13. FINANCIAL ANALYSIS

13.1 PURPOSE

As mentioned in the foregoing Chapter, this project will bring about considerable benefits when completed while, on the other hand, it will require the vast amount of investment. Meanwhile, in the aspect of revenues the fare and charge rates are restrained at a low level as a policy because the railway is the public means of transport. Therefore, the lengthy time may be required until the invested fund will have been returned fairly. Besides that, there will be a problem involved in the foreign currency portion of the fund for the off-shore purchase of material or engineering service. All those things considered, there are too many binding conditions incident to the management in a balanced finance. Since it is next to impossible and rather troublesome to make scrutinising check of all those conditions on an item-by-item basis, financial analysis is made herein on an assumed basis of such conditions as may be considered relatively common and normal.

13.2 PROJECT FINANCING PLAN

13.2.1 Initial Investment Sum

The 'initial investment sum' to be required until commencement of the commercial operation is indicated in Table 13-1. This investment sum is the necessary fund for starting of the electric operation of the train and does not include, as a matter of course, the existing assets which will remain in service even after completion of electrification. The total fund is estimated at 320 million LE, of which the foreign currency portion accounts for 78 percent, and totals to some 345 million LE including the interest accrual during the period of construction. The foreign currency portion constitutes purchase funds for rail, turnout equipment, transformers and electric cars which are all priced at the price level prevailing in early 1979, including taxes and duties as calculated below. The domestic currency portion budgeted for all the ground facilities includes the land acquition of 9.7 million LE worth. The exchange rate is estimated at 1 US$ = 0.7 LE and 1 US$ = 200 yens (on conversion basis in early 1979). For financial analysis the price increase rate is assumed as 6 percent per annum. The interest accrual during the construction period is based upon the rate suggested by the ER authorities as stated later.

Customs tariff: Locomotive 2%
Electric car 15%
Spare parts for vehicle repair 25%
Transformer 20%
Electric wire/cable 25%
Signal and telecommunication systems 15%
Rail and turnout 10%

Taxes: Statistic tax 1%
National defense tax 10%
Port tax 0.2%

Table 13-1 Initial Investment

(Million LE)

	Domestic currency	Foreign currency	Total
Ground facilities	61.3	120.2	181.5
Rolling stock	7.5	131.0	138.5
Subtotal	68.8	251.2	320.0
Interest accrual during construction period			24.7
Total			344.7

(on the early '79's price basis)

13.2.2 Additional Investment Sum

According to Chapter 3 Demand Forecast, it is estimated that the traffic volume after completion of electrification will continue its increase at an annual average rate of about 4.1 percent for the said section at average in terms of passenger-kilometer. To cope with this situation, it will become necessary to provide additional number of rolling stock, which will in turn require additional installation and expansion of the car depot. The total additional fund to be required for the period of analysis, including the fund for those appurtenant works, will reach 255.6 million LE, as broken down in Table 13-2, the foreign currency portion of which will account for 82 percent.
The fact that the foreign currency fund accounts for a larger percentage is due mainly to additional purchases of rolling stock with the aim to strengthen the carrying capacity of the railway.

Table 13-2 Additional Investment

(Million LE)

Year	Ground facilities		Rolling stock		Total		
	Local currency	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Total
1984~1988	0.7	1.3	10.8	8.0	11.5	9.3	20.8
1989~1993	9.3	9.4	0.8	76.8	10.1	86.2	96.3
1994~2003	13.5	29.0	11.6	84.4	25.1	113.4	138.5
Total	23.5	39.7	23.2	169.2	46.7	208.9	255.6

(on the early '79's price basis)

13.2.3 Financing Arrangement

It is a matter of equally vital importance to make financing arrangements as well as to plan the capital investment. The financing source available may be divided into the equity fund financing and the loan fund financing from the external source. The annual amount of expenditures should naturally vary depending upon whether each of those two sources will be utilized severally or both of those two will be used in a combined pattern. Still more, the method of such financing arrangements may be diversified with various complexities depending upon purpose, profitability and any other factors of the project. Although the project may possibly be financed wholly or partially by governmental aid or grant in view of its nature as the public service work, the financing arrangements for this project fund are proposed an assumption that the external loan fund would be used entirely to the full amount.

Thus, calculation was made on two cases of interests. One is that the total fund would be available from the combined sources of both export credit finance (supplier's credit) and low-interest, long-term loan fund from the government-run financing institution, on the basis of about 7 percent annual average rate of interest applicable to the funds of both foreign and domestic currency portions at average. The other case is based on interest rate suggested by the ER authorities.

The ER's proposed condition on the interest rate is as follows.

Domestic currency:

12-year installment payment (6.5% interest rate)
with a grace period of 3 years (5% interest rate)

Foreign currency:

12-year installment paymet (12% interest rate)
with a grace period of 4 years (12% interest rate)

Although the governmental subsidies may be granted to cover any possible shortage which may arise in the total fund after commencement of commercial operation, assumption was made herein on the basis of applying to any case the same rate of interest as applied to the domestic currency loan fund, since the project fund is all to be financed from the loans as stated earlier.

13.3 COMMERCIAL REVENUES AND OPERATING EXPENDITURES

13.3.1 Commercial Revenues

The commercial revenues normally increase or decrease depending upon the volume of passenger traffic and the level of fare rate. In forecasting the revenues the estimated figures for the traffic volume are taken from those calculated in the foregoing '3. Demand Forecast'. Meanwhile, the fare rate is assumed on the justifiable ground as follows. Namely, in case of this project which needs vast amount of capital investment, the fare/charge must be increased accordingly, from time to time, not only to offset the benefit which all the passengers will receive but also to expedite fair return from the invested capital so as to help the management sustain its sound finance.

For the reasons mentioned above, the increase rate of fare/charge and its frequency are assumed on the two cases; the one is the case where the rate would be increased simply to accord with the future rising tendency of prices and the other is, besides the preceding case, where the rate would allow for some extra increment to cover a fair return from the invested capital. In the former case, the increase rate is assumed at 20 percent in 1981 during the construction period, in 1984 when the commercial operation will start and every 3 years thereafter. As the result, the annual average rate of increases for the coming 25-year period summing up both construction and maintenance (under this financial analysis) periods would be about 6.27 percent, which would nearly correspond to the annual price increase rate of 6 percent as forecasted.

The fare rate used as the basic data for this forecast is taken from the average fare/charge rate per passenger-kilometer by car classes as referred to the data* available from the Egyptian Railways. With regard to the estimated revenues for the period under this financial analysis, those in the former case are as shown in Appendix Table-2 and the same in the latter case as shown in Appendix Table-3.4.

13.3.2 Operating Expenditures

By reference to the data** furnished by the Egyptian Railways, the operating expenses are calculated by being divided approximately into both variable and unvarying - fixed - portions as against any increase or decrease of the passenger traffic volume, allowing for the possible saving of expenses to result from electrification, so that the forecast can be made as closest as the real circumstance of business. The maintenance cost of the existing assets is estimated with due consideration to the traffic density, the single or double tracks and the total operating km length.

In the estimate of power unit cost, it is assumed herein tentatively as 2.6 milli-M per kWh as mentioned in appendix.

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* General Business Status Analysis of the Egyptian Railways

** Details of Production, Trading & Profits and Loss Accounts

13.4 FINANCIAL OBSERVATIONS

13.4.1 Application of Interest Rate as Suggested by the ER (Calculated Example I)

Table 13-3 Summary of Financial Analysis (I)

Million LE %

Year	Income	Profit	Interest payable	Short-term loan	Fixed assets	Interest payable / Income	Turnover rate of fixed assets
1984	33.40	Δ41.73	45.03	25.49	392.32	134.8	8.5
1989	49.10	Δ29.64	48.37	49.05	350.05	98.5	14.0
1994	86.70	Δ21.25	62.36	35.77	515.19	71.9	16.8
1999	152.90	2.99	81.28	0.00	666.42	53.2	22.9
2003	215.90	71.89	62.12	0.00	642.61	28.8	33.6

Table 13-3 summarizes the major financial figures selected from the financial statement as the Calculated Example I. As clearly noted from the Table, it is in 1998 that the profit after decucting the expenses from the income will be yielded to the account, for which a time length of 15 years will be required starting from the initial operation data. It is further extimated that the cumulative loss in the account will turn into nil not earlier than in 2004. This is mainly because of the following reasons.

1) The investment of vast sum is required to accomplish such a large-scale project.

2) The total project fund is financed by loans and credits.

3) The interest rate for the loan funds is estimated at a relatively higher level.

4) The fare rate is increased, not ahead of the price rise, but only following after that.

To further explain the above, it should be brought to attention that the share of the interest payable against the loan in the annual total income will still remain at such a relatively high rate as 29 percent even far ahead in 2003, starting from the rate of 135 percent in the initial year of commercial operation. This is evidently because of the relatively higher rate of interest as against the load fund for the project. In addition to that, the short-term borrowing to cover the possible shortage of operating fund will continue each year until 1998, reaching its maximum sum of 50 million LE in 1987. Same as is the case of financing the capital investment, it is also a matter of equal importance but difficulty to seek the appropriate source of financing the fund on such short-term loan basis. It is therefore hoped that the strong governmental back-up to the project will be extended in terms of subsidies to cover shortage of the construction fund or to mitigate the burden of interest payment and reduction or exemption of customs duties for offshore purchases under this project. In terms of the turnover rate of fixed assets, the actual ER's figure recorded in 1977 shows 30 percent, while this calculated example predicts that the rate will boost up from 8.5 percent in the initial year of operation to 33.6 percent by 2003. This estimated rate may be considered nearly reasonable as the railway industry but the required time length for the maximum reach may be rather lengthy.

13.4.2 Application of Interest Rate as Suggested by the ER with Substantial Fare/Charge Rate Increases (Calculated Example II)

Table 13-4 Summary of Financial Analysis (II)

Million LE %

Year	Income	Profit	Interest payable	Short-term loan	Fixed assets	Interest payable / Income	Turnover rate of fixed assets
1984	39.90	Δ35.23	45.03	18.99	392.32	112.9	10.2
1989	71.90	Δ4.21	45.74	23.62	350.05	63.6	20.5
1994	129.10	30.97	52.54	0.00	515.19	40.7	25.1
1999	233.60	108.01	56.97	0.00	666.42	24.4	35.1
2003	346.90	222.45	42.56	0.00	642.61	12.3	54.0

In the foregoing Calculated Example I, estimate is based upon such assumption that the fare/charge would be revised at an increase rate of 20 percent every 3 years to absorb the price increase rate of 6 percent per annum. The fare increase rate is averaged at 6.27 percent annually, almost compatible with the estimated increase rate of commodity prices. Because of the close tightness between the two, there would be no sufficient return from the initial investment, as a result of which the outstanding portion of the short-term borrowings would still total to 329.9 million LE even in 2003. Therefore, the Calculated Example II deals with the study result for the fare/charge rate increases reflecting the expectable return, more or less, from the invested capital and absorbing, on the other hand, the possible increase of commodity prices, in which case an extra 10 percent increase will be allowed for every 5 years in addition to the basic increase in escalation to the 6 percent annual price increase. The partial summary of calculations is as shown in Table 13-4. As compared with the Calculated Example I, the time when the both ends will meet and the cumulative loss of account will disappear will be advanced earlier, in 1990 and 1995 respectively. Furthermore, 1991 will be the final year of borrowing the short-term loan fund to make up for possible shortage of finance and some surplus will be produced in and from 1998.

13.4.3 Use of Plural Number of Financing Sources with Substantial Fare/Charge Rate Increases (Calculated Example III)

Table 13-5 Summary of Financial Analysis (III)

Million LE %

Year	Income	Profit	Interest payable	Short-term loan	Fixed assets	Interest payable / Income
1984	39.90	Δ16.69	28.62	7.59	392.32	71.7
1989	71.90	11.47	30.06	15.30	350.05	41.8
1994	129.10	54.40	29.11	0.00	515.19	22.5
1999	233.60	132.38	32.59	0.00	666.42	14.0
2003	346.90	251.49	13.52	0.00	642.61	3.9

This Calculated Example is the result of analysis made on the same conditions as given to the foregoing Calculated Example II, except that it is based upon the annual average interest rate of about 7 percent as applicable to both domestic and foreign currency portions alike at average.

According to this Example, it is expected that the balancing point between revenues and expenditures will be reached earlier in 1989 and the cumulative total loss will come into nil in 1991, providing possibility of favorable turn into surplus each year in and from 1995. Therefore, if those surplus is used for future investment to be required additionally and, besides that, used as an extra addition to the fixed sum of repayment for the long-term loan or credit, it can be expected that the future financial status will be improved further by taking off the burden of interest payment. It may also be possible, under the improved financial condition, that the estimated increase rate of fare/charge will be reduced to some extent if and when it is deemed appropriate to do so.

13.4.4 Conclusion

As obviously concluded from the foregoing examples of calculation, it is assumed very difficult to keep the financial balance in healthy balance only be such extent of the fare/charge increase that may cover the price rise alone, since the investment of vast sum should be required for execution of the project.

However, if the fare/charge rate can be increased, as proposed in the third example of calculation, reflecting not only full coverage for the price increases but also certain return to be expected more or less from the invested capital, it may be possible that the project will be managed with sound financial condition, together with efficient financing arrangements available.

14. SAFETY SECURITY

14.1 SAFETY MEASURES AGAINST ELECTRICAL INSTALLATION

Full care for safety security will be required to prevent any danger from super-high voltage power receiving at substations involved and power supply at 25 kV super-high voltage current to the overhead catenary.

Each substation will be provided with be provided with protection fence to keep out the general public. Protective device will also be required at the level crossing with the railway so as to prevent loaded trucks from accidental contact with the overhead catenary.

Even in the ordinary time it is advisable to try to keep out all the outsiders beyond a limit of 1.2 m from the overhead catenary and other dangerous parts served at high voltage rating.

14.2 SAFETY MEASURES AGAINST HIGH SPEED CONVERSION OF TRAIN

As the train increases its speed by electrification, safety measures will have to be taken at the level crossing with the railway and also for protection of passengers by construction of the overload foot bridge at the station.

15. EDUCATIONAL TRAINING PROGRAMME

15.1 NECESSITY OF TRAINING

The electrification project of the railway between Cairo and Alexandria is to construct the nation's first AC-operating system for a long-distance main line. With a number of AC-operated electric cars to be put into operation, the suitable training programme will have to be provided for the personnel to make them familiar with the new jobs of various patterns to be created as the result of electrification.

15.2 CONTENT

The content of technical training will be divided into the following engineering fields.

(a) For motormen

- Operating technique of electric cars
- Temporary repair and remedy of any trouble incurred on electric cars
- Handling method of new signal and telecommunication systems

(b) For inspection and repair workers

Technical matters related to inspection and repair of new electric cars

(c) For maintenance crew of electrical installation

- Technical matters related to inspection of facilities
- Technical matters related to operation of facilities
- Technical matters related to remedies from electrical trouble

15.3 METHOD AND PERIOD OF TRAINING

Prior to education of average workers, training will be provided for the personnel of leading class. Those foremen will be selected, by their technical specialities, from among those who are now executing the work on the existing Cairo-Alexandria line. It is most advisable that they should receive training practica on the desk and should, if possible, be assigned to the on-the-job training in any other country where the AC electric train is operated. For those electrical technicians it will be most useful for them to engage themselves in the actual construction work under the electrification project, in that it will certainly make them fully familiar with the way how the new system can be operated.

Educational training for those average workers will be provided through the trained foremen. Since the training period in whatsoever area of engineering may require 4 to 6 months, it is considered most effective that car depots and electrified sections should be opened as trial, in at least 6-month advance of the scheduled completion date, for the purpose of on-the-job training.

SUPPLEMENTAL STUDY ON A FORMULA FOR ELECTRIFYING LINE SECTORS ON THE EGYPTIAN RAILWAYS

CHAPTER I OBJECTIVES OF THE STUDY

1.01 This Supplemental Study aims at setting up a generalized formula, under which electrification on a certain line section of the ER is, as a rule of thumb, worthy of consideration, in relation to spot traffic volume expressed by a daily number of trains (called N hereafter).

1.02 The Study has been made in accordance with the "Supplemental Note of the Japanese Mission's Understandings on the Revision of the Draft Final Report -- Electrification between Cairo and Alexandria, Egyptian Railways, Arab Republic of Egypt" dated October 7, 1979.

CHAPTER II METHODOLOGY ADOPTED

2.01 In carrying out the Study, the same methodology as that used in the brochure entitled "Technical Development of Japanese National Railways" published by the JNR in 1979 (called the JNR brochure hereafter) has been adopted. The reasons for this are that: i) the ER now appears to be interested in the "JNR brochure", particularly in the descriptions appearing on Pages 20 and 21 of the "JNR brochure"; and therefore, ii) it would be worthwhile to compare the results to be obtained in the case of the ER with those already obtained in the case of the JNR.

2.02 The spot traffic volume N expressed by a daily number of trains, which constitutes an economic point of turnout in the case of the JNR, is estimated at about 40 including both up and down trains, as seen on top of Page 21 of the "JNR brochure".

2.03 The above estimation is based on a concept of the "profitability percentage on additional investment" (η), as defined below:

$$\eta(\%) = \frac{\text{(Annual expenses for diesel operations)} \text{ minus } \text{(Annual expenses for electric operations)}}{\text{(Amount of investment for electrification)} \text{ minus } \text{(Amount of investment for dieselization)}} \times 100 \quad ..(1)$$

The right side shows a percentage of the ratio of the difference between annual expenses for diesel operations and those for electric operations against the difference between the amount of investment for electrification and that for dieselization. The above expenses comprise personnel expenses, energy expenses, maintenance expenses and depreciation charge. Therefore, if input data concerning the above expenses and investment amounts are appropriately assumed, both the numerator and denominator of the right side become linear expressions in N. Given N, the profitability percentage can be calculated. In the case of the "JNR brochure", for instance:

$$\eta = 7\ (\%) \quad \text{when } N = 39.$$

2.04 In the equation (1) in the preceding paragraph, the amount of investment for dieselization is assumed to be the purchase price of DL's and DMU's. The reason for this is that in Japan, even though DL's and DMU's generated from electrification are not yet fully depreciated, they are normally assigned to other non-electrified line sections elsewhere in Japan to cope with either increased traffic or replacement of DL's and DMU's on those other non-electrified line sections. This policy would also be applicable to the ER, because the age-wise inventory of DL's and DMU's on the ER clearly indicates a similar situation to that of Japan.

2.05 The estimation of N appearing in the "JNR brochure" is based on the mixture of the number of passenger and freight trains, the composition in number being 72 and 28%, respectively. However, in the case of the ER, the estimation to be described in the following Chapters refers to passenger trains only in accordance with the Scope of Work for the feasibility study on the Cairo-Alexandria electrification, which is limited to passenger services.

2.06 The estimation to be described in the following Chapters is macroeconomic, only based on quantifiable data. It goes without saying, however, that final judgment on electrification should be made on the basis of a detailed feasibility study including considerations on unquantifiable factors other than those mentioned in this Chapter.

CHAPTER III INPUT DATA ASSUMED

3.01 Standard line section

The Cairo-Alexandria line has varied traffic volumes, section by section. The number of scheduled trains differs by section accordingly. Also, on the Cairo-Qualiub section, trains of diesel traction to and from the branch lines would remain to be operated even after electrification. For those reasons above, it is not practical for the estimation to cover an entire line Cairo-Alexandria. Therefore, the section between Benha and Tanta has been taken up as the standard line section.

3.02 Number of trains and their make-ups

According to 1976 statistics, the occupancy ratio of passengers on the ER main lines was about 52%. Based on this, the number of trains and their make-ups have been estimated on the assumption that the occupancy ratio is about 60%. This assumption is applicable to both electric and diesel operations, except the following aspect. This means that the number of coaches per DMU is 14 instead of 12. The reason for this is that the existing DMU comprises six coaches, out of which the front and rear coaches have a half number of passenger seats as compared with other coaches in-between, the effective number of coaches being five. Therefore, it has been assumed that in this Study, the EMU make-up of 12 coaches is equivalent to the DMU make-up of 14 coaches.

3.03 Unit prices of rolling stock

Unit prices of electric rolling stock, both EL's (per stock) and EMU's (per make-up), have been estimated, with consideration on actual data on the ER and JNR being taken into account. Those of diesel rolling stock, both DL's (per stock) and DMU's (per make-up), have been estimated, with consideration on actual data on the ER, the market price in USA, etc. being taken into account. Unit prices of both electric and diesel rolling stock include customs duties and other taxes.

3.04 Daily run in km per rolling stock on line

Daily run in km per electric rolling stock on line has been estimated on the basis of the maximum speed of 110 km/h for EL's and 160 km/h for EMU's, respectively. Daily run in km per diesel rolling stock on line has also been estimated on the basis of 110 km/h for both DL's and DMU's.

3.05 Maintenance expenses of rolling stock

A total of maintenance expenses, personnel and material, in the workshop expressed in LE/km for both EL's and DL's (per stock) as well as both EMU's and DMU's (per make-up) have been estimated with considerations of actual data on the JNR and of actual situation on the ER being taken into account.

3.06 Energy consumption

Power consumption in KWH/km for electric rolling stock as well as diesel fuel oil consumption in litre/km for diesel rolling stock have been estimated on the basis of computer-calculated results on the line Cairo-Alexandria. Energy consumption for both EL's and DL's has been estimated per stock and that for both EMU's and DMU's has been estimated per make-up.

3.07 Unit prices of energy

For electric power unit prices, the following three prices have been assumed:

(i) 24 milliemes/KWH,
(ii) 2.6 milliemes/KWH, and
(iii) 12 milliemes/KWH.

The 24 milliemes/KWH are now applicable to the Helwan Line, and the 2.6 milliemes/KWH to the National Alminium Refinery. The 12 milliemes/KWH have been assumed as an intermediate value. The unit price of diesel fuel oil of 25 milliemes/litre is the actual purchase price by the ER.

3.08 Rolling stock depreciation rate

This means a rate of annual depreciation charge and is obtained by dividing the purchase price of rolling stock (1.0) less its salvage value (0.1) by service life. The service life has been assumed as 30 years for electric rolling stock and 20 years for diesel rolling stock.

3.09 Investment amount for ground facilities

This is for electrification. However, since such facilities as the rolling stock center are almost commonly required, whether electrified or dieselized, their investment amount is assumed to be offset and has been excluded.

3.10 Ground facility depreciation rate

The service life has been assumed to be 30 years for electric facilities and 60 years for civil facilities, which are associated with electrification.

3.11 Ground facility maintenance expenses rate

This means a rate of annual maintenance expenses (for materials only) against the investment amount needed for ground facilities for electrification. The rate has been estimated, with considerations being taken into account on actual data on JNR line sections, whose physical strength of facilities is similar to that on the Cairo-Alexandria line.

3.12 Personnel expenses

Annual personnel expenses per ER employee for 1979 have been estimated on the basis of 1976 data of the ER as well as the latest annual increase rate on the average of nation-wide wages and salaries in Egypt.

3.13 Man power needed for maintaining electric facilities

It has been assumed that man power of 0.5 person per km on the average for 486 km of catenary distance (associated with the main line) between Cairo and Alexandria is assigned. Average man power per route km needed for maintaining electric facilities has then been calculated.

3.14 Man power needed for depot repairs of rolling stock

Man power needed for inspection and light repairs in the depot of diesel rolling stock (excluding heavy repairs to be made in the workshop) has been estimated on the basis of the ER-prepared table concerning job-wise personnel composition, etc. Then, man power to be needed for inspection and light repairs in the depot of electric rolling stock has been assumed on the basis of man power estimated above for diesel rolling stock, with considerations on possible workload for electric rolling stock being taken into account.

3.15 Table 1 summarizes input data assumed.

TABLE 1 Summarized Input Data

			Electrification			Dieselization		
			Daily train nos. (Up & down)	Composition (%)	Coach nos. per train	Daily train nos. (Up & down)	Composition (%)	Coach nos. per train
TRAIN · MAKEUP	Loco.	Express	28	26	8	28	26	8
		Semi Express	24	23	8	24	23	8
		Local	16	15	8	16	15	8
	Multiple Unit	Limited Express A	14	13	12	14	13	14
		Limited Express B	24	23	12	24	23	14
		Total	106	100		106	100	
UNIT PRICE OF ROLLING STOCK	Loco.	Express	940 10^3LE			792 10^3LE		
		Semi Express	940			792		
		Local	940			792		
	Multiple Unit	Limited Express A	6133 10^3LE *			4947 10^3LE *		
		Limited Express B	6133 *			4947 *		
DAILY RUN		Loco.	356 km			305 km		
		Multiple Unit	564			305		

TABLE 1 Summarized Input Data

			Electrification	Dieselization
MAINTENANCE EXPENSES OF ROLLING STOCK	Loco.		0.11 LE/km	0.30 LE/km
	Multiple Unit		0.46 *	1.49 *
ENERGY CONSUMPTION	Loco.	Express	20.0 KWH/km	7.5 litre/km
		Semi Express	23.9	8.9
		Local	24.3	9.2
	Multiple Unit	Limited Express A	26.0 KWH/km	8.6 litre/km
		Limited Express B	27.1 *	9.2 *
Unit Price of Energy			0.024 LE/KWH 0.0026 0.012	0.025 LE/litre

TABLE 1 Summarized Input Data

		Electrification	Dieselization
DEPRECIATION RATE OF ROLLING STOCK	Loco.	0.03	0.045
	Multiple Unit	0.03	0.045
INVESTMENT AMOUNT FOR GROUND FACILITIES	Sub-station	30984 10^3LE	
	Catenary	86150	
	Signaling & Telecom.	9925	
	Design & Supervision	13130	
	Civil Works Improvement	627	
	Land	1465	
	Total	142281	
GROUND FACILITIES	Depreciation Rate	0.013	
	Maintenance Rate	0.01	

TABLE 1 Summarized Input Data

		Electrification	Dieselization
Personnel Expenses		589 LE/person.yr.	589 LE/person.yr.
Man power for Electric Facilities		1.17 persons/route km	
MAN POWER FOR ROLLING STOCK	Loco.	2.7 persons/loco	5.4 persons/loco
	Multiple Unit	20.4 persons/multiple unit	47.6 persons/multiple unit

Note: i) Unit price of rolling stock, maintenance expenses of rolling stock and investment amount for ground facilities include customs duties and other taxes.

ii) Customs duties and other taxes are shown below:

Customs duties

Locomotive	2%
Multiple unit	15
Spare parts for rolling stock	25
Sub-station	20
Catenary	25
Signaling & telecommunications	15
Civil works	10

Other taxes

Statistical	1%
Defense	10
Port	0.2

iii) * denotes numerical values per make-up.

iv) Exchange rates:

1US$ = ¥200

1US$ = 0.7LE

CHAPTER IV PROCESS OF ESTIMATION

4.01 Investment amount of ground facilities per route km.

$$142281^{10^3 LE} \div 208^{\text{route km}} = 684^{10^3 LE/\text{route km}}$$

4.02 Investment amount of rolling stock required for N trains per route km.

Electric rolling stock

EL : $N(0.26+0.23+0.15) \times 940^{10^3 LE} \div 356^{km} = 1.690N^{10^3 LE/\text{route km}}$

EMU : $N(0.13+0.23) \times 6133^{10^3 LE} \div 564^{km} = 3.915N^{10^3 LE/\text{route km}}$

Total: $5.605N^{10^3 LE/\text{route km}}$

Diesel rolling stock

DL : $N(0.26+0.23+0.15) \times 792^{10^3 LE} \div 305^{km} = 1.662N^{10^3 LE/\text{route km}}$

DMU : $N(0.13+0.23) \times 4947^{10^3 LE} \div 305^{km} = 5.839N^{10^3 LE/\text{route km}}$

Total: $7.501N^{10^3 LE/\text{route km}}$

4.03 Depreciation charge per annum.

Ground facilities

$$684^{10^3 LE/\text{route km}} \times 0.013 = 8.9^{10^3 LE/\text{route km}}$$

Electric rolling stock

$$N(5.605^{10^3 LE/\text{route km}} \times 0.03) = 0.168N^{10^3 LE/\text{route km}}$$

Diesel rolling stock

$$N(7.501^{10^3 LE/\text{route km}} \times 0.045) = 0.338N^{10^3 LE/\text{route km}}$$

4.04 Energy expenses per annum.

Electric rolling stock

$$EL : N \times \alpha \times (0.26 \times 20.0^{KWH/km} + 0.23 \times 23.9^{KWH/km} + 0.15 \times 24.3^{KWH/km}) \times 365^{days} = 5235\,\alpha N$$

$$\alpha \begin{cases} 24 \text{ milliemes/KWH} : 0.1256N^{10^3 LE/route\ km} \\ 2.6 : 0.0136N \\ 12 : 0.0628N \end{cases}$$

$$EMU : N \times \alpha \times (0.13 \times 26.0^{KWH/km} + 0.23 \times 27.1^{KWH/km}) \times 365^{days} = 3509\alpha N$$

$$\alpha \begin{cases} 24 \text{ milliemes/KWH} : 0.0842N^{10^3 LE/route\ km} \\ 2.6 : 0.0091N \\ 12 : 0.0421N \end{cases}$$

Combined (EL + EMU): $0.2098N^{10^3 LE/route\ km}$; $0.0227N$; $0.1049N$

Diesel rolling stock

$$DL : N \times 0.025^{LE/litre} \times (0.26 \times 7.5^{litre/km} + 0.23 \times 8.9^{litre/km} + 0.15 \times 9.2^{litre/km}) \times 365^{days} \div 1000^{LE} = 0.0491N^{10^3 LE/route\ km}$$

$$DMU : N \times 0.025 \times (0.13 \times 8.6^{litre/km} + 0.23 \times 9.2^{litre/km}) \times 365^{days} \div 1000^{LE} = 0.0295N^{10^3 LE/route\ km}$$

Combined (DL + DMU): $0.0786N^{10^3 LE/route\ km}$

4.05 Maintenance expenses of rolling stock per annum.

Electric rolling stock

$$EL : N \times (0.26 \times 0.11^{LE/km} + 0.23 \times 0.11^{LE/km} + 0.15 \times 0.11^{LE/km}) \times 365^{days} \div 1000^{LE} = 0.0257N^{10^3 LE/route\ km}$$

$$EMU : N \times (0.13 \times 0.46^{LE/km} + 0.23 \times 0.46^{LE/km}) \times 365^{days} \div 1000^{LE} = 0.0604N^{10^3 LE/route\ km}$$

Combined (EL + EMU): $0.0861N^{10^3 LE/route\ km}$

Diesel rolling stock

DL : $N \times (0.26 \times 0.30^{LE/km} + 0.23 \times 0.30^{LE/km} + 0.15 \times 0.30^{LE/km}) \times 365^{days} \div 1000^{LE} = 0.0701N^{10^3 LE/route\ km}$

DMU : $N \times (0.13 \times 1.49^{LE/km} + 0.23 \times 1.49^{LE/km}) \times 365^{days} \div 1000^{LE} = 0.1958N^{10^3 LE/route\ km}$

Total (DL + DMU): $0.2659N^{10^3 LE/route\ km}$

4.06 Maintenance expenses of ground facilities per annum.

$$684^{10^3 LE/route\ km} \times 0.01 = 6.84^{10^3 LE/route\ km}$$

4.07 Personnel expenses per annum.

Man power for maintaining electric facilities

$$1.17^{persons} \times 589^{LE/person} \div 1000^{LE} = 0.689^{10^3 LE/route\ km}$$

Man power for depot repairs of rolling stock

Electric rolling stock

EL : $N \times 0.589^{10^3 LE} \times (0.26+0.23+0.15) \times 2.7^{person/loco} \div 356^{km} = 0.0029N^{10^3 LE/route\ km}$

EMU : $N \times 0.589^{10^3 LE} \times (0.13+0.23) \times 20.4^{persons/multiple\ unit} \div 564^{km} = 0.0077N^{10^3 LE/route\ km}$

Total (EL + EMU): $0.0106N^{10^3 LE/route\ km}$

Diesel rolling stock

DL : $N \times 0.589^{10^3 LE} \times (0.26+0.23+0.15) \times 5.4^{person/loco} \div 305^{km} = 0.0067N^{10^3 LE/route\ km}$

DMU : $N \times 0.589^{10^3 LE} \times (0.13+0.23) \times 47.6^{persons/multiple\ unit} \div 305^{km} = 0.0331N^{10^3 LE/route\ km}$

Total (DL + DMU): $0.0398N^{10^3 LE/route\ km}$

4.08 Table 2 summarizes the process of estimation.

TABLE 2 Summarized Process of Estimation

(Unit: 10^3LE/route km)

		Electrification	Dieselization
ANNUAL EXPENSES	Depreciation Charge	8.9 + 0.168N	0.338N
	Maintenance Expenses of Rolling Stock	0.0861N	0.2659N
	Maintenance Expenses of Ground Facilities	6.84	
	Energy Expenses (0.024 LE/KWH	0.2098N	0.0786N
	Energy Expenses (0.0026	0.0227N	
	Energy Expenses (0.012	0.1049N	
	Personnel Expenses for Rolling Stock	0.0106N	0.0398N
	Personnel Expenses for Ground Facilities	0.689	
	Sub-total	16.43 + (0.474N) / (0.287N) / (0.369N)	0.722N
Investment Amount of Rolling Stock		5.605N	7.501N
Investment Amount of Ground Facilities		684	
Sub-total		684 + 5.605N	7.501N

Note : "N" denotes the spot traffic volume expressed by a daily number of trains, up and down.

4.09 When the numerical values and linear expressions in N, both appearing in Table 2, are applied to the equation (1) in Para. 2.03 above, the following three equations are obtained:

Electric power unit prices in milliemes per KWH	Profitability percentage on additional investment (%)
24 :	$\eta_1 = \frac{-16.43 + 0.248N}{684 - 1.896N} \times 100$ .... (2)
2.6 :	$\eta_2 = \frac{-16.43 + 0.435N}{684 - 1.896N} \times 100$ .....(3)
12 :	$\eta_3 = \frac{-16.43 + 0.353N}{684 - 1.896N} \times 100$ .....(4)

4.10 Given N, the profitability percentages can be calculated as shown in Table 3:

TABLE 3 Relationship between N and η

N	Profitability Percentage on Additional Investment (%)		
	η_1	η_2	η_3
50	-0.7	0.9	0.2
100	1.7	5.5	3.8
150	5.2	12.2	9.1
200	10.9	23.1	17.8
250	21.7	44.0	34.2
300	50.4	99.2	77.8

Note : "N" denotes the spot traffic volume expressed by a daily number of trains, up and down.

CHAPTER V RESULTS AND CONCLUSIONS

5.01 It is a generally accepted principle that there are two major advantages in electrifying a certain railway line section: one is less maintenance expenses required for electric rolling stock than those required for diesel rolling stock, the other less energy expenses required for electric traction than those required for diesel traction. Table 2 in Para. 4.08 supports the former, but does not necessarily support the latter. In other words, among the three cases assumed of electric power unit prices, only one case (2.6 milliemes/KWH) gives less energy expenses required for electric traction than those required for diesel traction, because in Table 2:

$$0.0227 \text{ N} < 0.0786 \text{ N}.$$

The other two cases based on electric power unit prices of either 24 milliemes/KWH on the Helwan line or 12 milliemes/KWH assumed as an intermediate value are unlikely to give less energy expenses for electric traction than those for diesel traction, because in Table 2:

$$0.2098 \text{ N} > 0.0786 \text{ N and}$$
$$0.1049 \text{ N} > 0.0786 \text{ N}.$$

In conclusion, therefore, it can well be said that in Table 3 in Para. 4.10, the relationship between N and η_2 based on the equation (3) in Para. 4.09 will give a right picture.

5.02 Equation (3) in Para. 4.09 indicates that:

$$\eta_2 = 7(\%) \qquad \text{when N} = 113.$$

This result corresponds to the statement appearing in the "JNR brochure", i.e.:

$\eta = 7(\%)$ when $N = 39$ (see Para. 2.03).

5.03 A question may arise where does this difference in N between the ER and JNR come from? Major reasons are:

i) While the ER is of standard gauge, the JNR is of narrow gauge of 1,067 mm (the "JNR brochure" does not include Shinkansen lines);

ii) While the standard line section to be electrified on the ER is of double track, the standard line section to be electrified on the JNR is of single track (about 40% of the JNR network are already electrified);

iii) While 160 km/h operations are envisaged on the ER, less than 100 km/h operations continue on the JNR narrow-gauge lines to be electrified;

iv) While the permissible axle load of rolling stock on the ER is 22 tons, the corresponding figure on the JNR is 16 tons; and

v) It is considered unavoidable that the majority of investment items has to be imported in the case of the ER and that the investment amount becomes relatively costlier.