaneously plan to achieve a production of 80 locomotives by 1982-83 and 96 locos by 1987-88. The capacity of production at Chittaranjan Locomotive Works should also take into account the need for locomotives on replacement account at the turn of the century when nearly 40 to 50 locomotives per year would reach the end of their economic life.

4.7 Observations

4.7.1 The Committee observe that in dealing with the density of traffic, if nett tonne kilometres per route kilometre are considered, it does not bring in its ambit the running of passenger carrying trains nor does it take into account running of empty wagons. In order to get a correct workload of the section and the fuel consumed, a more logical norm would be to take GTKMs per route kilometre. The Committee has done its exercises only in GTKMs.

4.7.2 The Committee observe that based on the recommendations of the Working Group constituted by the Railways, a substantial economy can be achieved in the cost of electrification. It is essential that these economy measures are implemented and inputs in both design and research augmented to reduce cost of electrification further. In addition, the Committee also observe that items not directly connected with electrification should not form part of electrification schemes.

4.7.3 The Committee observe that a firm indication of availability of funds for the projects sanctioned would permit the projects to be completed in minimum time. This will lead to economy.

PHASING OF ELECTRIFICATION PROJECTS

(SHEET-1 OF 2 SHEETS)

A. PHASING OF PROJECTS.			PLAN 78-83					PLAN 83-88								
SL. No.	NAME OF SECTIONS	ROUTE Km.	COST IN CRORES OF RS.	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
ON GOING SCHEMES :-																
1.	MADRAS-TRIVELLORE	42	5.89	C												
2.	MADRAS-GUDUR	141	19.38	C	C											
3.	VIJAYAWADA-GUDUR	293	37.23	C	C											
4.	WALT AIR-KIRANDUL	472	41.00	D	D											
NEW SCHEMES :-				23.00	15.50	3.50										
5.	DELHI-JHANSI	414	43.40		A		A									
6.	MATHURA-GANGAPUR CITY	153	15.30	1.00	6.00	12.00	14.00	9.50	0.90							
7.	VADODARA-RATLAM & GODHRA-ANAND	340	34.00		1.50	3.00	4.00	6.00	0.80							
8.	GOMOH & BOKARO AREAS	148	10.00		2.00	3.50	8.50	9.00	10.50	0.50						
9.	SITARAMPUR-DANAPUR	354	35.40		1.00	2.00	4.00	2.50	0.50							
10.	DANAPUR-MUGHAL SARAI	203	20.30		2.00	5.50	6.50	11.00	10.00	0.40						
11.	BHUSAVAL-NAGPUR	393	39.30			1.00	3.00	7.50	6.00	2.80						
12.	JHANSI-BINA	151	15.10					1.00	6.00	11.00	14.00	6.50	0.80			
13.	BINA-KATNI-ANUPPUR	429	42.90					1.00	2.80	5.00	5.00	1.30				
14.	BINA-BHOPAL-RATLAM	421	42.10						3.00	9.50	12.00	14.00	4.40			
15.	BHOPAL-ITARSI	91	9.10							2.00	7.00	14.00	14.00	5.10		
16.	SONENAGAR-BARKAKHANA	301	26.50							0.50	1.50	3.00	3.00	1.10		
17.	DURG-NAGPUR *	265	26.50							1.70	3.00	12.00	9.00			
18.	CHAMPA-KORBA	45	3.00								0.60	2.20	12.00	11.00		
19.	MURI-CHANDIL	61	5.00								0.50	1.50	1.00			
											0.50	2.30	2.20			
B. REQUIREMENT OF FUNDS (IN CRORES OF Rs.)																
i) FOR ON GOING SCHEMES				23.00	15.50	3.50	—	—	—	—	—	—	—	—	—	—
ii) FOR PROPOSED SCHEMES				1.00	9.50	21.50	35.00	40.00	45.00	45.00	45.00	45.00	50.00	29.40	—	—
iii) YEARWISE TOTAL REQUIREMENT OF FUND.				24.00	25.00	25.00	35.00	40.00	45.00	45.00	45.00	45.00	50.00	50.00	—	—
iv) REQUIREMENT OF FUNDS FOR PLAN PERIODS.				← 149.00			→ 230.00									
* ALTERNATE :-																
BHUSAVAL-NAGPUR		301 ROUTE Km.														
ANUPPUR-BILASPUR		151 ROUTE Km.														
													@ INCLUDES PROVISION FOR NEW PROJECTS TO BE TAKEN UP.			

PHASING OF ELECTRIFICATION PROJECTS

(SHEET-2 OF 2 SHEETS)

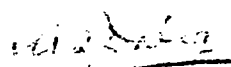
	PLAN 78-83					PLAN 83-88							
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90	1990-91
C. ENERGISATION :													
i) ROUTE KILOMETRE ENERGISATION IN EACH YEAR	151	313	163	321	567	340	502	203	544	429	421	566	
											618		
ii) ROUTE KILOMETRE ENERGISATION DURING THE FIVE YEAR PLAN.	← 1515					← 2018					← 1184 →		
											THROW FORWARD		
D. LOCO REQUIREMENT :													
i) PROJECT WISE	20 WKRE	89 MKRE	49 WKRE		85	51	22	53	31	82	65	63	24
ii) YEARWISE FOR NEW SECTIONS	20	60	60	18	40	45+27	24+22+26	27+27	4+60	22+50	15+63	24+42	40
						72	72	54	64	72	78	66	
ii) YEARWISE FOR SECTIONS ALREADY ELECTRIFIED	35	-	6	54	40	12	20	38	29	24	18	30	56
iv) TOTAL YEARWISE REQUIREMENT OF LOCO PRODUCTION	55	60	66	72	80	84	92	92	93	96	96	96	96
v) TOTAL REQUIREMENT OF LOCO PRODUCTION FOR FIVE YEAR PLAN.	← 333					← 457 →							
						INPUTS TO C.L.W. TO INCREASE THE PRODUCTION CAPACITY TO REACH ULTIMATELY 96 LOCOS PER YEAR IN 1987-88.							
E. EMPLOYMENT GENERATION :													
1. TEMPORARY FOR CONSTRUCTION													
APPROXIMATE NUMBER OF MEN EMPLOYED	15760	16420	16420	22980	26260	29550	29550	29550	29550	32830			
2. PERMANENT FOR MAINTENANCE :													
i) FOR INDIVIDUAL PROJECTS ENERGISED DURING THE YEAR @ 2 MEN PER ROUTE KILOMETRE.	302	626	326	642	1134	680	1004	406	1088	858	1236	1132	
ii) CUMULATIVE TOTAL.	-	928	1254	1896	3030	3710	4714	5120	6208	7066	8302	9434	
F. H.S.D. OIL/ELECTRIC ENERGY REQUIREMENT : ⊕													
i. a) H.S.D. OIL REPLACED BY ELECTRIC ENERGY IN (000) TONNES	-	-	-	-	-	62.91	136.53	187.81	221.38	366.15	430.56	541.27	
b) COST OF H.S.D. OIL IN CRORES OF RS. @ RS. 1080.18 PER TONNE C.I.F.	-	-	-	-	-	6.79	14.75	20.28	23.91	39.54	46.50	58.46	
ii. ELECTRIC ENERGY REQUIREMENT IN MILLION KWH.	-	-	-	-	-	262.13	552.01	765.16	904.50	1491.91	1746.69	2193.57	
													44

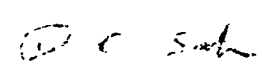
NOTE : ↓ INDICATES ENERGISATION OF A SECTION

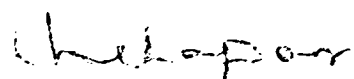
4.8 Summing up

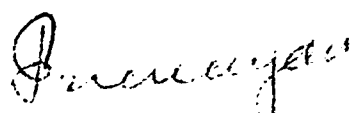
- 4.8.1 On the basis of the study, the Committee find that the break-even level for electrification is about 30 million GTKM (about 11 million nett tonne kilometres) per route kilometre per annum. The break-even level (economic) comes down when a scarcity value is attached for shadow pricing of diesel oil. On the other hand, it goes up if economies suggested in the cost of electrification are not implemented.
- 4.8.2 The results of this study are significantly different from those of Sahai Committee and the study of NCAER. The difference is mainly due to change in relative costs of inputs.
- 4.8.3 The Committee recommend that decision to electrify should be based on the results of the economic costs. However, in the current situation the break-even levels are not very different on the financial costs. There is, thus, little conflict in the results between the two.
- 4.8.4 Since it takes about 6 to 7 years to conduct a cost-cum-feasibility survey and complete electrification on a section, sections which are anticipated to have a traffic density of 30 million tonnes or above may be surveyed for electrification.
- 4.8.5 The Committee find that economic return (without adding scarcity value) on investment is as high as 20% when the traffic density at energisation is about 50 million GTKM per route kilometre per annum. The Committee, therefore, recommend that there should be no financial constraint in taking up high density routes.
- 4.8.6 In the last five years, no new sections have been sanctioned for electrification, as a result of which, there will be no energisation of sections after 1980-81,

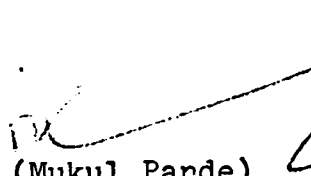
The Committee, therefore, recommend that the sections for which survey work is ready and will have a traffic density above 30 million tonnes at the time of proposed date of introduction of Electric Traction, should be taken up on a top priority basis so that the overall pace of electrification is not vitiated and there is no break in the workload of the existing teams. This will also be in conformity with the Energy Policy of the Government.

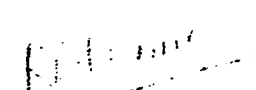

 (M. Q. Dalvi)
 U.N.D.P. Adviser
 Planning
 Commission.

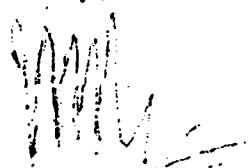

 (P. C. Sah)
 Consultant
 Project Appraisal
 Division,
 Planning Commission.

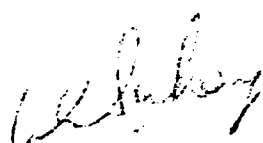

 (Mahesh Kapoor)
 Jt. Director
 Corporate Planning,
 Railway Board.
 (Now Dy. Adviser
 Transport
 Planning Commission)


 (Pratap Narayan)
 Jt. Director Rly.
 Planning-I,
 Railway Board.
 (Now Executive
 Director,
 Fertiliser Industry
 Coordination
 Committee).


 (Mukul Pande)
 Jt. Director
 Mech. Engg. (Fuel)
 Railway Board.


 (K. B. Verma)
 Dy. Director
 Stat. CA.
 Railway Board.
 (Now Dy. Director
 Finance Accounts
 Railway Board)


 (J. A. Raj)
 Chief Engineer
 Railway Electrification
 Northern Railway, Allahabad.


 (A. A. Sahay)
 Joint Director Railway
 Electrification (Elec)
 Railway Board.

(Convener).

(Secretary).

ANNEXURES

Directors' Committee Report on Electrification Programmes
in the Sixth Five Year Plan (1979-84).

.....

ELECTRIFICATION PROGRAMME IN THE SIXTH FIVE YEAR PLAN.

INTRODUCTION:-

While deciding to include the electrification of Delhi-Bina section (Phase I) in the Budget, 1977-78, the Board vide their notings at pages 7-8/n of file No. 72/RE/161/31 (extracts enclosed as Annexure I) had decided that the strategy for electrification during the Sixth Plan should be prepared by a Committee comprising of DRP, DTT, DEB, DF(B) and JDRE(E). This Note has accordingly been prepared.

CORPORATE PLAN PROJECTIONS
FOR ELECTRIFICATION:-

2. Annexure II is a statement indicating the sections proposed for electrification during the Corporate Plan period covering the three Five Year Plan periods (Fifth, Sixth and Seventh Plans). Of the sections mentioned in the statement at Annexure II, energisation of about 1227 route kms would have been achieved by the end of the Fifth Five Year Plan as indicated below:-

Sections likely to be energised by the
end of the Fifth Five Year Plan.

Sections.	Route kms.	Remarks.
(i) Virar-Sabarmati	437	Energisation during Fifth Plan was 200 route kms.
(ii) Panskura-Haldia	69	Energised in July, 1975.
(iii) Tundla-Delhi	259	Energised in July, 1976.
(iv) Madras-Vijayawada (Partial)	270	Vijayawada-Bitrugunta and Madras-Gummidipundi section.
(v) Waltair-Kirandul (Partial)	150	Kirandul-Jagdulpur section.
(vi) Madras-Trivellore	42	
TOTAL:	<u>1,227</u>	Actual energisation in the Fifth Plan will be 990 RKMss.

contd...

TARGET OF ENERGISATION
IN THE SIXTH PLAN:-

3. The Corporate Plan of Indian Railways envisages electrification of about 4,800 route kms during Fifth, Sixth and Seventh Five Year Plans. With the energisation of about 1,000 route kms by the end of the Fifth Plan, the balance 3,800 route kms would remain to be energised during the Sixth and the Seventh Five Year Plans. On the assumption that Electrification during the Sixth and the Seventh Plans would be more or less at the same level, energisation in each of these periods can be assumed to be about 1,900 route kms. The suggested electrification programme for the Sixth Five Year Plan has been prepared keeping this target in view.

RESIDUAL PORTION OF ELECTRIFICATION
SCHEMES ALREADY IN PROGRESS/APPROVED:-

4. As indicated in para 2 above, only partial energisation will take place in the Fifth Plan so far as Madras-Vijayawada and Waltair-Kirandul electrification schemes, already in progress, are concerned. Thus, against the total route kilometrage of 438 kms for Madras-Vijayawada scheme, only about 270 route kms are likely to be energised in the Fifth Plan and the balance 163 route kms would get energised in the Sixth Plan. Similarly, out of a total of 471 route kms for Waltair-Kirandul electrification scheme, only about 150 route kms are likely to be energised in the Fifth Plan leaving a balance of 321 route kms to be energised in the Sixth Plan. The Board have already approved electrification of Delhi-Bina section (including (DAL) (Phase I) and this work has been included in the Budget for 1977-78. This would also, therefore, be a scheme in progress when the Sixth Plan commences and would get completed in that Plan. Thus, about 928 route kms (163+321+444) would get energised in the Sixth Plan from amongst the schemes already in progress/approved. Energisation of another about 970 route kms in the Sixth Plan will have to be planned to achieve the target (1900 RKMs) for the Sixth Plan. While identifying the future sections to be taken up for electrification, it would, however, be necessary to identify about 2,000 route kms for electrification to ensure that work is in progress on about 1,000 route kms at the commencement of the Seventh Plan. This is necessary to maintain continuity of electrification work on the Railways so that energisation of about 350 route kms is ensured annually in the first few years of the Seventh Plan.

contd....

FACTORS TO BE CONSIDERED WHILE
IDENTIFYING SECTIONS FOR ELECTRIFICATION:-

49

5. Annexure III is a statement showing the likely traffic density of the sections proposed for electrification in the Corporate Plan period, excluding schemes already in progress/completed/approved. These sections have been arranged in the descending order of the likely traffic density by the end of the Corporate Plan period. This statement also includes a few minor sections that have been proposed for electrification on the ground of continuity of traction.

5.1 From the statement at Annexure III, it would be seen that the sections that are likely to have the highest traffic density by the end of the Corporate Plan period are Vadodara-Ratlam/Godhra-Anand, Katni-Anuppur-Bilaspur, Son Nagar-Barkakana, Bina-Bhopal-Itarsi and Bina-Katni. Purely on the traffic density considerations, therefore, these sections totalling about 1,500 route kms would qualify for being considered for electrification in the Sixth Plan. While traffic density is, no doubt, an important criterion for identifying the sections to be taken up for electrification, other factors like operational advantages and flexibility, dispersal of electrification schemes, continuity of traction, number of working parties, etc. etc. would also have to be borne in mind. For example, while it is true that the likely traffic density on Son Nagar-Barkakana section by 1988-89 would be very high (54.5 million gross tonne per route km), as explained subsequently, greater advantage would accrue operationally if electrification of Sitarampur-Patna-Mughalsarai section, which is likely to have traffic density of 43.5 million GTKMs/route km, is undertaken first. It would also be necessary to bear in mind the fact that electrification projects have long gestation period of 4 to 5 years, apart from about 2 years required for planning, survey and finalisation of the proposals. Yet another factor which is required to be taken due cognizance of is that concentration of electrification works on any single Railway/Divisional system may pose difficulties in execution on account of necessity of giving traffic blocks and the need for regulation of traffic etc. etc. In this context, therefore, it may be preferable to spread out the sections for electrification to different Railway/Divisional systems.

contd...

5.2 In the 16th meeting of the Controlling Committee for electrification with the Railway Board held on 13.7.72, the Board had indicated the tentative priorities for new electrification schemes to be taken up during the Fifth Five Year Plan. They had also laid down the following broad criteria for selecting sections for electrification, in the order given below:-

- i) Sections forming part of the important trunk routes, specially those on the quadrilateral and the diagonal connecting the four main metropolitan cities of Delhi, Calcutta, Madras and Bombay should be the first preference.
- ii) Other sections with adequate traffic density and where cheap electricity is available.
- iii) Sections contiguous to the electrified track and carrying heavy traffic like coal, ore, etc.
- iv) Suburban sections around metropolitan cities.

THE PROPOSALS:-

6. Keeping in view the various factors mentioned in para 5 above, the following programme of electrification/energisation in the Sixth Five Year Plan is suggested:

Priority.	Railway.	Section.	RKMs.	Extent of energisation		
				V Plan.	VI Plan.	VII Plan.
<u>(A) Schemes in progress/approved</u>						
	South-Eastern	Waltair-Kirandul	471	150	321	-
	Southern & South-Central	Madras-Vijayawada	433	270	163	-
	Central & Northern	Delhi-Bina (Phase I) (inc. DAL)	444	-	444	-
TOTAL (A)			1348	420	928	-

contd....

Priority.	Railway.	Section.	RKMs.	Extent of energisation		
				V Plan.	VI Plan.	VII Plan.
(B) <u>New Schemes</u>						
I	Western	Vadodara-Ratlam & Godhra-Anand	338	-	338	-
II	Western	Mathura-Gangapur City	153	-	153	-
III	Eastern/ South- Eastern	Gomoh-Bokaro- Anchal Area	132	-	132	-
IV	Eastern	Sitarampur-Patna-Mughalsarai	557	-	354	203
V	Central	Bhusawal-Nagpur	393	-	-	393
VI	South- Eastern	Nagpur-Durg	265	-	-	265
VII	Central	Delhi-Bina (Phase II)	151	-	-	151
TOTAL (B)			1989	-	977	1012
GRAND TOTAL			3337	420	1905	1012

With the programme of electrification proposed above, new schemes aggregating to 1989 route kilometres would be commenced and energization of 1905 route kilometres would be achieved in the Sixth Plan. Work on schemes aggregating to about 1000 route kilometres would be in progress when the Sixth Plan ends and these schemes will fructify in the first 3 years of the Seventh Plan.

BRIEF JUSTIFICATION:-

7. Brief justification for recommending the above section for electrification is as under:-

contd....

7.1 Vadodara-Ratlam & Godhra-Anand sections (W.Rly.)

Amongst all the new sections proposed for electrification in the Corporate Plan, Vadodara-Ratlam section has the highest traffic density at present and is likely to retain this position during the Corporate Plan period. Electrification of the Bombay-Delhi route having already been completed upto Vadodara (and also covering Vadodara-Ahmedabad section), electrification of Vadodara-Ratlam and Godhra-Anand sections would enable electrification of all BG services south of Ratlam and Ahmedabad. The cost-cum-feasibility survey for electrification of these sections is already in progress and the foot-by-foot survey can be ordered straightaway so that the same survey team could undertake the job. Processing of this scheme can be completed in 1977-78 so that it may be possible to consider inclusion of this scheme in the last year (1978-79) of the Fifth Plan.

7.2 Mathura-Gangapur City Section (Western Rly.)

The Board have already approved electrification of Delhi-Bina section (Phase I) and the same has been included in the Railway Budget for 1977-78. With the electrification of this section, of the two streams of traffic merging/bifurcating at Mathura, the Central Railway stream would not pose any problems on electrification, but for the stream of traffic to and from Western Railway, there would be a serious problem of change of traction in Mathura Yard, which is a small transit yard. Besides, change of traction after only about 90 miles for passenger trains and still less for freight traffic would not be desirable. The alternative to the change of traction at Mathura is to continue running diesel-hauled trains on Tughlakabad-Mathura electrified section for the Western Railway traffic which again is not at all desirable. In the circumstances, therefore, a feasible solution is to electrify Mathura-Gangapur City section (only 153 kms) also simultaneously with Delhi-Bina section (Phase I). Incidentally, it may be mentioned that under steam traction, the engine run was between Delhi and Gangapur. It may be further mentioned that the Survey Team for Delhi-Bina section had collected statistics and factual data for Mathura-Gangapur section also and, applying the cost norms for Delhi-Bina section, had found the electrification of the same remunerative (12.58% return as per DCF). Even from the point of view of traffic density it is comparable with that on Bina-Jhansi section. A detailed study needs, however, to be ordered immediately to be completed during

contd...

1977-78, so that work could commence in 1978-79 in order that energisation of this section could be synchronised with that of Delhi-Bina section (Phase I). Incidentally, no separate electrification team for this section may be necessary and the work could be entrusted to the team undertaking electrification of either Vadodara-Ratlam section for Delhi-Bina section.

7.3 Gomoh-Bokaro-Andal Area (Eastern & South Eastern Railways)

The need for electrification of the Gomoh-Bokaro-Andal area stems from the consideration of contiguity of traction. This important steel-coal belt area is at present served by diesel/steam traction surrounded though it is by electrified routes. It is highly desirable that in this small area aggregating to about 132 route kms, the same traction handles traffic as is available on the concerned adjoining sections. Before undertaking this scheme, however, a detailed electrification survey would be necessary. Electrification of this area could be so planned that the team doing work on Sitarampur-Mughalsarai could also handle the same.

7.4 Sitarampur-Patna-Mughalsarai section (Eastern Rly.)

According to the Corporate Plan projections, Sonnagar-Barkakana section of Eastern Railway is likely to have very high density of traffic (54.5 million GTKMs/route km) by the end of the Corporate Plan period. The traffic density on the Main Line section of Eastern Railway from Sitarampur to Mughalsarai via Patna by the end of the Corporate Plan period has been assessed as 43.5 million GTKMs/route km. Although, traffic density-wise, Sonnagar-Barkakana section ranks higher than Sitarampur-Mughalsarai section yet operationally greater advantages are likely to result from electrification of the latter section as compared to the former.

The major part of the passenger traffic stream between Delhi and Calcutta is routed via the Main Line of Eastern Railway. Consequently, the same has to be handled with diesel/steam locomotives not only on the non-electrified section but also on Sitarampur-Howrah electrified section in order to avoid change of traction at Sitarampur. If Sitarampur-Patna-Mughalsarai section is also electrified, the entire traffic between Calcutta and Delhi can be hauled by electric traction all the way which is very desirable. Additionally, an alternative electrified route to the Grand Chord

contd...

(where capacity is already fully saturated and otherwise heavy investment would be required to increase the same) will become available. This alternative route would also be utilized as and when required, particularly when any dislocation of traffic takes place on the Grand Chord which presently throws the entire operation of the Eastern Railway out of gear. Operationally, therefore, electrification of Sitarampur-Mughalsarai section will be more advantageous than that of Sonnagar-Barkakana section. Partial survey for electrification of Sitarampur-Garhara-Danapur section has already been completed and if the survey of the balance portion is ordered immediately, it should be possible to complete the same in 1978-79 and commence work on this scheme in the first year of the Sixth Plan.

7.5 Bhusawal-Nagpur section (Central Railway).

7.6 Nagpur-Durg section (South Eastern Railway)

Both these sections fall on the trunk route Bombay-Calcutta. Electrification of these sections was envisaged several years back but the same could not be sanctioned due to scarcity of resources. With the electrification of these sections, the entire trunk route from Bombay to Calcutta will be electrified which is in line with the Board's policy of according priority to electrification of trunk routes. All the preliminary work in connection with the electrification of these sections like techno-economic and feasibility survey and economic study etc. has already been completed and the projects can be sanctioned towards the middle of VI Plan (in 1980-81 and 1981-82) for energization in early VII Plan (1984-85 and 1985-86).

7.7 Delhi - Bina .. Phase II

It would be recalled that electrification survey/economic study had been carried out for Delhi-Bina section as a whole and Phase I of this scheme covering the portion Delhi-Jhansi has already been included in the Budget for 1977-78. It would be necessary to take up Phase II of the Scheme covering Jhansi-Bina section when Phase I is about to be completed in or around 1982-83. At that stage, electrification of Bina-Itarsi section can also be considered so that on the Delhi-Bombay and Delhi-Madras routes electrification from Delhi end could progress upto Itarsi.

contd...

REASONS FOR ACCORDING LOWER PRIORITY
TO ELECTRIFICATION OF KATNI-ANUPPUR-
BILASPUR, KATNI-BINA AND BINA-ITARSI
SECTIONS:-

8. While selecting the sections to be taken up for electrification in the VI Plan, we have given higher priority to the sections mentioned above over the sections falling on the C.I.C. coal route namely Anuppur-Katni, Katni-Bina and Bina-Bhopal-Itarsi sections although the likely traffic densities of these sections (see Annexure III) are comparatively more than some of the selected sections. In according lower priority to these sections, the main considerations that have weighed with us are explained below:

8.1 The major part of coal traffic from Korea-Rewa Coal fields is meant for destinations on Western Railway reached via Bhopal or via Bina moving, wholly or partially, over Bhopal-Ratlam section. This section is still a single line section but for small patches of doubling. Similarly, the newly-commissioned Guna-Maksi route is also a single line route. Before, therefore, electrification from the coal fields' end is extended upto Bina, it would be necessary to determine the pattern of movement of coal traffic beyond Bina by the two available routes. It will be equally necessary to go into the question of the traction to be used for movement of this traffic beyond Bina on these two routes since, prima facie, homogeneity of traction on both the routes is desirable. Electrification of Anuppur-Katni-Bina and Bina-Bhopal-Itarsi sections without resolving the problems of movement pattern/traction on Western Railway system may give rise to other problems. In view of this, electrification work on these sections, it is felt, can be taken up later.

FINANCIAL IMPLICATIONS:-

9. Although the exact cost of the new electrification projects for the Sixth Plan suggested above can be assessed only after detailed electrification surveys have been completed, approximately, however, it is felt, that these projects aggregating to about 1963 route kms would cost about Rs. 225 crores as indicated in Annexure IV. Work on certain schemes like Madras-Vijayawada, Waltair-Kirandul and Delhi-Bina (Phase I) would be in progress when the Sixth Plan commences and the amount of throwforward required to complete these schemes is roughly assessed as Rs. 56 crores. If electrification of Vadodara-Ratlam/Godhra-Anand, Mathura-

contd....

Gangapur City, Gomoh-Bokaro-Andal Area and partial energisation (upto Danapur) of Sitarampur-Mughalsarai sections is also completed in the Sixth Plan, another Rs.110 crores would be required. To progress the balance schemes that would fructify in the first 2-3 years of the Seventh Plan it has been assessed that another Rs.55 crores would be required in the Sixth Plan. In all, therefore, an outlay of Rs.220 crores (see Annexure IV) would be needed for electrification schemes in the Sixth Plan. If, however, the proposed economies in the cost of electrification based on the costs adopted for Bina-Delhi electrification estimates is taken into account, (updated Dec. 1976), the total requirement of funds in the VI Plan may be around Rs. 200 crores.

ORGANISATIONAL STRUCTURE:-

10. From the above it would be observed that the extent of energization proposed in the Sixth Plan (about 1,900 route kilometres) would be a considerable step up over the actual performance in Fourth Plan (932 route kilometres) and the likely performance in the Fifth Five Year Plan (about 990 route kilometres). This Committee is of the view that in order to satisfactorily achieve the objective, the organisational structure for Railway Electrification works would need to be strengthened. Revival of the erstwhile R.E. organisation and its possible bifurcation into 2 or more groups, each group being headed by an officer of appropriate rank on the lines of the erstwhile R.S. may be necessary.

S U M M A R Y:-

11. Summarizing, therefore, it is recommended that:

- i) Keeping in view the fact that electrification of about 4,800 route kilometres has been envisaged in the Corporate Plan and also that the actual energisation of sections proposed by the Fifth Plan end is likely to be about 1,000 route kilometres, the target of electrification in the Sixth and Seventh Plans may be fixed at 1,900 route kilometres.
- ii) Of the electrification schemes already in progress/approved, there is likely to be a throwforward of about 928 route kilometres from the Fifth Plan to the Sixth Plan. To achieve the target envisaged for the Sixth Plan (1900 route kilometres) energisation of another 970 route kilometres would have to be planned.

contd..

iii) While identifying the schemes where electrification works should commence in the Sixth Plan, about 2,000 route kilometres need to be identified so that continuity of work is maintained and energisation of about 350 route kilometres per annum is ensured in the Seventh Plan also.

iv) Based on the considerations of trunk routes, traffic density, continuity of traction and operational convenience etc. the following new sections, in order of priority, should be taken up for electrification:

<u>Prio- rity.</u>	<u>Railway.</u>	<u>Section.</u>	<u>RKMs.</u>	<u>Remarks.</u>
I	Western	Vadodara-Ratlam & Godhra-Anand	338	For energisation in the VI Plan.
II	Western	Mathura-Gangapur City	153	-- do --
III	Eastern/ S.E.	Gomoh-Bokaro- Andal Area	132	-- do --
IV	Eastern	Sitarampur-Patna -Mughalsarai	557	Partial energis- ation (about 350 kms) in VI Plan and balance in VII Plan.
V	Central	Bhusawal- Nagpur	393	For energisation in the VII Plan.
VI	South Eastern	Nagpur-Durg	265	-- do --
VII	Central	Delhi-Bina (Phase II)	<u>151</u>	-- do --
		TOTAL	<u>1,989</u>	

v) In order to implement the proposed electrification programme, the following time-table (see chart at Annexure V) would be required to be adopted for the new schemes to be taken up:

contd....

<u>Section.</u>	<u>Survey to be completed in.</u>	<u>Project to be sanctioned in.</u>	<u>Project to be completed in.</u>
1. Vadodara-Ratlam & Godhra-Anand	1977-78*	1978-79	1982-83
2. Mathura-Gangapur City	1977-78	1978-79	1981-82
3. Gomoh-Bokaro-Andal Areas	1977-78	1979-80	1983-84
4. Sitarampur-Patna-Mughalsarai	1978-79 [@]	1979-80	1984-85
5. Bhusawal-Nagpur	Already completed	1980-81	1984-85
6. Nagpur-Durg	--do--	1981-82	1985-86
7. Delhi-Bina (Phase II)	--do--	1982-83	1986-87

* Survey in progress. Foot-by-foot survey to be conducted.

@ Partial survey of Sitarampur-Garhara-Danapur already completed.

vi) To implement the proposed electrification programme, about Rs.200 crores would be needed in the Sixth Plan.

vii) As the programme of energisation in the Sixth Plan (about 1900 RKMs) would be considerably higher than the actual performance of the Fourth Plan (932 RKMs) and the likely performance of the Fifth Plan (about 990 RKMs), it would be necessary to strengthen the R.E. Organisation with possible bifurcation into two groups, each group headed by a senior officer of appropriate rank on the lines of the erstwhile R.E.

Sd/-
D.R.P.
7.6.77.

Sd/-
L.T.T.
7,6.77.

Sd/-
D.E.B.
7.6.77.

Sd/-
D.F.(B)
7.6.77.

Sd/-
J.D.R.E.(E)
7.6.77.

Annexure - 'I' of Directors' Committee Report.

Extracts of noting on pages 7-8/n of
File No. 72/RE/161/31.

.....

XXX

XXX

XXX

' For going to Planning Commission in Dec. 76, we
' may moot DLI-JHS as a new route for 77/78. For 6th Plan
' we must prepare a strategy. Same Committee of DRP, DTT,
' DEB, DFB and JDRE could prepare it.
'

Sd/-
A.M.E.E.
24/11.

XXX

XXX

XXX

1. As proposed.
2. I would also commend the suggestion at 'A'
above for urgent action.

Sd/-
F.C.
27.11.76.

Sd/-
C.R.B.
2/XII/76

.....

Annexure - 'II' of Directors' Committee Report.

Sections proposed for Electrification in
the Corporate Plan for the Indian Railways.

.....

Section.	Route Kms.
1. Virara-Sabarmati ...	437
2. Paraskura-Haldia ...	69
3. Tundla-Delhi ...	259
4. Madras-Vijaywada ...	433
5. Waltair-Kirandul ...	471
6. Madras - Trivellore ...	42
7. Delhi-Bina (Surveyed) ...	545
8. Bhusaval-Nagpur (Surveyed) ...	393
9. Sitarampur-Patna-Mughalsarai (partly surveyed) Alternatively Sonengar-Barkakana (301 kms)	557
10. Vadodra-Ratlam & Godhra-Anand (under survey) ...	338
11. Nagpur-Durg (surveyed) Alternatively Katni-Anuppur- Bilaspur (348 kms)	265
12. Gomoh, Bokaro & Andal areas ...	132
13. Bhopal-Ratlam ...	282
14. Bina-Bhopal-Itarsi ...	230
15. Bina-Katni ...	262
16. Muri-Chandil ...	61
17. Champa-Korba ...	45
TOTAL;	<u>4721 Route Kms.</u>

Annexure - 'III' of Directors' Committee Report.

Sections identified for electrification in the Corporate Plan period (excluding sections already electrified or where electrification works are in progress/approved) arranged in the descending order to likely traffic densities by the end of the Corporate Plan period.

(A) Sections proposed for electrification on the consideration of quantum of traffic.

<u>S.No.</u>	<u>Section.</u>	<u>Route Kms.</u>	<u>Likely traffic density by the end of the Corporate Plan period(1988-89) (in million GTKMs/RKM).</u>
1.	Vadodra-Ratlam & Godhra-Anand	338	58.00
2.	Katni-Anuppur-Bilaspur	348	55.0
3.	Sonenagar-Barkakhana	301	54.5
4.	Bina-Bhopal-Itarsi	230	49.5
5.	Bina-Katni	262	47.0
6.	Sitarampur-Patna-Mughalsarai	557	43.5
7.	Bhusaval-Nagpur	393	41.0
8.	Bhopal-Ratlam	282	36.0
9.	Nagpur-Durg	255	29.5

(B) Sections proposed for electrification on the consideration of continuity of traction.

<u>S.No.</u>	<u>Section.</u>	<u>Route Kms.</u>
1.	Gomoh-Bokaro-Andal Areas	132
2.	Muri-Chandil	61
3.	Champa-Korba	45

.....

Annexure - 'IV' of Directors' Committee Report.

Statement showing estimated cost of electrification Projects and requirement of funds in the VI Plan.

Scheme.	Estimated cost of the Project.	Likely expenditure in		
		V Plan or earlier.	VI Plan.	VII Plan.
<u>(A) Scheme in Progress/Approved.</u>				
1. Madras-Vijayawada	57.5	43.0	14.5	-
2. Waltair-Kirandul	33.5	30.0	3.5	-
3. Delhi-Bina(Phase I)	39.0	1.0	38.0	-
TOTAL (A)	130.0	74.0	56.0	-
<u>(B) New Schemes.</u>				
1. Vadodara-Ratlam & Godhra-Anand	44.0	0.5	43.5	-
2. Mathura-Gangapur City	19.0	0.3	18.7	-
3. Gomoh-Bokaro-Andal Area	17.0	0.2	16.8	-
4. Sitarampur-Patna-Mughalsarai	59.0	-	30.0	29.0
5. Bhusawal-Nagpur	43.0	-	34.0	9.0
6. Nagpur-Durg	28.0	-	17.0	11.0
7. Delhi-Bina(Phase II)	15.0	-	4.0	11.0
TOTAL (B)	225.0	1.0	164.0	60.0
GRAND TOTAL (A) + (B)	355.0	75.0	220.0*	60.0

* This amount may get reduced to about Rs.200 crores if the proposed economies in electrification projects is achieved.

.....

ELECTRIFICATION PROGRAMME IN THE SIXTH FIVE YEAR PLAN

PLAN SECTION	ROUTE Km.	V		VI				VII			
		1977-78	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	1984-85	1985-86	1986-87
MADRAS-TRIVELLORE	42								SURVEY & SANCTION		////
MADRAS - GUDUR	141 [@] 92								EXECUTION		=====
VIJAYAWADA-GUDUR	293 [@] 71										
WALTAIR - KIRANDUL	472 [@] 321										
TOTAL -	948										
DELHI - JHANSI AND D.A.L.	444										
VADODARA - RATLAM AND GODHRA - ANAND.	338	////									
MATHURA - GANGAPUR CITY	153	* ////									
COLLIERY LINES NEAR GOMOH AND BOKARO.	132	* ////									
SITARAMPUR - GARHARA - DANAPUR	354										
DANAPUR - MUGHALSARAI	203		////								
BHUSAVAL - NAGPUR	393										
DURG - NAGPUR	265										
JHANSI - BINA	151										

* SURVEYS NEED TO BE ORDERED IN 1977-78.

@ Km. TO BE ENERGISED IN 6TH PLAN.

ENERGISATION
TOTAL 1905 RKM
AVERAGE 381 RKM/YEAR

ANNEXURE - 2.

Extract of Para 19 of Minutes of meeting held between Ministry of Railways and Planning Commission on 5-12-77.

" 19. ELECTRIFICATION: Secretary, Planning Commission, felt that time had come for the Railways to reassess the position regarding the economic justification for electrification vis-a-vis dieselisation. The electrification programmes which had been going on, were based upon the conclusions of study made sometime back when the relative prices of oil, coal etc. were considerably different. It seemed necessary that the Railway Board, in consultation with the Planning Commission, might organise a study which would indicate on the basis of the latest economic prices of oil, coal etc., the density at which the electrification would be preferable to dieselisation and on that basis, to draw a long term programme for electrification for the future. Funding of this programme would then become easier as also as the stabilisation of locomotive production. The Ministry of Railways agreed to carry out this study and to draw up a new programme. Pending the finalisation of this study, a small token provision for new electrification scheme was fixed. It was also indicated that the Railway Board's earlier proposal for Delhi-Jhansi-Bina electrification would have to be re-assessed in terms of its interse priority of the new programme, to be drawn up."

ANNEXURE - 3.Cost of Electrification1. Increase in cost of Electrification:

1.1 Initial electrification schemes, work on which was commenced in 1958 on Eastern and South-Eastern Railways cost between Rs. 1.2 to Rs. 1.31 lakhs per track kilometre. Sub-stations were owned and maintained by Electricity Boards. The telecommunication cables were laid by Posts & Telegraphs Department.

1.2 In subsequent electrification works Railways were required to lay their own telecommunication cables and construct and maintain their own sub-stations. In addition, colour light signalling was provided at all stations as part of electrification. This increased the scope of work. Along with continuing inflation, cost of electrification of Rourkela-Durg section was Rs. 2.25 lakhs per track km by 1965-66.

1.3 Prices escalated sharply between 1972 and 1974 when whole-sale price index rose from 200.7 to 303.9* all electrification projects in progress during this period suffered due to this inflation. According to revised estimates - Electrification of Tundla-Delhi is likely to cost about Rs. 5.14 lakhs and Vijayawada-Gudur section Rs. 5.26 lakhs per track km. The latter work has also suffered delays for want of funds which has further increased the costs. The rise in costs of electrification has been shown in Table - 3.1

2. Economy in cost of Electrification:

2.1 Design modifications: - The Recommendations of the Cost Reduction Working Group (September, 1976) for reduction of cost of electrification, accepted by the Railway Board are:-

- (i) Use of regulated tramway equipment (without catenary wire) in yards and sidings.
- (ii) Use of aluminium alloy catenary replacing the costlier cadmium copper catenary.

Contd...

* Whole sale price index = 100 for base year 1961-62.

- (iii) Use of painted broad flange beam and rolled steel joist structures for support of overhead equipment as against galvanised ones. Painting is cheaper than galvanisation even after providing for periodic painting every 5 years.
- (iv) Use of single transformer at alternate sub-stations, reducing the standby capacity from 100% to about 75%.
- (v) Increase in span of overhead equipment, reverting back to 72 m as adopted in earlier electrification schemes.
- (vi) Reduction in volume of drawing work of contractors by eliminating duplication.
- (vii) Use of solid state electronic equipment in Remote Control, way side station control, repeater stations and control office equipment.
- (viii) Use of un-screened signalling cables for inter cabin slotting in conjunction with A.C. immunized relays.
- (ix) Use of 300 V instead of 110 V A.C. supply for signal lighting circuits.

2.2 Further, following economies have also become possible:-

- (i) Minimum use of Railways' own transmission lines as State Electricity Boards are now able to give power supply at 132 KV at required locations.
- (ii) Adoption of revised pure gravity foundation designs, evolved by R.D.S.O. in 1977.

2.3 Economy in establishment charges:- The recommendations of Cost Reduction Working Group also drew attention to the great possibilities in saving on account of curbs in establishment charges. These tend to increase when project time extends or if a large organisation is catered for. As there is a large measure of subjective thinking on the subject, the Committee examined the expenditure pattern of Tundla-Delhi Railway Electrification. The trends of increase of such charges when project time extends is evident from the table below:-

contd...

	Projects	
	<u>Tundla-Delhi.</u>	<u>Vijayawada-Gudur.</u>
(i) Work commenced	June, 1971	September, 1972.
(ii) Work completed	Dec. '76 (Organisation at reduced strength con- tinues)	Expected March '80.
(iii) Project dura- tion	5½ years	7½ years
(iv) Revised Estimated cost (In lakhs of Rs.)	3341	3723
	<u>% to total Project cost:</u>	
(v) Pay and allowances	6.55	8.12
(vi) Other General charges	2.69	2.78
(vii) Total General charges (sum of v & vi)	9.24	10.90

In item (v) above, after June 1977, i.e. six months after the complete energisation of Tundla-Delhi section, if this organisation had been shifted to a new Project, no major expenditure under General Charges would have been incurred on this estimate. The expenditure recorded has been as follows:

	<u>Provision in Estimate.</u>	<u>Utilised till June, 1977.</u>
Administrative (Officer months) ...	1158	1058
Field ...	1021	906
Cost of Officers and Staff (in lakhs of Rs.)	215.89	197.54
% of total estimate	6.55	5.90*

contd..

2.4 Assuming that if a conscious effort is made to economize, instead of adopting a blanket percentage for such charges according to normal estimating procedures, the Committee consider the following percentage of General Charges as realistic and attainable:

(a) Office accommodation, tools & plants and instruments. (other General Charges)	2.7%
(b) Pay and Allowances of Officers and staff	<u>5.8% *</u>
(c) Total General Charges	<u>8.5%</u> -----

* Only 0.1% reduction is allowed for a conscious effort to reduce this below that recorded for Tundla-Delhi.

2.5 It should be possible to economise further by reducing project time to 4 to 4½ years and ensuring a rationalised Railway Electrification Organisation. Unlike the Open Line Organisation, Electrification Organisation is result oriented. Open Line Organisation executes minor works spread over its entire jurisdiction, while Electrification Organisation executes a time-bound project in a particular route. This should enable lower direction and general charges to be achieved compared to that of Open Line. The Committee have, therefore, adopted a percentage of 8.5 for General Charges over the total cost for the study.

3. Costs adopted for the Study:

3.1 The costs, with and without the economy as adopted for Delhi-Jhansi section are indicated in Table 3.2. The gross cost per track kilometre adopting economy measures as enumerated in para 2 is estimated at Rs. 4.30 lakhs per track km, obtaining a reduction of 15.5% over the cost of Rs. 5.09 lakhs estimated without economy.

3.2 Certain expenditure is chargeable to Revenue, e.g. cost of compensation to P & T Department for premature surrender of their circuits and shifting of their telegraph lines, and is paid out of Revenue expenditure. Further certain existing assets need to be replaced on condition-cum-age basis while doing Electrification. Expenditure on this account, in any

contd...

case, would have become inevitable in the immediate future. These costs need to be separated from the gross cost. Although the work is taken up by Electrification team, it is done under replacement account. (Refer Board's instructions in 75/RE/128/2 dated 15.9.77 and Paras 701 and 713 of General Code - Part I of Indian Railways). When these costs are separated, gross capital cost per track km comes to Rs. 4.21 lakhs, if cost of colour light signal is included and Rs. 4.03 lakhs if cost of colour light signal is excluded. When cost estimates without economies are considered the respective costs come to Rs. 4.99 lakhs and Rs. 4.82 lakhs.

/

TABLE - 3.1

Trends in cost of Railway Electrification

(Figs. in lakhs of Rs.)

Name of section.	'RKM.	'TKM	As estimated		As completed		Cost of transmission		Completion/ revised estimate.		'Whole sale price indices of the year of completion Base yr. 1961-62.		
			'Year of sanction	'Total cost	'Cost per track Km.	'Year of completion.	'Total cost	'Cost per track Km.	'line original estimate	'Per track Km.		'Total Per track Km.	
Durgapur-Mughalsarai	541	1431	1959	1608.31	1.124	1962	1425.93	0.996			104.1		
Mughal sarai-Kanpur	336	905	1962	1153.07	1.274	1967	1160.51	1.232			166.00		
Rourkela-Durg	454	1145	1965	2466.59	2.15	1970	2556.36	2.23			179.2		
Kanpur-Tundla	222	542	1965	1327.09	2.45	1972	1222.46	2.26	156.473	0.289	156.473	0.289*	200.7
Virar-Sabarmati	437	1105	1967	3209.03	2.90	1974	3488.34	3.15				303.9	
Tundla-Delhi	250	650	1971	2337.94	3.60	1977 (Jan)	3341.27	5.14@	108.00	0.183	141.942	0.244	301.00 (Dec!76)
									<u>11.20</u>		<u>13.770</u>		
									119.20		158.712		
Vijayawada-Gudur	293	708	1972	2228.32	3.15	1980 (expected)	3722.77	5.26@					

* Completion estimate does not indicate the cost of power transmission line separately, saving under sub-head 3610 is mainly in OHE work so the completion cost of Tr.line has been taken same as the original cost.

@ Revised cost. Completion cost not received.

TABLE - 3.2

Standard Estimate for Electrification of Delhi-Jhansi Section

Sl. No.	Description.	(Figs. in lakhs of Rs.)							
		Total estimated cost of the Project chargeable to capital DRF & Revenue.		Cost per Track Km.		Total estimated cost of the Project chargeable to capital only.		Cost per Track Km.	
		Debit.	Credit.	On gross cost	On net cost.	Debit.	Credit.	On gross cost.	On net cost.
(A) Taking into account all economy measures:-									
1.	Taking into account cost of C.L.S.works	4366.20	234.34	4.30	4.07	4269.58	195.87	4.21	4.01
2.	Without taking into account cost of C.L.S.works	4187.48	203.57	4.12	3.92	4090.86	180.85	4.03	3.85
(B) Without taking into account various economy measures:-									
1.	Taking into account cost of C.L.S.works	5167.44	247.06	5.09	4.84.1	5071.11	208.59	4.99	4.79
2.	Without taking into account cost of C.L.S.works	4988.72	216.29	4.91	4.70	4892.39	193.57	4.82	4.62

NOTE: Standard Estimate provides for an Electric Loco Shed to home 100 Locos according to R.D.S.O's standard drawing.

....

ANNEXURE - 4.

Views of Kunzru and Wanchoo Accident
Enquiry Committees on provision of
Colour Light Signals.

KUNZRU COMMITTEE:

(Accident Enquiry Committee, 1962)

127. Provision of Electrical Signalling - We consider that, with the introduction of diesel and electric traction and running of heavier trains at higher speeds to cope with the increasing density of traffic, the adoption of modern electrical signalling in India has now become both essential and inexcusable. We have, therefore, to consider the use of track circuiting, colour light signalling, automatic block system, power signalling and route-relay inter-locking and also to study for adoption other safety devices in use in foreign countries after adapting them to suit our peculiar conditions of operation and traffic.

Colour Light Signalling.- Colour Light Signalling with two or more aspects with its powerful and penetrating light provides for better visibility of signals so that the drivers may see them better and act upon their indications. Such signalling ensures better identification of signal aspects in adverse atmospheric conditions and on electrified lines where the overhead structures form numerous obstructions. At present colour light signals are in use on a very modest scale, mainly on sections round-about Calcutta, Bombay and Madras and to some extent near Delhi. In addition, they have been installed at some selected big stations like Gorakhpur, Varanasi Cantt. Such limited installation of colour light signals is hardly adequate. As the colour light signalling help the driver in the vital matter of observing signals, we suggest that this should be programmed for all electrified sections, during the current Plan and for all suburban sections by the end of the Fourth Plan."

WANCHOO COMMITTEE:

(Accident Enquiry Committee, 1968)

Visibility of signals.

321. Colour Light Signals.- The importance of proper visibility of signals is hardly a matter which we need dwell upon. During our tours, it was repeatedly

contd...

represented to us that the visibility of colour light signals is far better than that of the conventional oil-lit signal lamps. Colour light signals throw a beam of light of such intensity that their indications are clearly seen by drivers from a long distance even in bright sunshine. The penetrating nature of their beams makes it possible for the drivers to see the signals and identify them even in adverse weather conditions. We recommend that on sections where electric power is available, colour light signalling should be provided as rapidly as possible.

....

ANNEXURE - 5.Requirement of Electric Locomotives
vis-a-vis Diesel Locomotives.

1. 2600 H.P. Diesel-Electrics WDM₂ and 3600 H.P. Electrics WAM₄ are the only main line locomotives in the current range of production. Their characteristics and performance have been considered by the Committee to assess their requirements for different types of traffic required in the Study.

2.1 Through Goods traffic: Having a higher H.P. and a starting tractive effort of 34 tonnes, the electric locomotive is capable of hauling heavier trains at higher speeds. At present, however, it cannot be used to its full advantage due to old bridge abutments limiting maximum tractive effort to 30 tonnes and limitations of speeds with the existing goods rolling stock. The Table below indicates the balancing speeds on the grades of the two types of locomotives:

Table - 5.1

Balancing speeds of WDM₂ Diesel and
WAM₄ Electric locomotives.

	Km/h	
	Balancing speed	
	WDM ₂	WAM ₄
<u>Loads:</u>		
A. <u>Box Wagons</u>		
3600 t on level	65	70
2800 t on 1 in 200	25	42
2400 t on 1 in 150	23	39
1800 t on 1 in 100	20	35
B. <u>4-wheelers:</u>		
2250 t on level	65	70
2250 t on 1 in 200	30	48
2000 t on 1 in 150	25	42
1580 t on 1 in 100	23	39

contd...

2.2 On routes identified for running of heavier freight trains of 3600/4500 tonnes, the potential of electric locomotives could be exploited further in future.

2.3 The Committee have examined the performance of diesel and electric locomotives as found in the Statistical Returns of four Railways viz. Eastern, Northern, Central and Western Railways. Tables 5.2 to 5.3 indicate Engine kilometres, Gross tonne kilometres hauled (Trailing) per annum per engine, both 'in use' and 'on line'*. The Committee have considered both Engines 'in use' and 'on line' statistics. Since 'on line' figures are affected by locomotives available and not actually used, the percentage of locomotives under repair and scheduled maintenance of both diesel and electric locomotives being about the same (See table 5.4), the Committee have considered Engines 'in use' figures as more reliable with which to judge the performance of locomotives.

2.4 The above statistics is further affected by a large number of 3000 H.P. four-axle A.C. electric locomotives of which 3600 H.P.- WAM4 types constitute only a minority of 30% on the four Railways considered. In case of diesels, the bulk of locomotives are 2600 H.P.- WDM2 (or equally powerful WDM4). These form 85% of the total population.

2.5 Electric locomotives have also recorded higher average speeds as compared to diesels.

2.6 Based on the above considerations, the Committee have adopted a ratio of 1:1.2 between WAM4 Electric and WDM2 Diesel for the Study.

3. Mail and Express trains: For service on the mail and express trains, against 16 to 17 coaches hauled by diesel locomotives, electric locomotives can haul upto 24 coaches. With a plan to haul trains with more coaches per train to deal with longer trains, after the terminals are developed, the potential of electric locomotives can be used more fully. Even today on Delhi-Howrah route, the electric locomotives haul 19 coaches on the the

contd...

*'On line' figures indicate the total locomotives available on a Railway while those 'in use' include those actually used for traffic. The difference between these 'on line' and 'in use' account for the locomotives under repairs and maintenance, stored in good condition, and those available for use, but not utilised for traffic.

Howrah-Kalka Mail. With longer composition of trains, diesel traction will require double heading. Since the terminals are not capable of taking such trains at present and the option of using 2 trains as an alternative also exists in place of double heading on diesel, particularly on routes where capacity is not a problem, the Committee have adopted the same ratio of 1:1.2 as taken for the goods trains, for mail and express passenger trains.

4. Stopping passenger trains: At present on dieselised sections, these are hauled by steam locomotives but these would be replaced by diesels gradually as the steam locomotives are condemned. In view of this, for stopping passenger trains, where number of coaches are less than 17, a ratio of 1:1 between Diesel and Electric has been adopted.

5. Locomotives adopted for Study: Keeping in view the performance over the last few years, the potential of using higher horse power in future and the known constraints of bridges, rolling stock and the alternative of two trains vis-a-vis one with double headed diesel locomotive, the Committee have adopted the ratio of 1:1.2 for goods and mail & express trains and 1:1 for stopping passenger trains.

Table - 5.2

Diesel and Electric Locomotives

Engine performance

a) Engine kilometres per day per engine 'On Line':

Years	Central Railway		Eastern Railway		Northern Railway		Western Railway	
	Die-'sel.	'Elec-'tric.	Die-'sel.	'Elec-'tric.	Die-'sel.	'Elec-'tric.	Die-'sel.	'Elec-'tric.
1974-75	293	356	190	246	293	287	272	273
1975-76	297	320	219	269	323	312	267	263
1976-77	314	281	263	257	305	321	306	286
1977-78	303	302	273	240	295	286	290	307

b) Engine kilometres per day per engine 'In Use':

1974-75	370	455	222	313	322	346	312	341
1975-76	364	455	260	335	355	365	349	448
1976-77	430	522	524	562	348	365	441	546
1977-78	416	535	525	554	336	326	429	558

{Figures taken from Annual figures of Statement 4A
(monthly) submitted by Railways to Railway Board.}

contd...

Table - 5.3

GTKM hauled (excluding weight of engine & departmental) per day (103)

a) Per Engine 'On Line' :

Year	Central Railway		Eastern Railway		Northern Railway		Western* Railway	
	Die- sel.	Elec- tric.	Die- sel.	Elec- tric.	Die- sel.	Elec- tric.	Die- sel.	Elec- tric.
1974-75	343	433	229	366	412	419	420	406
1975-76	363	381	266	403	464	494	428	352
1976-77	389	346	318	387	441	537	469	376

b) Per Engine 'In Use' :

1974-75	432	553	265	466	453	502	484	469
1975-76	444	542	318	502	508	582	557	603
1976-77	499	643	627	846	505	594	675	698

NOTE: (1) Total GTKMs taken from Annual Statistical Supplement of Indian Railways, Statement 16(Col.5) and number of locomotives 'on line' and 'in use' taken from Annual average of Monthly Statement 4A submitted by the Railways to Railway Board.

(2) Figures for 1977-78 for GTKM are not available.

* Complete section on Western Railway energised in December, 1974.

Table - 5.4

Percentage of locomotives under or awaiting repairs and maintenance of total locomotives holding on a Railway.

Year	Central Railway		Eastern Railway		Northern Railway		Western Railway	
	Die- sel.	Elec- tric. (A.C.)	Die- sel.	Elec- tric. (A.C.)	Die- sel.	Elec- tric. (A.C.)	Die- sel.	Elec- tric. (A.C.)
1974-75	20.2	18.3	13.7	21.4	9.0	15.2	13.0	5.5
1975-76	18.1	15.1	15.0	19.1	8.7	14.7	15.3	8.8
1976-77	22.1	16.4	23.7	25.0	12.6	13.7	14.5	7.8
1977-78	21.8	21.0	21.4	18.9	12.3	12.7	20.4	7.5

NOTE: These percentages have been derived from the annual cumulative of the monthly Statements 4A submitted by the Railways to Railway Board, and obtained as below:

Average total number on line - Average No. effective for use X10000

Average total number on line

.....

Fuel and Energy consumption norms
and their costs.

1. This norm is the rate of consumption of fuel or energy for the work done by the locomotive in hauling traffic. The specific fuel/energy consumption is affected by a number of factors. This includes the load of train, the topography of the route, type of stock used, type of bearings, speeds attained, the number of starts and stops and number of speed restrictions enroute. It further varies from driver to driver and in the case of diesel locomotives, on the condition of the diesel engine. Even under controlled trials for the same type of load and section, the results obtained exhibit considerable scatter*. The trials if attempted would need to be extended for a large period of time with the type of traffic changing all the time. Sections with diesel traction are not available for trials with electric traction. Reliable long term data of specific fuel consumption over a dieselised section is not available.

2.1 The Committee, therefore, decided that the best course would be to obtain the specific fuel/energy consumption figures from statistical data of the Railways averaged over a sufficiently long period of time to arrive at a stable value which could be considered valid.

2.2 As an overall assessment of the specific fuel and energy consumption, an all India norm including both passenger and goods GTKMs over a 10 - year period was attempted as shown at graph G-7. In arriving at all India figures, accountal of running of diesel engines of one Railway over the neighbouring Railway system, and in the case of electric traction apportionment of energy between goods and passenger services are not required. It is seen that in 1976-77 the overall specific fuel/energy consumption was the lowest ever recorded for both diesel and electric traction.

contd...

* Letter No. ETL/Policy dated 13.1.78 from Shri K.A.Jacob, Director General, Research Design and Standards Organisation, Ministry of Railways, Lucknow to Shri J.A.Raj, Convener.

2.3 Table - 1 indicates specific fuel and electric energy consumption rates of various B.G. Railways from 1974 to 1977. For comparison, similar norms obtained by Sahai Committee have also been furnished in the same table. It is noticed that the norms vary from Railway to Railway and even on the same Railway, over a period of time.

2.4 To arrive at reliable energy/fuel consumption norms for the sections identified for electrification, the Committee finally decided to take the consumption rates for Central, Northern and Western Railways averaged over a period of 3 years from 1974-75 to 1976-77 as the Project taken for study lies in that area. This averaging would yield sufficiently stable and reliable norms.

2.5 In arriving at the norms, it is essential to realise that for electric locomotives the traffic hauled by all the locomotives in the areas fed by a sub-station is accounted for against the energy consumption, while for diesel locomotives the work done by a locomotive of owning Railway and its fuel consumption on the other Railways have to be properly apportioned. This has been ensured.

3.1 While arriving at the specific fuel/energy consumption norms for goods traffic, the traffic hauled has been based on commercial documents although Indian Railways maintain another set of domestic figures which is based on the Vehicle Guidance given to the Guards. There is some difference in the GTKMs arrived at between the two sets of figures. This is on account of approximation used in arriving at the weights of trains in the Vehicle Guidance. On the other hand chance diversions of trains through alternative longer routes are not accounted for in the ~~Vehicle~~ commercial figures. The Committee, decided to consider the traffic figures based on Commercial Documents as more reliable of the two and have used the same to arrive at the norms.

3.2 Aberrations, introduced due to the following have also been removed from the calculation:

- (i) D.C. traction on Central Railway.
- (ii) Diesel Hydraulic locomotives of Central and Northern Railways.

contd...

(iii) Diesel Electric bankers on Central Railway.

(These have been obtained from the Domestic Statistics of the concerned Railways, and substracted from the figures of gross tonne kilometres and energy/fuel consumption totals).

4.1 The norms which have been arrived at are:-

	Specific fuel/energy consumption per 1000 GTKM.	
	<u>Electric traction</u> KvH	<u>Diesel traction</u> litres of H.S.Diesel.
Passenger, Mail & Express	... 20.71	4.77 (Mail & Exp.)
Goods	... 11.08	3.60

4.2 GTKM for passenger trains include both stopping passengers and mails & expresses. A further calculation is required to get separate norm for the two types of services for Electric. Diesels do not haul stopping passenger trains at present, and a norm for stopping passenger trains had to be evolved for diesel locos.

4.3 For Electric Traction, assuming the proportion of Central Railway figures between stopping passengers, mails and expresses, and goods as 3%, 13.8% and 83.2% respectively and assuming the Sahai Committee norm of stopping passenger trains at 25.1 kwh per 1000 GTKM, the figure for mails and expresses has been abstracted from the composite one arrived at. In case of Diesel Electrics, the norm for stopping passenger trains has been arrived at in proportion to the norms arrived at by the Sahai Committee for flat sections. The final figures taken for the purposes of the Study are as below:-

	<u>Electric traction</u> KWH	<u>Diesel traction</u> litres of HSD.
Passengers	... 25.1	5.52
Mail & Express	... 19.81	4.77
Goods	... 11.08	3.60

4.4 For Electric Traction the above norms include energy used for station lighting, colour light signalling and repeater stations. Based on the assessment made in the E.B. Study 7/71, 5 1.35% of the total energy arrived at from the above norms is also assumed as utilised for such purposes.

contd...

5. Economic benefits of Electrification at 25 kV system on Howrah-Rourkela section of S.E. Railway. Efficiency Bureau Study No. 7/1971, Ministry of Railways.

5. Comparison with Sahai Committee norms with those arrived at above, reveals that the spread of the norms for Diesel and Electric Locomotives are fairly similar. Specific fuel consumption figures obtained for Diesel Traction are lower than those in the Sahai Committee, while those for Electric Traction are higher. Such variations are not unexpected on account of the fact that, unlike the assumptions in Sahai Committee Report, the speeds and loads are lower, the diesel and electric locomotives operate on different sections and electric locomotives, being more powerful, achieve higher average speeds.

6. In arriving at the above norms for diesel fuel consumption, light running between sheds and yards, shunting enroute, consumption in sheds, on trials are not taken into account. Separation of consumption of electric energy for similar purposes is not possible and therefore the entire energy consumed has been assumed for hauling of traffic. This approximation is not expected to influence the results arrived at.

7.1 Analysis of cost of H.S.D.Oil and (Lubricating oil) (Financial & Economic) is given in Table - 2.

7.2 Analysis of cost of Electric energy (Financial & Economic) is as under:

7.2.1 Financial :- For Delhi-Jhansi power supply will be required at 6 sub-stations, one from Haryana, two from U.P., one from Rajasthan and two from M.P.. Basing the cost of energy on average purchase price from April to December, 1977 for U.P.S.E.B. and M.P.E.B. and on high tension industrial tariff of Haryana and Rajasthan at 40% load factor, the cost of energy per kwh is worked out as follows:-

	Paise.	No.of <u>Sub-stations.</u>
Haryana State Electricity Board ...	15.96	1
Uttar Pradesh State Electricity Board ...	24.73	2
Madhya Pradesh State Electricity Board ...	21.16	2
Rajasthan State Electricity Board ...	21.44	<u>1</u>
		<u>6</u>
Average rate for the section works out to ...	21.52 Paise.	

c ntd...

Similarly for Gangapur City - Mathura, Power supply will be needed at 2 sub-stations in Rajasthan at 21.44 Paise per kwh. Adding the latest levies on generation and surcharge on coal for thermal generation only an increase in cost of electricity of 2.4 Paise, a round figure of 24 Paise per kwh has been taken.

7.2.2 Economic cost.- The cost of generation for 1976-77 for a few State Electricity Boards as available from Central Electricity authority is given in table - 3. As the transmission and distribution costs of State Electricity Boards include the costs incurred on their entire transmission and distribution net work which includes the agricultural and rural lines with high maintenance costs and line losses, these are not relevant to costs of transmission at 132 kV at which the Railways buy their traction energy. The cost of an administration which has only such a net work should be examined. This is readily available from the Annual Report of D.V.C. for 1976-77, given in the same table.

If the same cost as that of D.V.C. for transmission and distribution is taken at 1 Paise per kwh and added to the cost of generation (as indicated in Table-3) the cost of electricity at Railways' sub-stations for 1976-77 would work out as under:-

<u>S.E.B.</u>		<u>Paise per kwh including transmission.</u>
M.P.	...	11.31
Gujrat	...	16.78
DESU	...	16.95
Bihar	...	16.17
DVC	...	12.69

However, taking a most adverse case, 20 Paise per kwh has been considered as the economic cost.

....

TABLE - 1

Figures of fuel/energy consumption for locomotives for the period 1974-75 to 1976-77 (3 years).

(From Indian Railways Annual Statistical Supplements)

(a) Diesel Traction

Diesel Fuel consumption per 1000 GTKM.

(in litres.)

Year.	Central.		Eastern.		Northern.		Southern.		South Central.		South Eastern.		Western.		All India.	
	P	G	P	G	P	G	P	G	P	G	P	G	P	G	P	G
74-75	5.18	3.94	5.50	3.42	5.23	3.37	5.48	3.37	4.93	3.55	5.46	4.12	5.13	3.68	5.29	3.81
75-76	4.59	3.78	5.22	3.54	5.02	3.33	5.52	3.82	3.67	3.56	5.16	4.04	4.81	3.88	4.88	3.75
76-77	4.25	3.71	5.19	3.24	4.81	3.24	5.39	3.92	3.22	3.57	4.17	3.56	4.95	3.74	4.84	3.57

(b) Electric Traction

Electric Energy consumption in KWH/1000 GTKM (including D.C.)

74-75	21.8	18.0	23.0	12.0	25.3	11.0					25.1	14.4	22.2	12.1	22.1	13.1
75-76	21.8	19.1	23.0	11.9	25.3	10.5					25.1	13.2	20.1	13.6	22.4	12.8
76-77	24.1	15.6	23.5	12.1	25.1	9.48					24.0	12.5	21.7	13.6	23.4	11.8

NOTE:- P - Passenger, G - Goods.

Sahai Committee norms

Diesel fuel in litres per 1000 GTKM

	Passenger	Mail & Express	Through Goods
Level ...	5.73	4.96	3.88
Grades 1:100 ...	7.05	5.95	4.00
	<u>Electric energy consumption in KWH/1000 GTKM</u>		
Level ...	25.7	18.80	9.92
Grades 1:100 ...	25.1	17.80	12.42

TABLE - 2.Cost of H.S.D. Oil & Lubricating Oil per Kilo Litre.I. FINANCIAL:-(A) H.S.D. Oil(Effective from
April, 1978.)

	Delhi-Jhansi Section. Rs.	Mathura-Gangapur City section. Rs.
(i) Basic rate at main installation Bombay	1113.90	1113.90
(ii) Central Sales Tax @ 4%	44.56	44.56
(iii) Freight including siding charges	113.00	79.00
(iv) DGS&D's Commission 1%	11.14	11.14
(v) Handling charges	10.00	10.00
TOTAL:	1292.60	1258.60

(B) Lubricating Oil

(i) Basic rate F.O.R. Bombay	7400.00	7400.00
(ii) Central Sales Tax @ 4%	296.00	296.00
(iii) Freight assuming 50% supply in drums and 50% in tank wagons	119.20	83.33
(iv) DGS & D's Commission 1%	74.00	74.00
(v) Handling charges	10.00	10.00
TOTAL:	7899.20	7863.33

contd...

II. ECONOMIC:-(A) H.S.D. Oil

Financial cost.	Economic cost.	
	Without premium on Foreign Exchange.	With 15% premium on Foreign Exchange.
Rs.	Rs.	Rs.

DELHI-JHANSI SECTION:-

(i) Basic price (C.I.F. value)	898.00	898	1032.70
(ii) Duties and taxes	271.60	-	-
(iii) Freight charges (internal transport)	113.00	60	60
(iv) Handling charges	10.00	10	10
TOTAL:	<u>1292.60</u>	<u>968</u>	<u>1102.70 *</u>

* With 15% premium on Foreign Exchange plus additional 10% scarcity value, the cost of H.S.D.Oil will be Rs. 1192.50 per Kilo litre.

MATHURA-GANGAPUR CITY SECTION:-

(i) Basic price (C.I.F. value)	898.00	898.00	1032.70
(ii) Duties & taxes	271.60	-	-
(iii) Freight charges (internal transport)	70.00	42.90	42.90
(iv) Handling charges	<u>10.00</u>	<u>10.00</u>	<u>10.00</u>
TOTAL:	<u>1258.60</u>	<u>950.90</u>	<u>1085.60 **</u>

** With 15% premium on Foreign Exchange plus additional 10% scarcity value, the cost of H.S.D.Oil will be Rs. 1175.40 per Kilo litre.

(B) Lubricating Oil;

	Delhi-Jhansi section.	Mathura-Gangapur City section.
	Rs.	Rs.
Financial cost	7899.20	7863.33
Less Sales Tax	<u>303.82</u>	<u>302.44</u>
Economic cost	<u>7595.38</u>	<u>7560.89</u>

TABLE - 3.

(a) Pooled cost of generation by Electricity authorities.

Source:- Central Electricity Authority.

	(Paise per kwh)			
	1973-74.	1974-75.	1975-76.	1976-77.
Rajasthan	7.03	7.10	9.76	N.A.
M.P.	5.95	8.6	8.06	10.31
Gujrat	6.94	12.62	15.30	15.78
U.P.	12.23	13.66	N.A.	N.A.
Maharashtra -				
Hydro	2.25	1.99	2.92	N.A.
Thermal	9.83	10.75	13.23	N.A.
D&SU	10.51	14.86	17.69	15.95
Bihar	12.97	15.79	16.63	15.17
W.B.	7.80	8.87	13.36	N.A.
Orissa	5.56	7.18	6.90	N.A.

(b) Cost of generation, transmission & distribution of electricity by D.V.C. for 1976-77.

Source:- Annual Report of D.V.C. 1976-77.

i) Cost of generation	8.65	9.75	9.98
<u>Other costs of transmission & distribution</u>			
ii) Transmission & distribution	1.02	1.04	0.99
iii) Aux. consumption, transmission losses, purchase & subsidiary expenses	1.59	1.81	1.71
Total (ii) & (iii)	2.61	2.85	2.70
Cost of kwh for sale (i)+(ii)+(iii)	11.26	12.60	12.69

ANNEXURE - 7.Cost of repairs & maintenance of
Diesel and Electric Locomotives.

.....

1. The expenditure on account of repairs and maintenance of diesel and electric locomotives have continued to fluctuate from year to year and escalated in the last few years. Such fluctuations have also been noted by Sahai Committee.

2.1 Basically WDM₂ diesel and WAM₄ electric locomotives are similar in a number of details. They have identical wheels and bogies, similar suspension and drive through nose suspended traction motors. The two types of locomotives are different only in their means of providing power to traction motors and the power rating of the motors.

2.2 Electric locomotives have a current collecting Pantograph, transformer, tap changer, rectifier and auxiliary machines e.g. exhauster and compressors, driven electrically. The power handling equipment, i.e. transformers and rectifier are static equipment. The rotating equipment with wearing parts are relatively light, like tap changers, arno convertor, exhauster and compressors. The economic life of the locomotive according to Railways' Code is 35 years.

2.3 The diesel electric locomotive on the other hand has a 16-cylinder diesel engine which drives a generator, producing electric current which is then applied to traction motors. It has a super-charger and an expressor mounted on the same shaft. A governor and control gear which control the amount of current to the traction motor form the basic main equipment. "The power pack" consisting of engine and generator has an economic life span of 18 years when it needs to be replaced. Other components of the locomotives have an economic life span of 36 years. Need for replacement of cylinder blocks due to deformation at 10 year time interval has also been felt recently.

3.1 The comparison of cost of repairs and maintenance between the two types of locomotives, therefore, reduces itself mainly to difference in repairs and maintenance costs between that of prime-mover (the diesel engine) generator, controls and the ancillaries like super-charger and the Expressor on the diesel engine, and the power

contd...

handling and auxiliary equipment of electric locomotives. The repairs and maintenance of wheels, bogies, and traction motors are likely to be about the same on both the types. Since the power pack of the diesel engine ages at double the rate of the rest of the equipment of both electric and diesel locomotives, cost of its repairs is likely to increase at a faster rate.

3.2 On account of steep increase in cost of wages and materials in recent years, averaging of costs of repairs and maintenance over a period of years is likely to give low figures. It is more realistic to obtain such costs for the latest year for which complete accounts have been received. It has also to be ensured that these costs are realistic and extraneous factors such as heavy expenditure on account of accumulated overdue repairs and acquisition of spares without utilization during the period are eliminated from the routine repairs and maintenance costs. Costs for 1976-77 have been taken.

4. The committee were unable to abstract a conclusive data on costs of repairs and maintenance from the available statistical data on account of the reasons detailed below:-

- (i) Statistical data of a Railway furnishes the overall costs. The break up of the cost amongst sheds and on different types of locomotives is not available. Even these bookings at times are inaccurate.
- (ii) In the accounting procedure followed on the Railways system the detailed heads of accounts for items of works done for diesel and electric locomotives are different. In booked expenditure some details of work done on diesel locomotives are available, but such bookings for electric locomotives are not available. Further, it is not possible to separate the cost of normal repairs and maintenance from that on accumulated work or special repairs done, both for running repairs and periodic overhauls.
- (iii) For electric locomotives special repairs, accident repairs, modifications like conversion of Ignitrons to Silicon rectifiers due to obsolescence etc. are booked alongwith the periodic overhauls and termed as workshop repairs. In addition the costs of mechanical repairs include repairs to electric multiple units also. In the data published in Indian Railways Annual Statistical Supplement, other

contd...

costs like repairs and maintenance to track bonding, plant in generating stations etc. are also considered part of electric traction and combined with locomotive repairs.

- (iv) In diesel traction inaccuracies in booking had been observed in the past on certain Railways on account of un-skilled shed staff being booked to Operating expenses (as against Repairs and Maintenance) and fueling point staff booked to heads of steam traction.

5. Costs of Repairs & Maintenance

The Committee, therefore, felt that the best course would be to obtain costs of normal repairs and maintenance from the spending units i.e. Running Sheds for Running Repairs and from workshops for periodic overhauls for the types of locomotives being considered by the Committee.*

5.1 Running Repairs

In regard to running repairs and maintenance costs, the Committee considered the following sheds as representative from which the repairs and maintenance costs for 1976-77 were collected to derive the costs on engine KM basis. These are: Ratlam shed, which homes 122 WDM₂ diesel electric locomotives and the adjacent Vadodara Electric Locomotive shed which homes a total of 56 WAM₄ and WCAM₁ (similar to WAM₄, with additional equipments to make it suitable for running both on AC 25 KV and DC 1500 V. system) locomotives, both on the Western Railway. It has been ascertained from the sheds that no special work has been carried out in these two sheds. The figures as collected from these two sheds are as below :-

contd...

* Similar conclusions were drawn in Efficiency Bureau, Ministry of Railways' Study No. 7/1971 - Economic benefits of Electrification at 25 kV system on Howrah - Rourkela section on S.E. Railway.

T A B L ELocomotive repairs and maintenance costs 1976-77.

LOCO TYPE :	...	Diesel.	AC Electric.		
SHED :	...	Ratlam, W.Rly.	Vadodara, W.Rly.		
HOLDING :	...	Max. - 126 Min. - 122	Max. - 57 Min. - 56		
		Detailed head of account.	Expendit- ure in thousand rupees.	Detailed head of account.	Expendit- ure in thousand rupees.
Wages	B 2611	3532 *	H 2132)	6323
Materials	B 2611	16300	H 2132)	
Wages	B 2612	258	-)	
Materials	B 2612	296	-)	
Wages	-		H 2141(b))	
Materials	-		H 2141(b))	
D.A.	B 2413	1167	H 2511)	
(Machines & Tools) -					
Wages	B 2631	45	H 2161	(74
Materials	B 2631	155	H 2161	(
Supervisory staff	-	**	H 2001		321
Office staff		203			39
		21956			6757
		-----			-----
Engine KMs in thousand		15494			6361
Cost per engine KM (In rupees)		1.417			1.062

contd...

NOTES: - * Includes staff at Bandra for running repairs of Ratlam based locos.

-** Included in B 2611.

5.2 Workshop repairs:

For P O H of diesel electric locomotives, the unit cost of P O H for the year 1976-77 of Kharagpur shops has been taken for the study. At Kharagpur, in 1976-77, 65 locos were given periodic overhauls. Of these 49 were WDM₂ and 15 WDM₁ type and one WDS5. The 15 WDM₁ overhauled are older engines, but have only 12 cylinders against 16 of WDM₂. It is felt that any distortion to costs introduced by taking into account the P O H of WDM₁ locomotives will be minor. Kharagpur Shops do not compute unit P O H cost for different types of locomotives separately. The unit cost of P O H of diesel electric locomotive for 1976-77 is Rs. 3.19 lakhs per locomotive.

For P O H of electric locomotives, there are two workshops, which are nominated for overhaul of electric locomotives. Of the two, Kanchrapara and Bhusaval, only the latter is nominated for P O H of WAM₄ electric locomotives from which unit cost of P O H has been obtained. This is Rs. 2.26 lakhs per locomotive.

In the study, it is assumed that 1/6th of the total number of locomotives are given their periodic overhaul every year, so that the entire cycle is completed in 6 years' time.

ANNEXURE - 8.

(A) Energy policy of Government of India and (B) Extract of Chapter - 10, "Energy" from Draft Five Year Plan 1978-83.

(A) NATIONAL ENERGY POLICY:-*

7.1 Energy is one of the basic and most essential inputs for the economic progress of the country, and the well being of the people. Accordingly, the development of various forms of energy has high priority in the country's overall developmental activities. The dramatic changes in the world energy situation since 1973, and their impact on the overall economy focussed attention on the need for an integrated approach to planning and development of the energy sector, and formulation of a comprehensive energy policy to guide the energy economy on desired lines. The Fuel Policy Committee submitted its report in August, 1974. While considering the recommendations of the Fuel Policy Committee, it was considered opportune to devote attention to the general problems of energy in the country, and formulate a broad outline of a coherent and well thought-out energy policy, which could make available energy to all sectors of the economy in adequate quantities, in a reliable manner and at the cheapest possible price.

7.2 During the year, the Government approved the broad outline of the national energy policy. The main components of the policy approved by the Government were as follows:-

- (a) To the extent practicable and economic, Coal shall be the principal source of energy in the country and, therefore, its exploration, exploitation and utilisation should be programmed accordingly.
- (b) The policy for oil shall be to reduce the quantity of imports and to maximise indigenous production.
- (c) Use of oil shall be substituted, wherever technically and economically possible, by other forms of energy.

Contd...

* Extracted from Chapter - VII, Annual Report, 1976-77, Ministry of Energy, Department of Power.

- (d) The rate of growth of electricity production should be adequate to meet future needs, including the additional demands arising from the use of electricity in place of oil.
- (e) Electricity production should be based on the use of hydro-power, coal and nuclear energy.
- (f) The policy relating to commercial forms of energy should be reviewed every year in the first instance.
- (g) A study of the transport systems, in terms of energy needs, should be made so as to plan the future growth of this sector.
- (h) Meeting rural energy needs shall be given high priority.
- (i) A rapid increase should be made in the use of bio-gas.
- (j) The social forestry programme should be implemented more effectively.
- (k) Alternative fuels to kerosene should be provided and consumption of kerosene discouraged, particularly by the use of the price mechanism.
- (l) Energy production and utilisation must be made as efficient as possible.
- (m) The pricing for energy should be such that at reasonable level of operating efficiency, an adequate return to the industry is guaranteed, and it is able to generate large funds for development purposes. Prices should also promote the desired pattern of energy use and promoting energy conservation.
- (n) The non-conventional energy sources like solar and geo-thermal energy, tidal power, etc., should be developed with the greatest priority to solar energy and bio-gas.
- (o) The R & D programmes relating to energy should be pursued vigorously.

contd...

- (p) Implementation of the energy policy should be adequately monitored and frequently reviewed.

7.3 The implementation of the various components of the energy policy requires interaction between several Ministries/Organisations in the Centre. Discussions have been taken up with the concerned Ministries/Organisations to work out the detailed proposals in regard to implementing the major components of the above policy."

- (B) Extract of Chapter - 10 "Energy" from Draft Five Year Plan 1978-83. *

CHAPTER - 10

ENERGY

X X X X X X X

10.3 Viewed from the angle of energy supply, coal will be the main source for the next few decades whether through direct use or thermal power generation. The performance of the coal industry in the recent past inspires confidence that it could meet the increasing energy demand arising in the coming years. With its versatility of application and ease of transport over long distances, the importance of electricity as a source of energy will increase further. As between electricity in its primary form generated from hydel and nuclear source and its secondary form generated from coal, it is the latter which will be predominant during the next five years. The long time required for the proper investigation of hydro projects and the even longer time taken for construction will inevitably mean a relatively slow growth of hydro generation. As for nuclear power, it is the consideration of costs which will primarily determine its pace of expansion. Having regard to its relatively higher capital requirements, creation of new nuclear power generation capacity will be restricted to locations where nuclear power is competitive with coal based power. Till such time as fast breeder reactors using our thorium deposits become technically dependable and commercially viable and the problem of dealing with operational mishaps and disposal of spent fuel have been overcome, nuclear power is unlikely to play a major role in our power programme. Further rise in consumption of oil products will be kept within manageable limits through appropriate measures,

contd...

* Planning Commission 18-4-78.

such as substitution of oil by coal in industries for furnace and steam raising, gradual electrification of railway traction and replacement of diesel pumps sets by electrical pump sets through an intensified programme of rural electrification.

X X X X X X

PETROLEUM

Plan 1978-83.

10.48 It is estimated that the consumption of petroleum products will reach a level of about 36 million tonnes in 1982-83. The demand projections for the period 1978-83 are given below:-

TABLE 10.6 : Demand Projections of Petroleum Products:

Year (1)	Quantity of Product. (2)
(In million tonnes)	
1976-77 (Actual)	24.07
1977-78 (Anticipated)	25.64
1978-79	28.01
1979-80	30.15
1980-81	32.47
1981-82	34.36
1982-83	36.32

10.49 In the next five years, exploration for oil will be intensified; this is necessary not only to ensure an adequate reserve-to-production ratio to sustain the present level of production, but also to be able to meet the country's increasing demand for petroleum in the coming critical decades when international oil supplies may start tapering off or prove prohibitively expensive.

DELHI-JHANSI & MATHURA-GANGAPUR CITY SECTION

Forecast of daily Goods throughput
(In terms of 4 wheelers)

ANNEXURE - 9.

SECTION	1983-84				1988-89				1993-94				
	Ave- rage No. of train.	Loa- ded.	Empty.	Total.	Ave- rage No. of train.	Loa- ded.	Empty.	Total.	Ave- rage No. of train.	Loa- ded.	Empty.	Total.	
AGRA - JHANSI	UP	14.6	530	380	910	16.9	610	437	1047	19.4	701	503	1204
	DN.	18.0	1095	25	1120	21.2	1285	30	1315	24.9	1513	36	1549
MATHURA-AGRA	UP	15.3	550	400	950	17.3	614	460	1074	19.6	687	529	1216
	DN.	18.5	990	160	1150	21.3	1155	167	1322	24.6	1353	175	1528
TUGHLAKABAD- MATHURA	UP												
	(CR)	17.6	425	670	1095	19.2	489	704	1193	21.0	562	743	1305
	(WR)	11.7	425	300	725	13.1	489	323	812	14.7	562	350	912
	DN.												
	(CR)	20.2	1255	-	1255	22.8	1417	-	1417	25.9	1611	-	1611
	(WR)	12.1	690	60	750	14.0	799	72	871	16.3	930	86	1016
MATHURA-BAYANA	UP	11.7	425	300	725	13.5	489	345	834	15.5	562	397	959
	DN.	11.6	690	30	720	13.4	799	36	835	15.7	930	43	975
BAYANA-GANGAPUR CITY	UP	15.2	585	360	945	17.5	673	414	1087	20.2	774	476	1250
	DN.	14.6	830	80	910	17.1	967	96	1063	20.1	1131	115	1246

NOTE:- (i) 20% increase in traffic other than POL and Coal for every 5 year period for Dn. direction and 15% for Up direction have been considered in the forecast beyond 1983-84.

(ii) No increase is considered for POL and Coal beyond 1983-84.

DELHI-JHANSI & MATHURA-GANGAUR CITY SECTION

Traffic projections for Mail & Express trains based on annual growth rate of 4.7% over base year 1977-78.

Sl. No.	SECTION.	Train No. Dn/Up	Year 1977-78			Year 1983-84			Year 1988-89			Year 1993-94		
			No. of coaches.			No. of coaches.			No. of coaches.			No. of coaches.		
			Passenger	Other	Total	Passenger	Other	Total	Passenger	Other	Total	Passenger	Other	Total
1.	JHANSI-DELHI	5/6	11	2	13	14	2	16	17	2	19	19	2	21
2.	AGRA-DELHI	7/8	13	1	14	17	1	18	20	1	21	23	1	24
3.	JHANSI-NEW DELHI	15/16	17	1	18	22	1	23	26	1	27	30	1	31
4.	JHANSI-NEW DELHI	17/18	6	7	13	8	7	15	9	7	16	11	7	18
5.	JHANSI-NIZAMUDDIN	21/22	13	2	15	17	2	19	20	2	22	23	2	25
6.	JHANSI-NEW DELHI	57/58	13	2	15	17	2	19	20	2	22	23	2	25
7.	AGRA-NEW DELHI	79/80	9	2	11	12	2	14	14	2	16	16	2	18
8.	AGRA-NIZAMUDDIN	149/150	11	1	12	14	1	15	17	1	18	19	1	20
9.	JHANSI-NIZAMUDDIN	137/138	15	1	16	19	1	20	23	1	24	26	1	27
10.	JHANSI-NEW DELHI	121/122	10	3	13	13	3	16	15	3	18	18	3	21
		123/124	12	2	14	15	2	17	18	2	20	21	2	23
		125/126	11	3	14	14	3	17	17	3	20	19	3	22
11.	JHANSI-NIZAMUDDIN (5 days)	131/132	13	4	17	17	4	21	20	4	24	23	4	27

contd...

ANNEXURE - 9. (Contd.)

Sl. No.	SECTION.	Train No.	Year 1977-78			Year 1983-84			Year 1988-89			Year 1993-94		
			No. of coaches			No. of coaches			No. of coaches			No. of coaches		
			Dn/Up	Pass-enger	Other	Total	Pass-enger	Other	Total	Pass-enger	Other	Total	Pass-enger	Other
12.	JHANSI-NIZAMUDDIN	143/144 (1 day)	14	1	15	18	1	19	21	1	22	25	1	26
13.	JHANSI-NIZAMUDDIN	77/78 (4 days)	14	1	15	18	1	19	21	1	22	25	1	26
Total coach day per week			...		1144			1429			1659			1881
Daily average coach day			...		163			204			237			269

Probable composition of trains (In terms of coaches)

<u>Trains</u>	<u>Year 1977-78.</u>	<u>Year 1983-84.</u>	<u>Year 1988-89.</u>	<u>Year 1993-94.</u>
(a) With 22 coaches ...	As above.	-	1	6
(b) With 20 coaches ...	--do--	2	1	-
(c) With 17 coaches ...	--do--	8	9	8
(d) With 14 coaches ...	--do--	2	3	-
TOTAL No. of Trains (Daily)		12	14	14

MATHURA - GANGAPUR CITY SECTION

Sl. No.	SECTION	Train No.	Year 1977-78			Year 1983-84			Year 1988-89			Year 1993-94		
			Dn/Up	No. of coaches		Pass-enger	No. of coaches		Pass-enger	No. of coaches		Pass-enger	No. of coaches	
				Other	Total		Other	Total		Other	Total		Other	Total
1.	DELHI-GANGAPUR CITY	3/4	14	3	17	18	3	21	21	3	24	25	3	28
2.	DELHI-GANGAPUR CITY	19/20	13	4	17	17	4	21	20	4	24	23	4	27
3.	DELHI-GANGAPUR CITY	23/24	9	4	13	12	4	16	14	4	18	16	4	20
4.	NEW DELHI-GANGAPUR CITY (2 days = Pashchim Exp.) (5 days = A.C. Express) *	25/26	13	3	16	17	3	20	20	3	23	23	3	26
5.	NEW DELHI-GANGAPUR CITY (2 days)	171/172	12	2	14	15	2	17	18	2	20	21	2	23
Total coaches per week: ...			469		530		663		763					
Daily average coach day: ...			67		83		95		103					

Probable composition of trains (In terms of coaches)

<u>Trains</u>	<u>Year 1977-78.</u>	<u>Year 1983-84.</u>	<u>Year 1988-89.</u>	<u>Year 1993-94.</u>
(a) With 22 coaches ...	As above	-	1	2
(b) With 20 coaches ...	--do--	1	-	-
(c) With 17 coaches ...	--do--	2	2	2
(d) With 14 coaches ...	--do--	2	3	2
Total No. of Trains (Daily)		5	6	6

* Converted to a daily train in terms of coaches.

ANNEXURE-9 (Contd.)

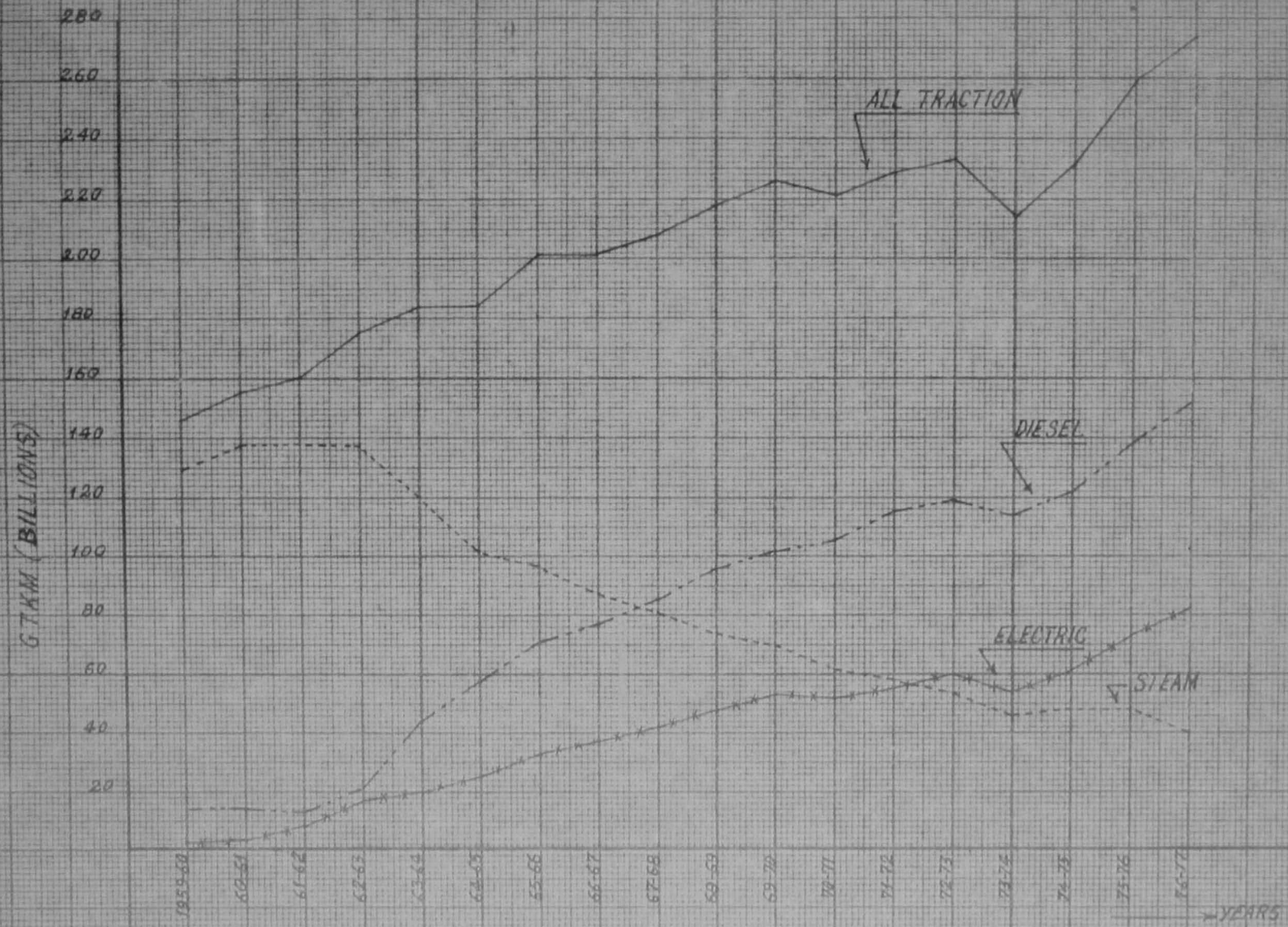
G R A P H S

AND

M A P S

(G-1)

FREIGHT TRAFFIC HAULED UNDER DIFFERENT MODES OF TRACTION (B.G.)



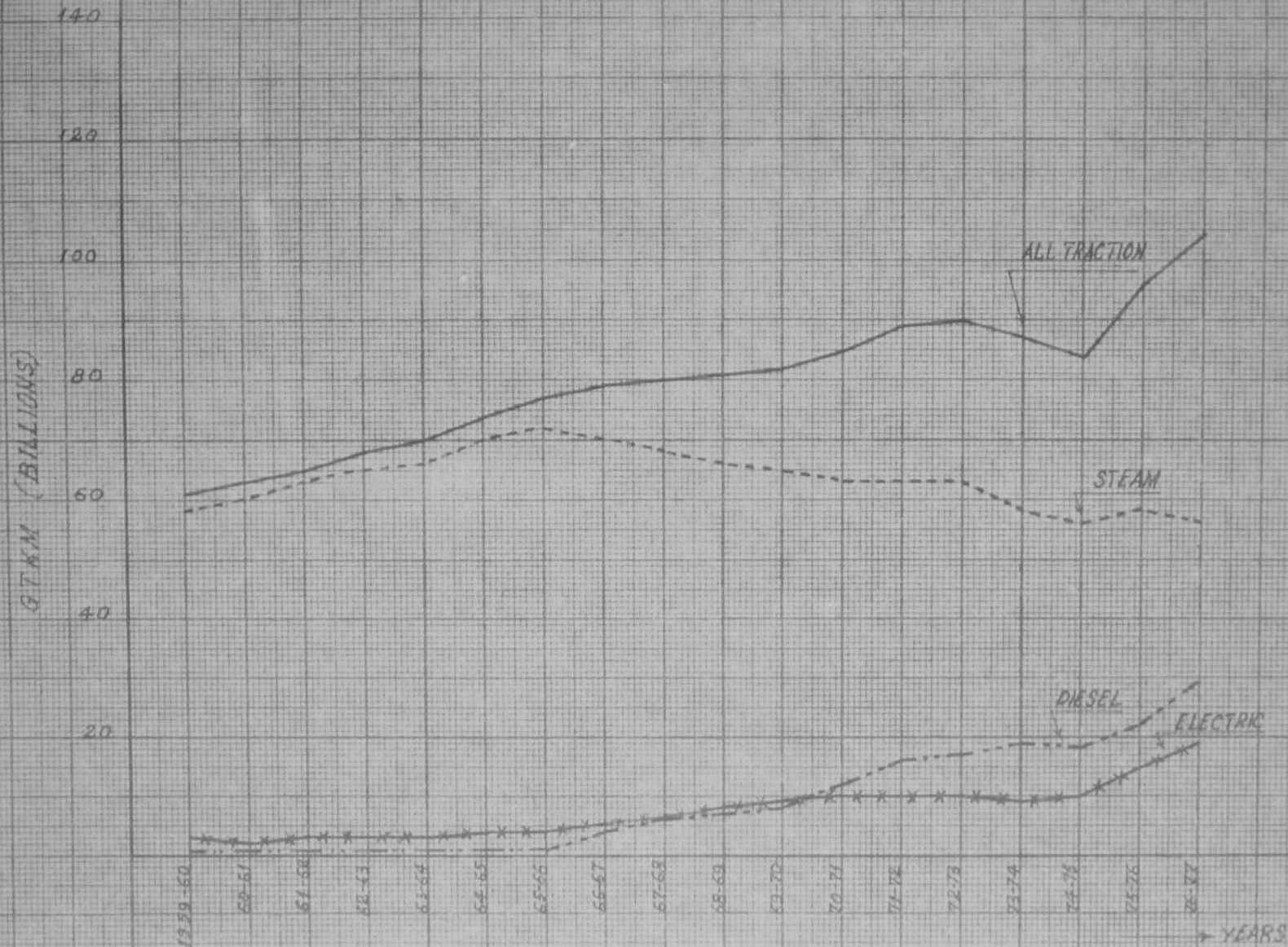
DRG NO. RB/RE(F) DRG/7X/69

G-1

101

(G-2)

PASSENGER TRAFFIC HAULED UNDER DIFFERENT MODES OF TRACTION (B.G.)
(EXCLUDING EMU'S)



DRG. NO. RE/RE(B) DRG./78/70

G-2

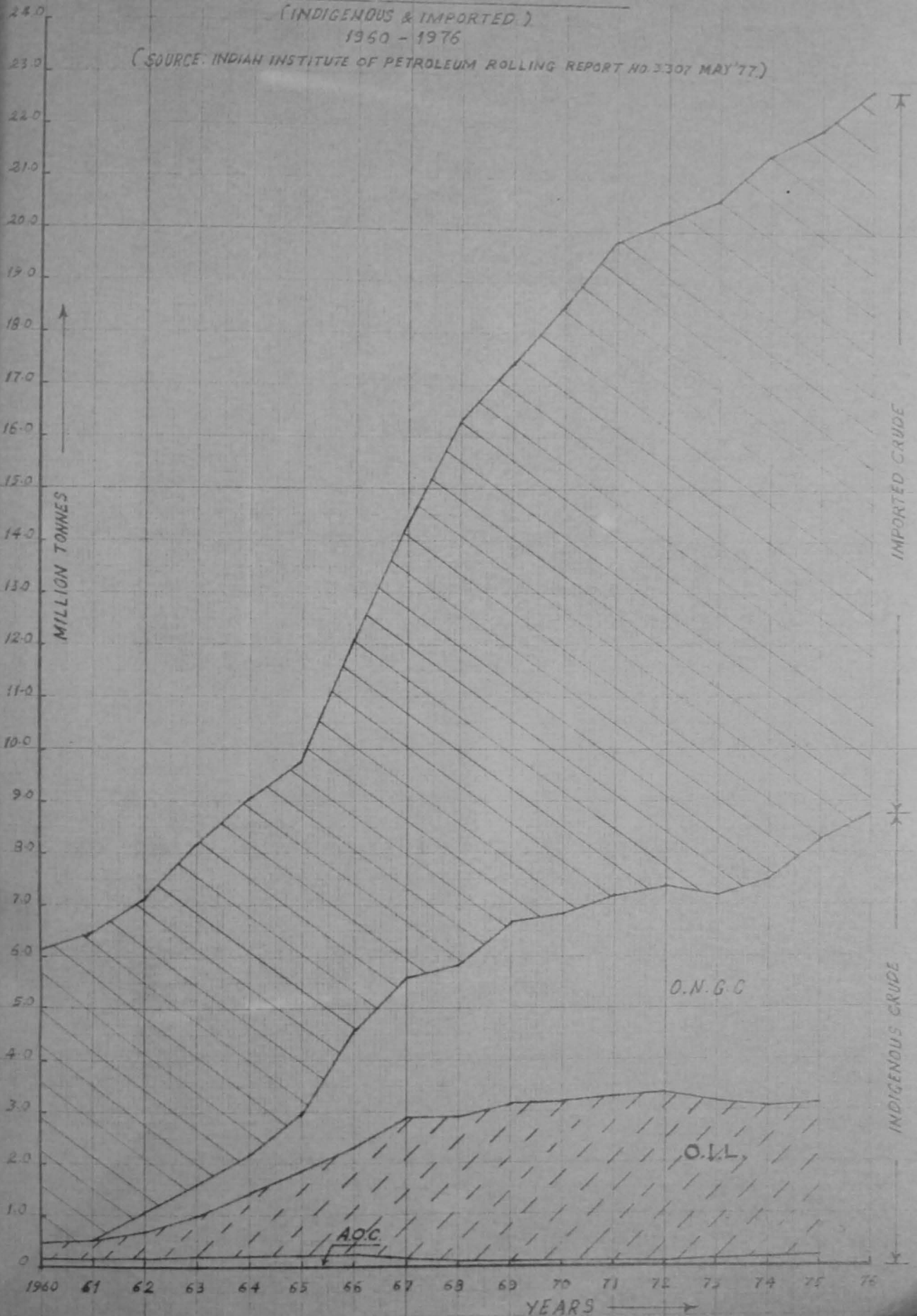
107

AVAILABILITY OF CRUDE OIL

(INDIGENOUS & IMPORTED)

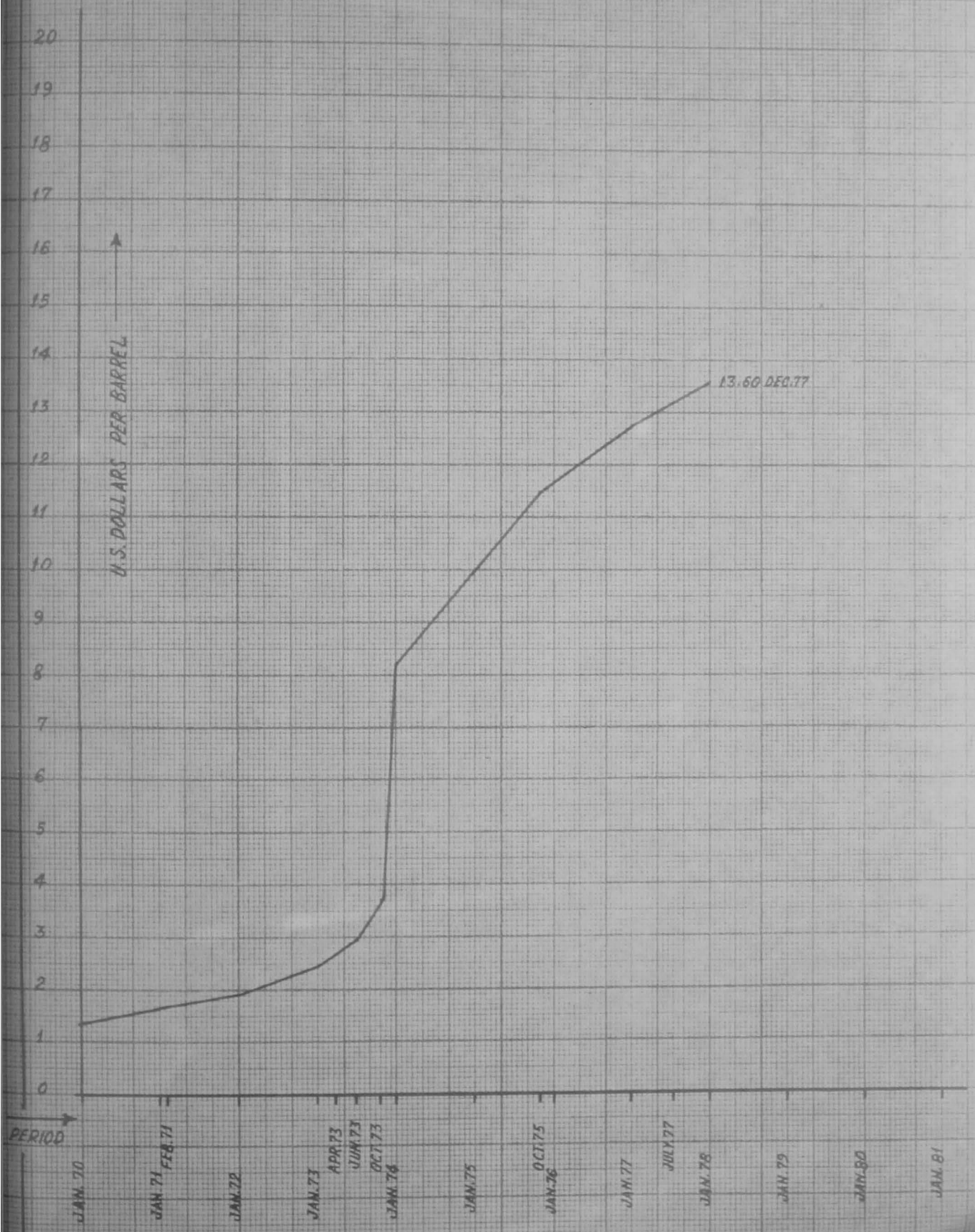
1960 - 1976

(SOURCE: INDIAN INSTITUTE OF PETROLEUM ROLLING REPORT NO.3307 MAY '77)



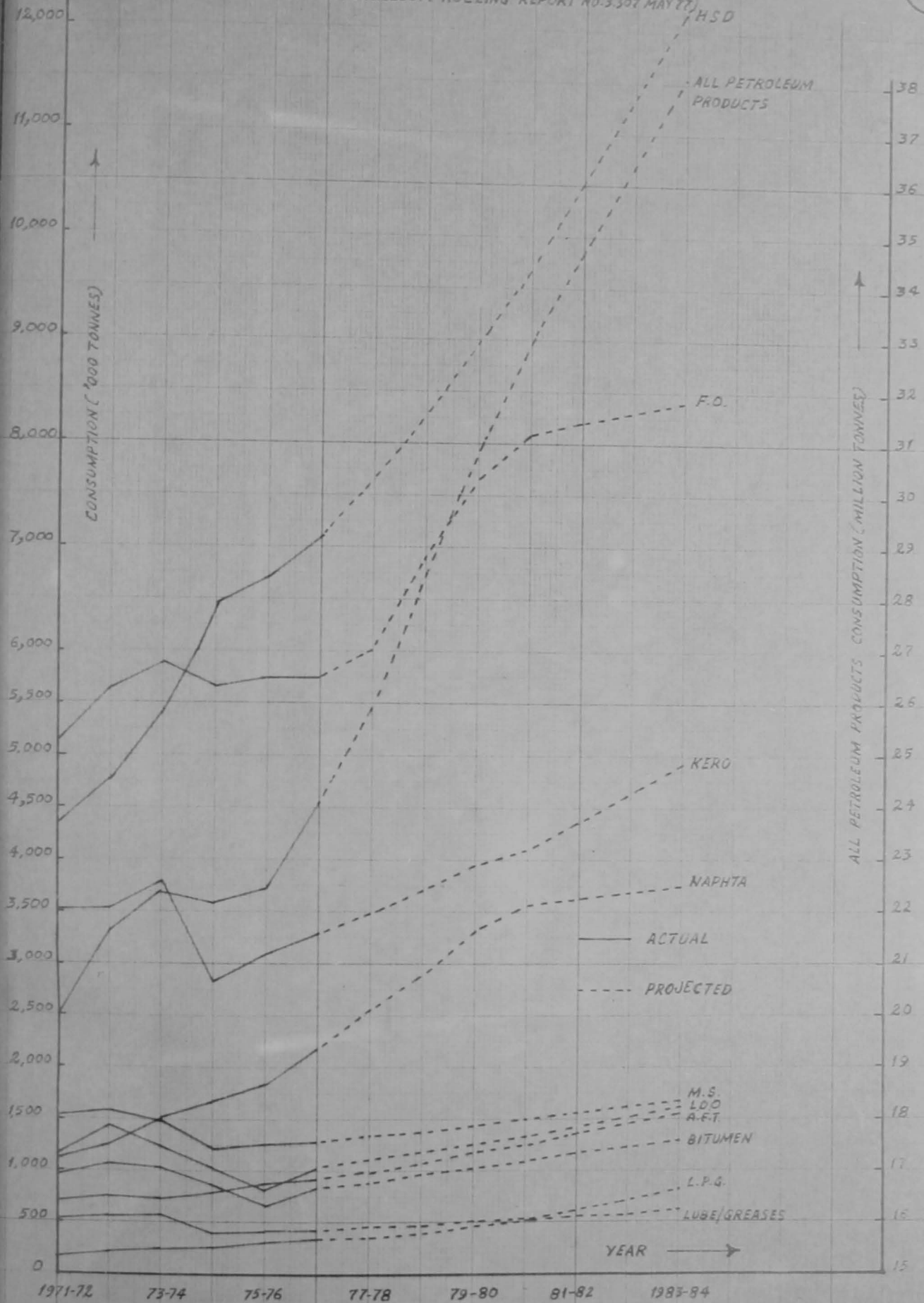
MARKET PRICE OF PERSIAN GULF OIL

G-4 (10)



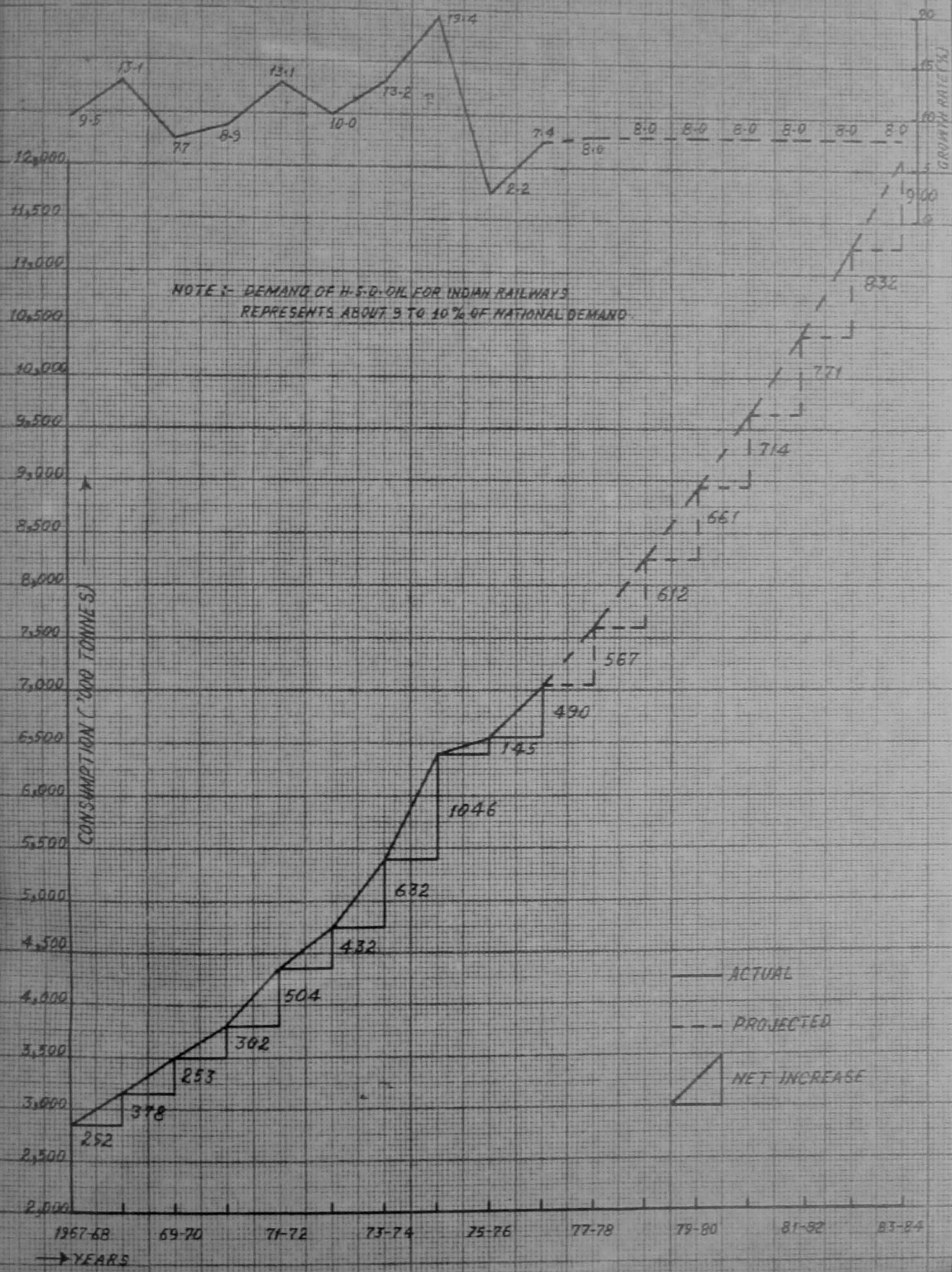
CONSUMPTION OF PETROLEUM PRODUCTS

(SOURCE: INDIAN INSTITUTE OF PETROLEUM ROLLING REPORT NO. 3397 MAY '77)



CONSUMPTION PATTERN OF H.S.D. OIL

(SOURCE: INDIAN INSTITUTE OF PETROLEUM ROLLING REPORT NO. 3-302 MAY 77)



NOTE:- DEMAND OF H.S.D. OIL FOR INDIAN RAILWAYS REPRESENTS ABOUT 9 TO 10% OF NATIONAL DEMAND.

— ACTUAL
 - - - PROJECTED
 ▽ NET INCREASE

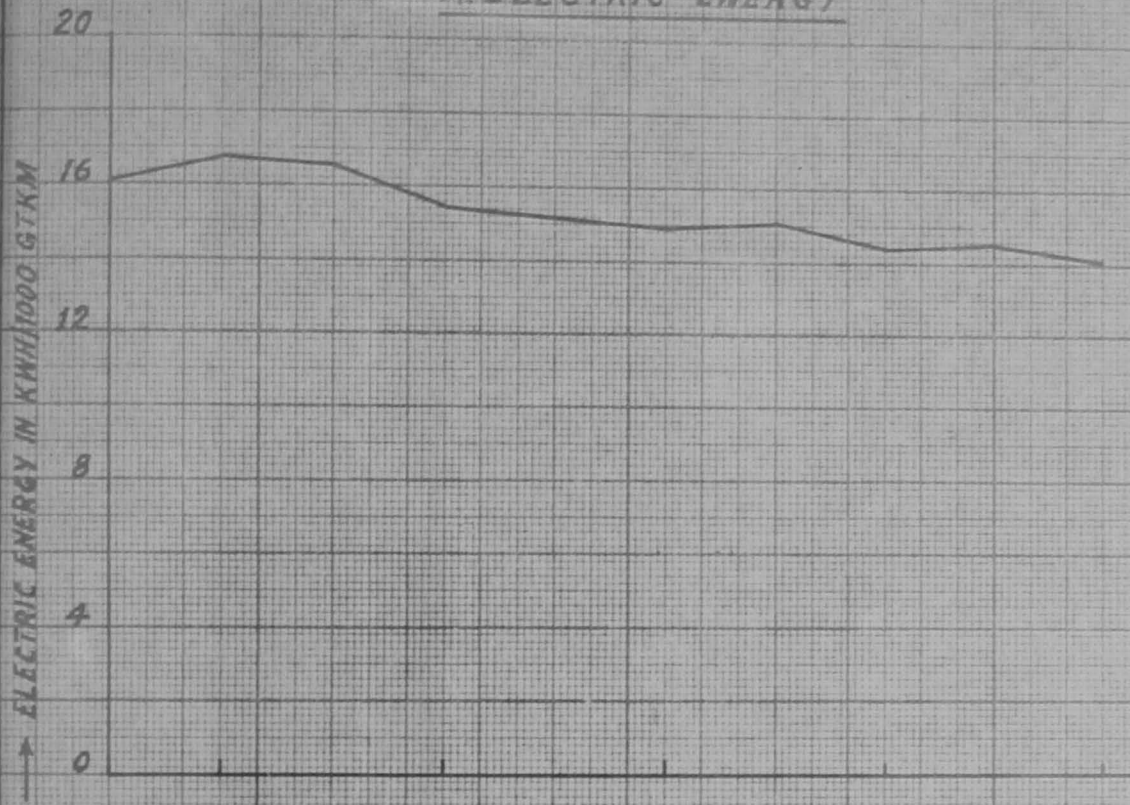
TREND OF SPECIFIC CONSUMPTION PER 1000 GROSS TONNE
KILOMETRE OF ELECTRIC ENERGY AND DIESEL OIL ON
INDIAN RAILWAYS FROM 1967-68 TO 1976-77 (10 YEARS)

107

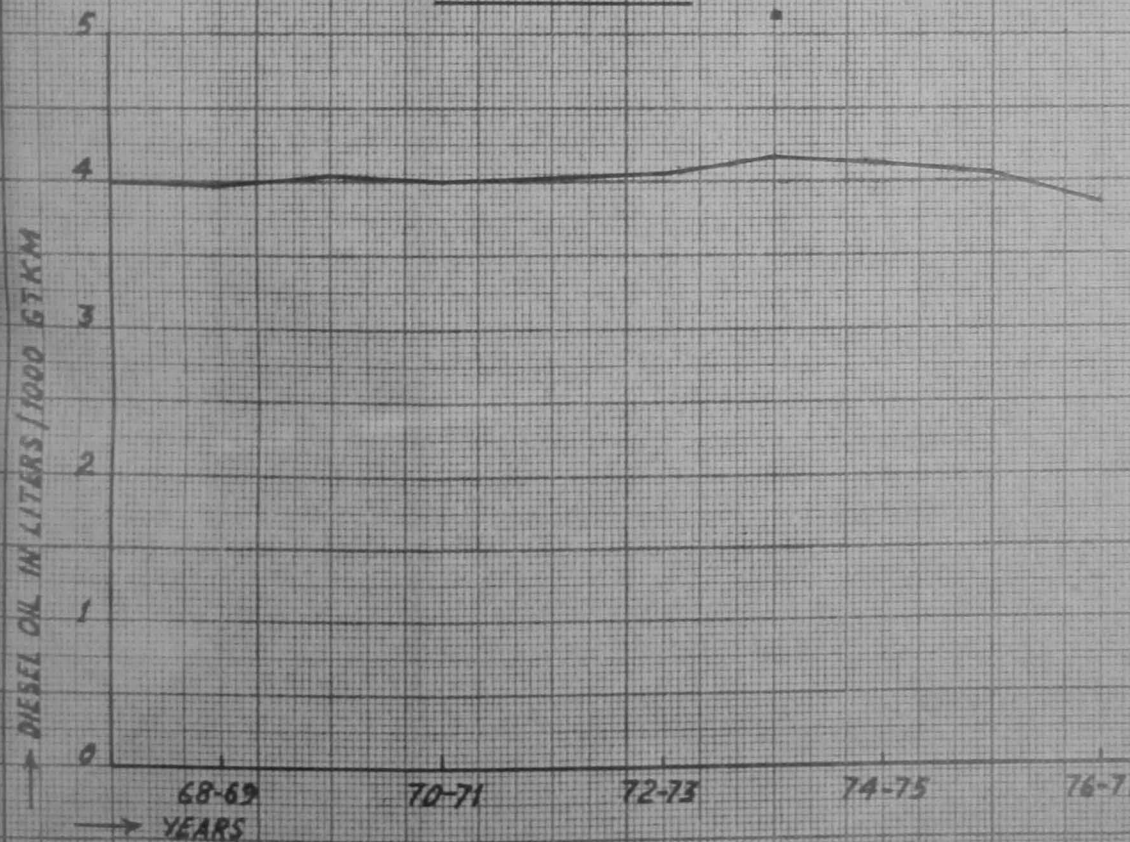
(BROAD GAUGE ONLY)
(PASSENGER AND GOODS COMBINED)

G-7

A. ELECTRIC ENERGY



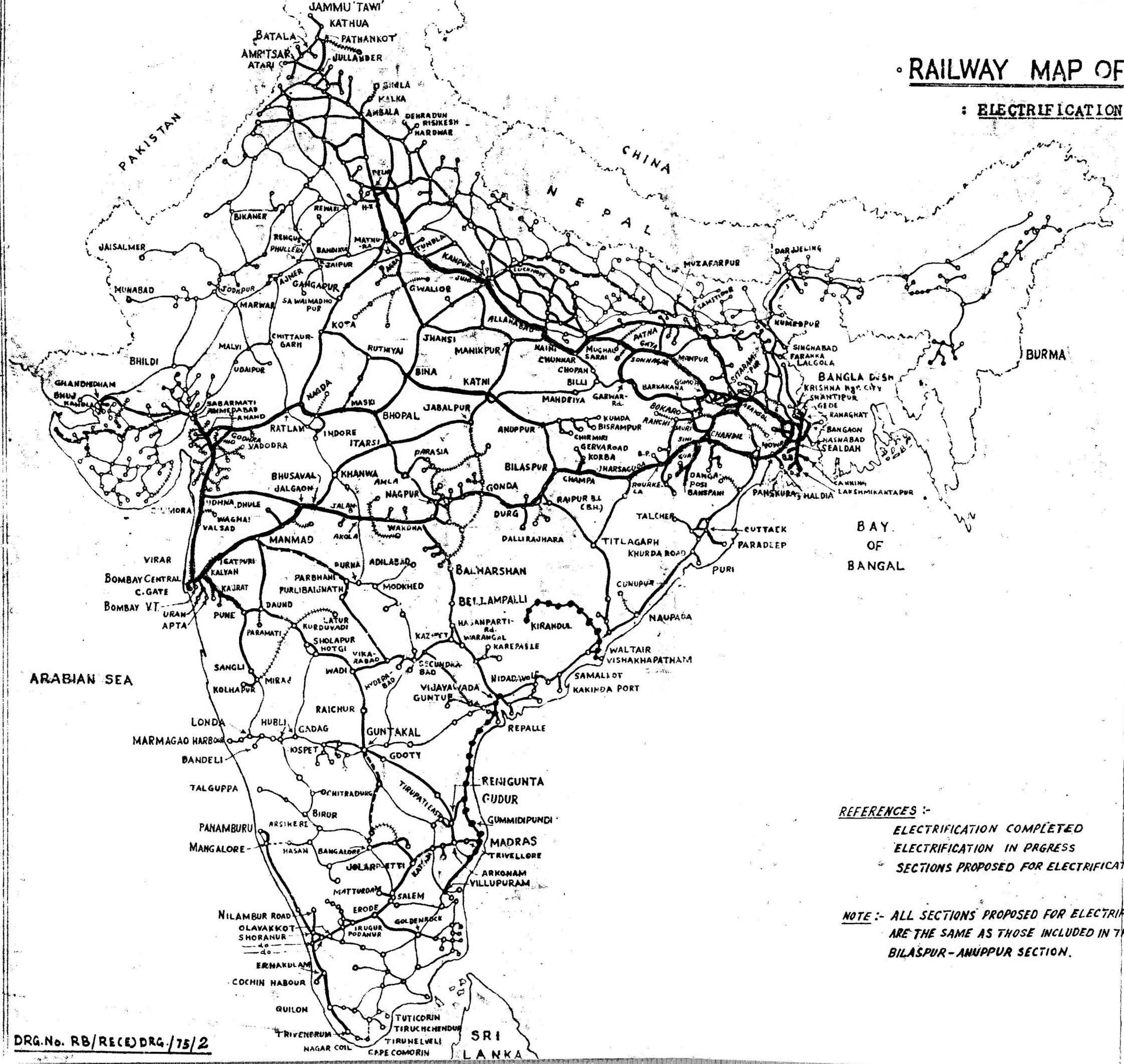
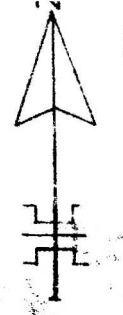
B. DIESEL OIL



RAILWAY MAP OF INDIA

ELECTRIFICATION

B.G. ———
 M.G. ———
 N.G. +++++



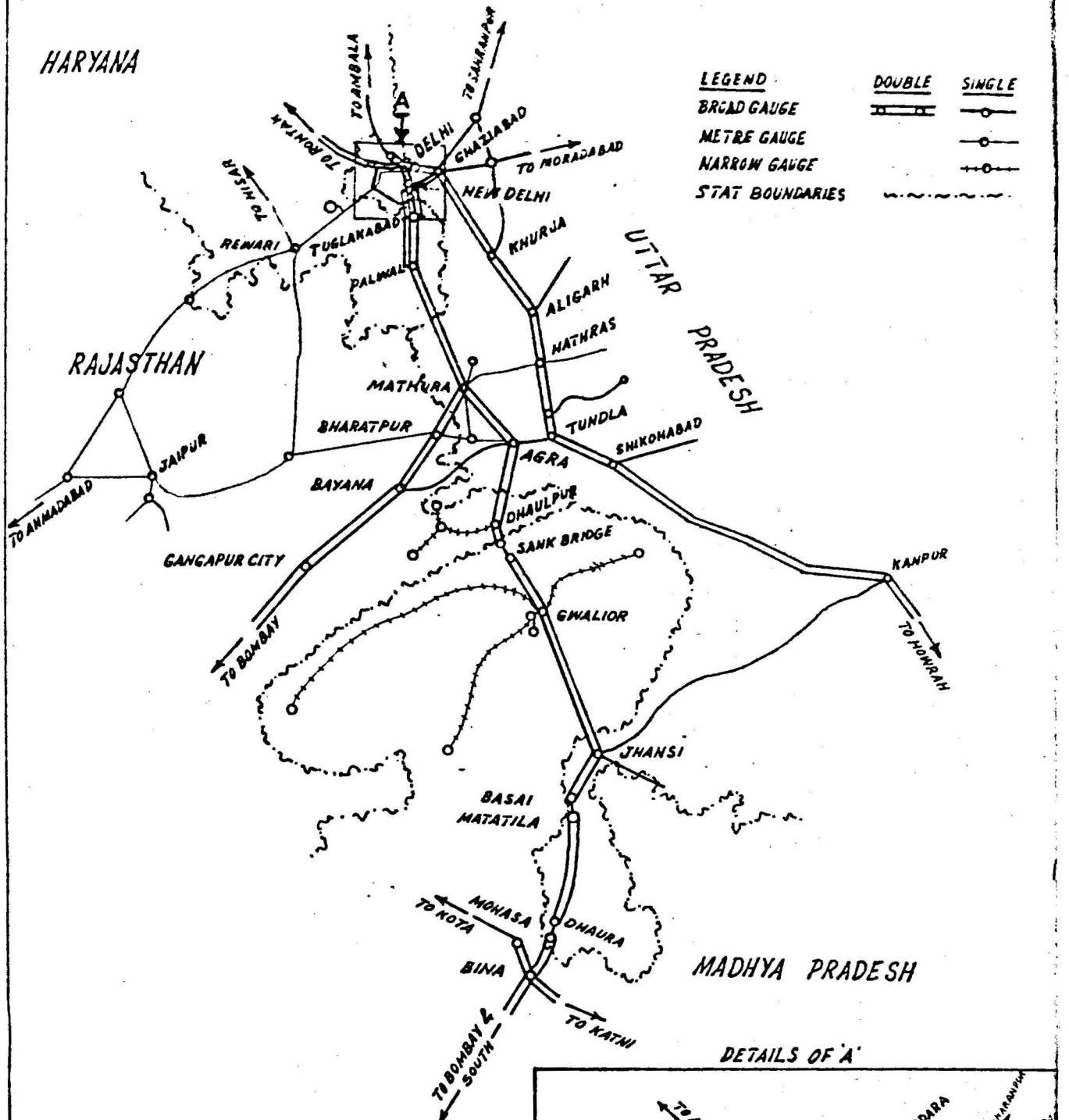
REFERENCES :-
 ELECTRIFICATION COMPLETED
 ELECTRIFICATION IN PROGRESS
 SECTIONS PROPOSED FOR ELECTRIFICATION IN CORPORATE PLAN

NOTE :- ALL SECTIONS PROPOSED FOR ELECTRIFICATION BY THE COMMITTEE ARE THE SAME AS THOSE INCLUDED IN THE CORPORATE PLAN EXCEPT BILASPUR-ANUPPUR SECTION.

ROUTE MAP OF DELHI-JHANSI AND MATHURA-GANGAPUR CITY (WITH INTERCONNECTION)

MAP-2

100

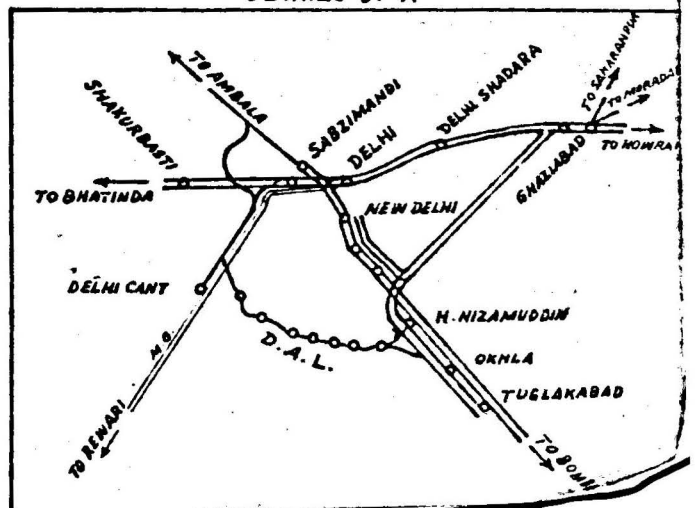


LEGEND	DOUBLE	SINGLE
BROAD GAUGE		
METRE GAUGE		
NARROW GAUGE		
STAT BOUNDARIES		

ROUTE LENGTH OF SECTIONS

SECTIONS	ROUTE Km.
DELHI-MATHURA	145
MATHURA-AGRA	54
AGRA-JHANSI	215
TOTAL:	414
MATHURA-BAYANA	76
BAYANA-GANGAPUR CITY	77
TOTAL:	153

DETAILS OF 'A'



ABBREVIATIONS
(Used in the Report)

CIC	-	Central India Coalfield
CIF	-	Cost, Insurance & Freight
CLS	-	Colour Light Signals
CLW	-	Chittaranjan Locomotive Works
DCF	-	Discounted Cash Flow
DLW	-	Diesel Locomotive Works
GTKM	-	Gross tonne kilometre
HSD	-	High Speed Diesel
IRR	-	Internal Rate of Return
NTKM	-	Nett tonne kilometre
POH	-	Periodical overhaul
POL	-	Petroleum, Oil, Lubricant.
RDSO	-	Research, Designs and Standards Organisation, Ministry of Railways
RKM	-	Route kilometre
TKM	-	Track kilometre
TTKM	-	Trailing tonne kilometre

REFERENCES

1. Study of Electrification and Dieselisation on Indian Railways, Govt. of India - 1963.
2. Economics of Diesel & Electric Traction - National Council of Applied Economic Research - August, 1970.
3. Report and Recommendation of the Working Group for Reduction of Costs of Electrification, Ministry of Railways, September, 1976.
4. Annual Reports 1976-77 & 1977-78, Ministry of Petroleum.
5. Efficiency Bureau, Ministry of Railways, Study No. 7/1971 (Economic Benefits of Electrification at 25 kV system on Howrah - Rourkela Section of S. E. Railway).
6. Demand projections for Petroleum Products (1976-77 to 1980-81 and 1983-84). Rolling Report No. 3.307, May 1977 - Indian Institute of Petroleum.
7. Draft Five Year Plan 1978-83, Planning Commission 18.4.78.
8. Annual Report, Ministry of Energy 1976-77 & 1977-78.
9. Indian Railways^h Corporate Plan 1974-1989.
