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THE REPUBLIC OF INDONESIA

REPORT
OF
THE FEASIBILITY STUDY
ON
THE ELECTRIFICATION PROJECT OF MAIN LINE IN JAVA

SUMMARY

FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

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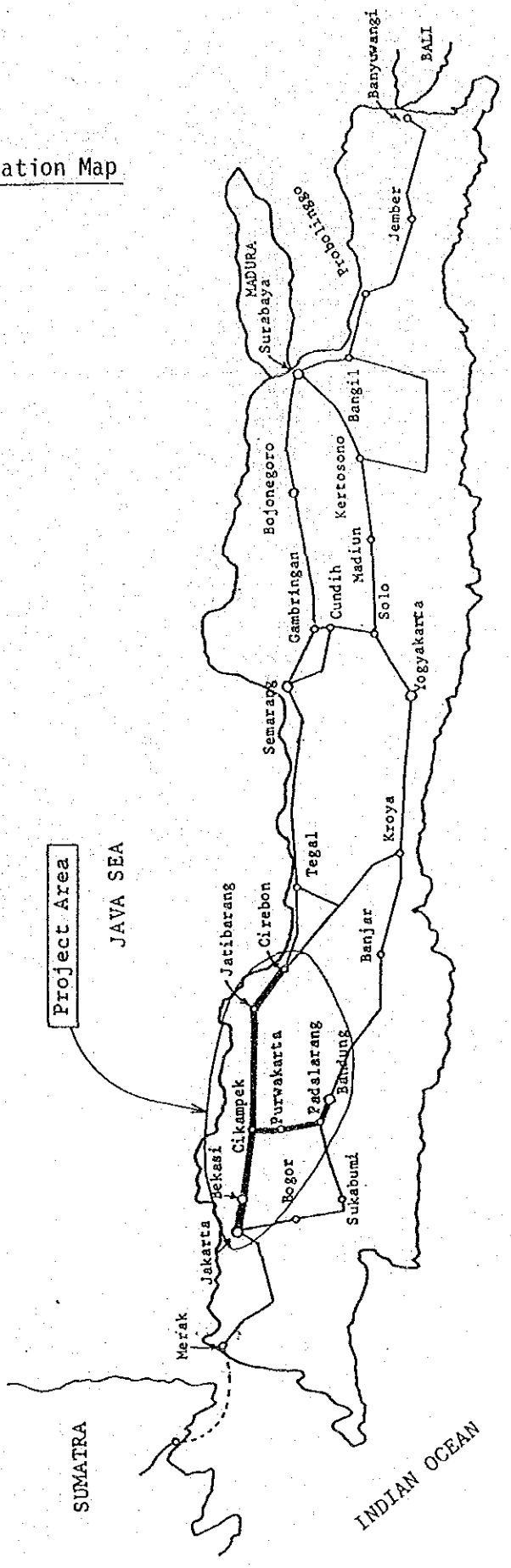
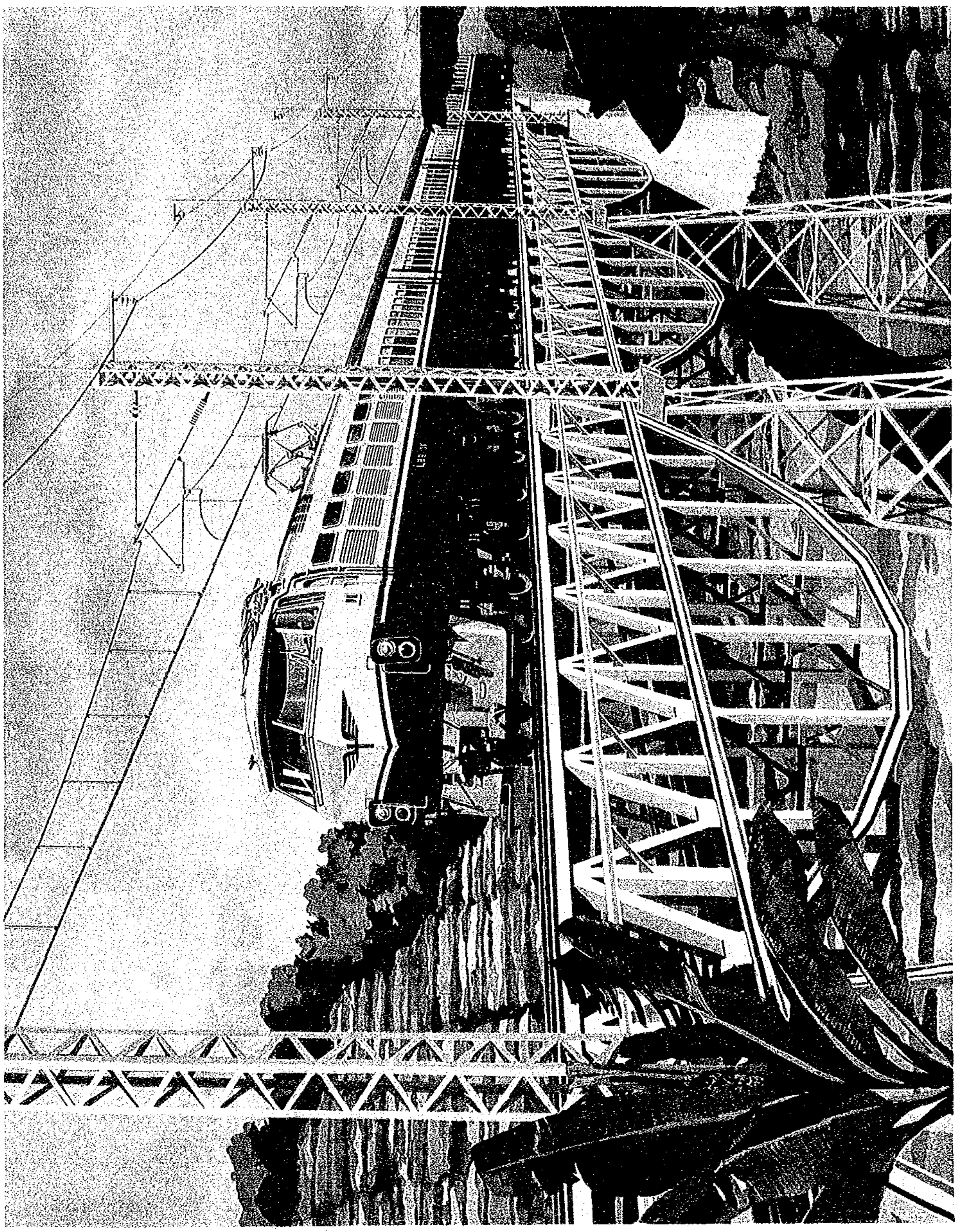
Project Location Map





CONTENT

1. Study Objective and Method

(1) Objective

The objective of this study is to examine the feasibility of the electrification project of the Jakarta - Cirebon and Cikampek - Bandung sections (hereinafter referred to as "the Section").

The railway sections relevant to this study are shown in Fig. S.1.

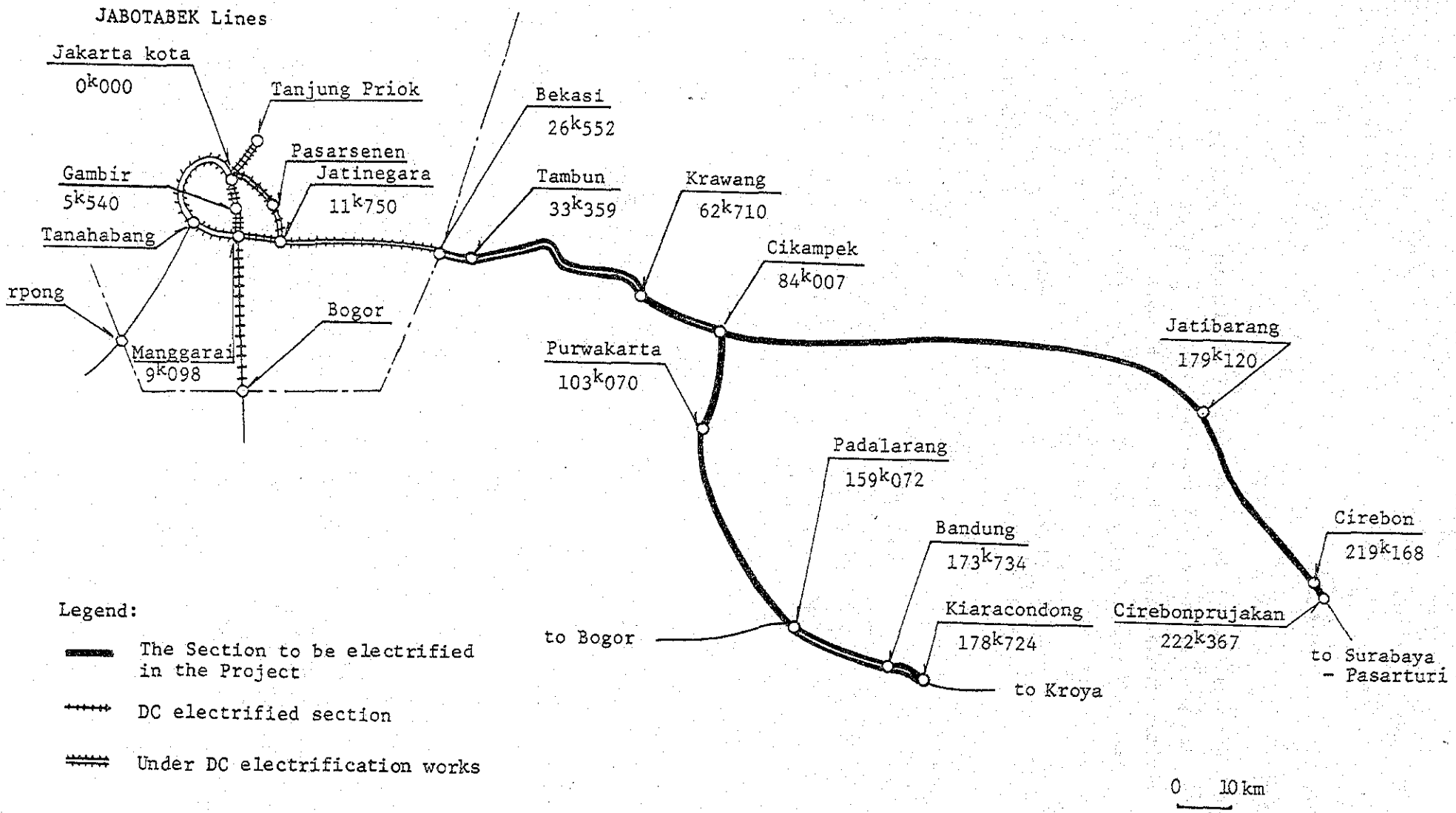


Fig. S.1 Railway Map of Electrification Project Area

(2) Method

This study was carried out according to the steps shown in Fig. S.2.

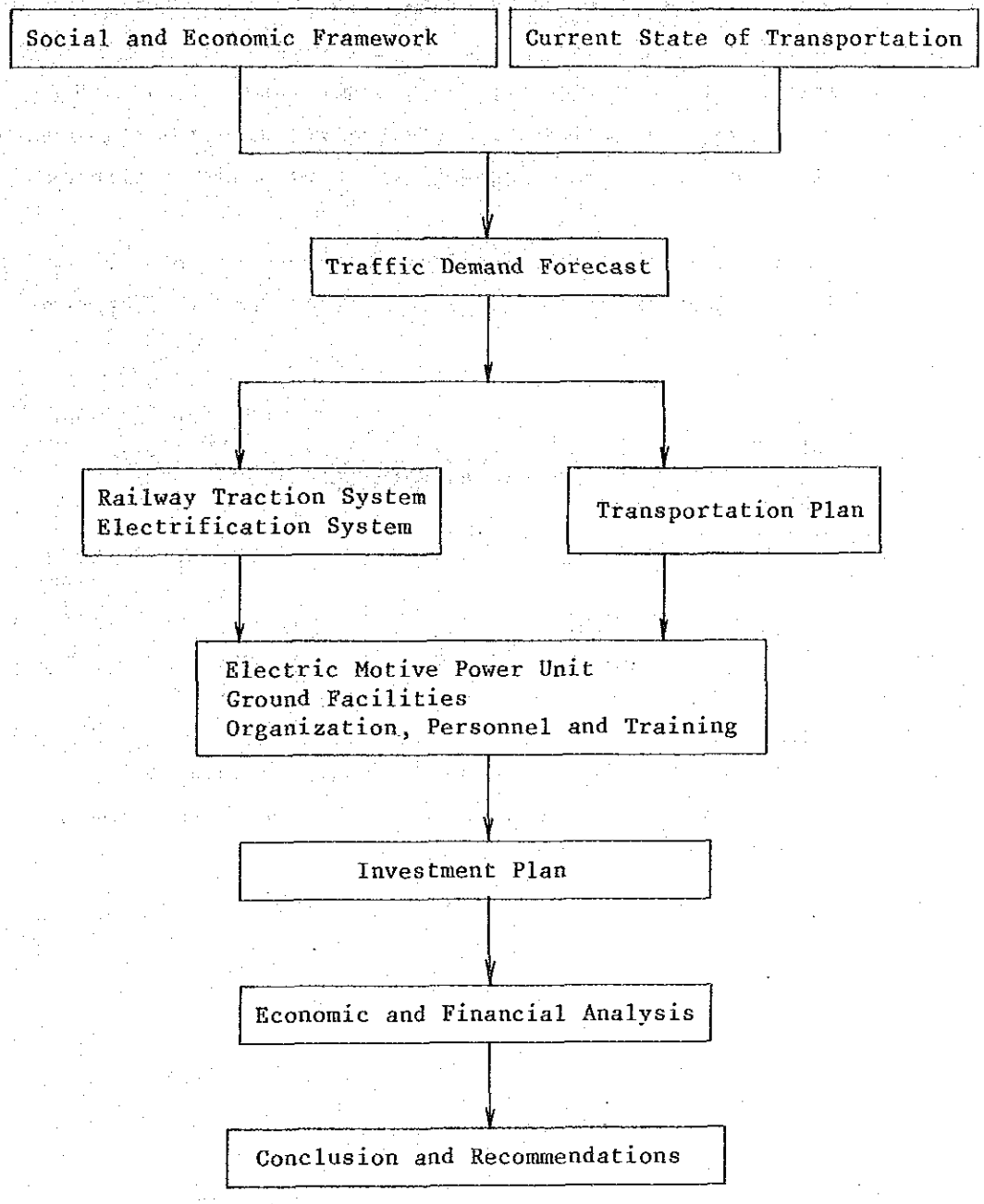


Fig. S.2 Study Steps

2. Social and Economic Framework

(1) Outline

Indonesia realized an annual average growth rate of 6.3% in terms of actural GDP in the last 10 years, thanks to its plentiful petroleum resources (see Table S.1). The expansion was particularly conspicuous in the manufacturing, construction and transportation sectors (see Table S.2). Indonesia's economy is characterized by heavy reliance on the state of the world petroleum market, which has shown declining tendency.

Industrialization and liberation from an excessive reliance on petroleum have been given top priority in the national development plans.

Table S.1 GDP Growth Rate (Actual)

	1969-1973 (REPELITA I)	1974-1978 (REPELITA II)	1979	1980	1981	1982	1983	1979-1983 (REPELITA III)	1974-1983
Average annual growth rate	7.7%	6.9	6.3	9.9	7.9	2.25	2.15*	5.7	6.3

Note: *Estimated from the average annual growth rate (5.7%) between 1979 - 1983 and the actual growth rate between 1979 - 1982.

Source: Statistical Year Book of Indonesia (1983)

Table S.2 Sectoral Composition of GDP (Constant)

(Unit: billion Rp.)

Sector	1972		1977		1982	
	Amount	%	Amount	%	Amount	%
(Constant prices of 1978)						
Agriculture	2,479.0	40.8	2,981.3	33.6	3,669.8	29.8
Mining	674.0	11.1	1,070.0	12.0	939.8	7.6
Manufacturing	564.0	9.3	1,057.7	11.9	1,900.7	15.4
Electricity, gas, water	26.2	0.4	49.0	0.6	105.5	0.9
Construction	222.0	3.7	463.8	5.2	757.8	6.1
Transportation, communication	229.0	3.8	438.7	4.9	716.6	5.8
Commerce, finance, service	1,873.0	30.9	2,821.5	31.8	4,235.2	34.4
GDP	6,067.2	100.0	8,882.0	100.0	12,325.4	100.0

Source: NOTA KEUANGAN 1984/85

(2) Energy situation

95% of the domestic energy consumption depends on petroleum and natural gas. Accordingly new development and diversification of energy resources are being vigorously sought.

(3) Forecast

The future social and economic framework is forecast based on REPELITA IV as follows;

a. Economic growth rate

1985 - 1988 5%

1989 - 1992 4.5%

1993 - 2007 3.5%

b. Population growth rate (Java)

See Table S.3.

Table S.3 Forecast of Java Population Growth Rate

Area / Year	Java	JABOTABEK		Other areas
		DKI Jakarta	Botabek	
1983 - 1988 (REPELITA IV)	1.8%	1983-1985 3.8%	3.0%	1983-1992 1.4%
1988 - 2002	1.7	1985-1990 3.1	3.5	1992-1997 1.6
		1990-1995 2.3	2.6	1997-2002 1.6
		1995-2000 2.0	2.3	
2002 - 2007	1.7*	2000-2005 1.8	2.0	2002-2007 1.7*
		2005-2007 1.7*	2.0*	

Note: *Estimated value in the study

Source: Statistical Year Book of Indonesia (1983)

3. Current State of Transportation

(1) Outline

Bus and truck account for most of the transportation in Java. It must be noted, however, that problems such as traffic congestion, traffic accidents, and air pollution have been spreading in the arterial highways and in urban areas as a consequence of the conspicuous increase in the number of automobiles. The railway system handles inter-city passenger and commuter transportation, as well as a small amount of freight, but both account for a small share.

Air and coastal shipping also account for a small share both in terms of passenger and freight.

(2) Conditions of the Section

The service levels and the transportation shares of rail and bus in the Section are shown in Table S.4.

Insufficient railway facilities and rolling stock are time-worn and obsolete, resulting in a low degree of safety, frequent delay and service suspension. The average delay time of long distance passenger trains exceeds 60 minutes.

Table S.4 Rail and Bus Service

Service / Section	Rail			Bus			Share(%)	
	Time (hr:min.)	Charge (Rp.)	Frequency	Time (hr:min.)	Charge (Rp.)	Frequency	Rail	Bus
From Jakarta to Cirebon	3:20 ~ 4:37	1st 7800 2nd 4500 3rd 2900	18	7:35	2000 ~ 2400	432	9.4	90.6
From Jakarta to Bandung	4:16 ~ 3:15	1st 6000 2nd 4500 3rd 1800	5	6:15	1500 ~ 1750	428	8.7	91.3

4. Traffic Demand Forecast

(1) Methodology

A passenger/consigner will choose the mode of transporation which requires the minimum amount of disutility.

If the project is not implemented ("Without the Project"), the railway share among all means of transportation would remain unchanged, assuming that the conditions of the other modes of transportation would also remain unchanged. On the other hand, if the project is implemented ("With the Project"), running time would be shortened by the rise in train speed, resulting in passengers transported by bus and commodities transported by truck and ship to be diverted to the railway.

The future railway traffic is forecast based on the present OD traffic, transportation patterns by mode, and the future socio-economic framework, for the with and without the project cases. In this study, inter-zonal traffic demand by modes is forecast for 35 zones of Java. The flow chart of the forecast process is shown in Fig. S.3.

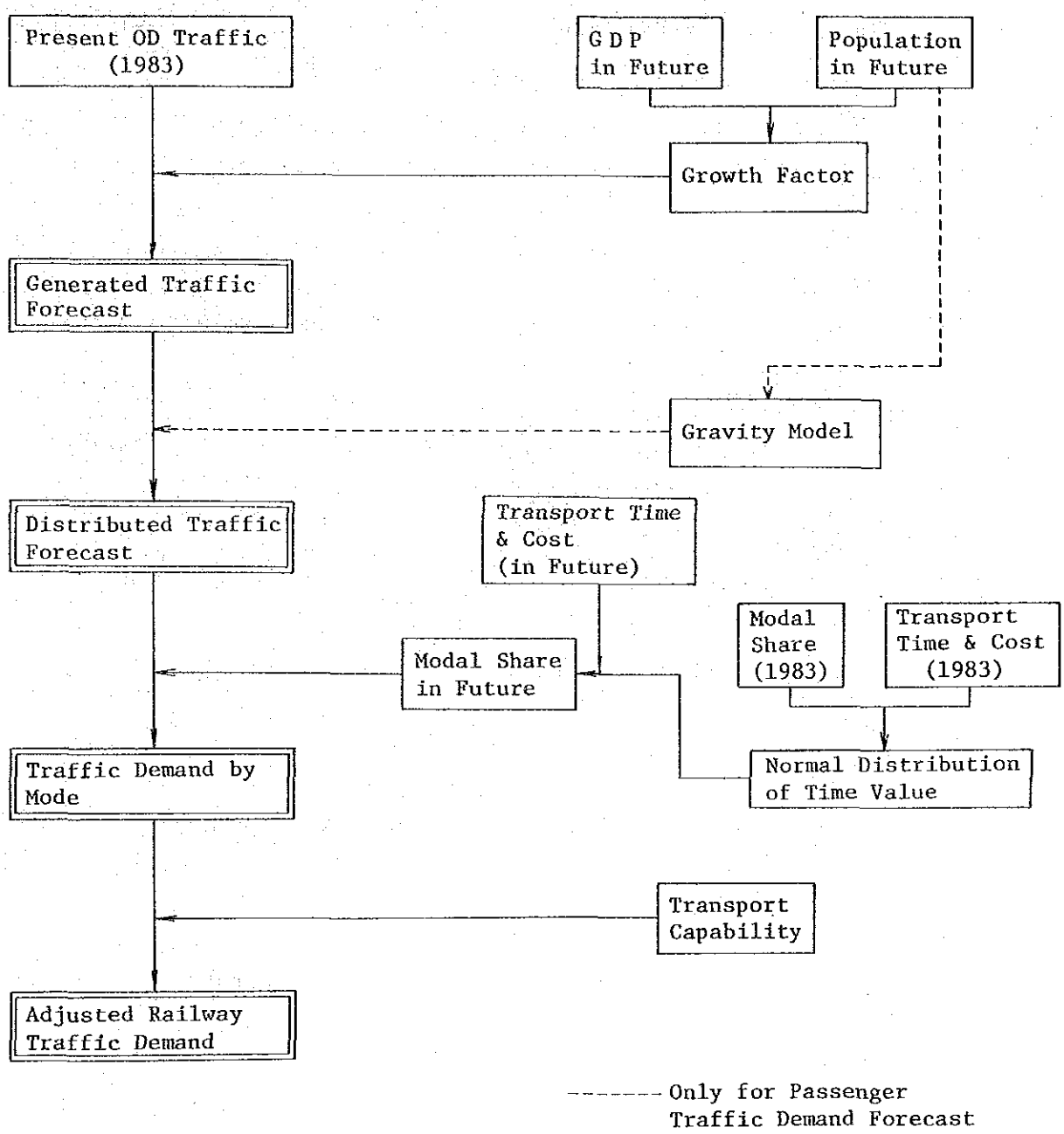


Fig. S.3 Flow Chart of Traffic Demand Forecast

(2) Premises

a. Transportation modes to be studied

- Passenger: Railway and road (bus)
- Freight: Railway, road (truck), and coastal shipping

b. Conditions

(a) Railway

-"Without the Project"

Current link-running time, fare/tariff, and terminal transport time/cost before electrification.

-"With the Project"

Link-running time after electrification, current fare/tariff and terminal transport time/cost.

(b) Road

Current fare/tariff, schedule time and terminal times and costs.

Increase in tolls and decrease in link-running time due to the new highways will be taken into account.

(c) Ship

Current tariffs, schedule time and terminal times/costs.

(3) Results

a. Total railway traffic demand in Java

(a) Passenger

"With the Project", traffic demand will increase by 2.1 times in 1992. "Without the Project", it will increase only by 1.6 times.

In other words, "With the Project" the railway's share will increase from 7.8% in 1983 to 10.6% in 1992.

(b) Freight

"With the Project", freight traffic demand will increase by 1.7 times in 1992. "Without the Project", it will increase by 1.3 times.

In other words, "With the Project" the railway's share will increase from 4.4% in 1983 to 5.5% in 1992.

b. Railway link traffic demand

(a) Jakarta - Cirebon

(i) Passenger

"With the Project", traffic demand will increase by approximately 2.7 times in 1992. "Without the Project", it will increase by 1.6 times.
In other words, "With the Project", the railway's share will increase from 14.0% in 1983 to 24.0% in 1992.

(ii) Freight

"With the Project", the railway's share will increase from 5.8% in 1983 to 16.4% in 1992.

(b) Jakarta - Bandung

(i) Passenger

"With the Project", traffic demand will increase by approximately 4.5 times in 1992. "Without the Project", it will increase by 2.4 times.
In other words, "With the Project" the railway's share will increase from 10.7% in 1983 to 19.4% in 1992.

(ii) Freight

"With the Project", the railway's share will increase from 2.6% in 1983 to 4.6% in 1992.

c. Railway critical link traffic

Critical traffic is estimated taking into account the transport capability of each link.

The link traffic demand and critical link traffic for 1992 and 2007 are shown in Table S.5.

Table S.5 Link Traffic by Section

(Both way; Per year)

Year	Section	Passenger (1,000 pass.)		Freight (1,000 tons)	
		Traffic demand	Critical traffic	Traffic demand	Critical traffic
1983	Bekasi - Cikampek	-	8,408	-	284
	Cikampek - Cirebon	-	6,710	-	305
	Cikampek - Bandung	-	1,619	-	122
1992	Bekasi - Cikampek	25,111	25,111	1,190	1,106
	Cikampek - Cirebon	17,827	17,827	1,476	1,373
	Cikampek - Bandung	7,211	7,211	361	354
2007	Bekasi - Cikampek	48,247	33,868	2,138	1,478
	Cikampek - Cirebon	33,863	19,503	2,594	1,669
	Cikampek - Bandung	14,185	12,725	529	432

5. Railway Traction System

AC/DC dual current electric locomotive is selected for the long distance train operation over DC and AC electrified sections, after comparative study on eight alternatives, including complete conversion of JABOTABEK electrification system from DC to AC.

6. Transportation Plan

(1) Premises

This plan is prepared based on the demand forecast results under the following premises.

a. One type of AC/DC dual current locomotives will haul both passenger and freight trains.

b. A passenger train make-up will be 10 or 6 cars.

c. The maximum train speed will be 100 km/h for passenger trains and 85 km/h for freight trains.

d. The maximum hauling load will be 400 t for passenger trains and 1,000 t (on Jakarta - Cirebon section) and 600 t (on Cikampek - Bandung section) for freight trains.

e. Passenger trains will depart from or arrive at terminal stations between 5 a.m and 10 p.m.

(2) Train operation

a. Operation time

Operation time of super express/ express passenger trains in the Jatinegara - Cirebon section is shortened by 22% and in the Jatinegara - Bandung section by 10% (See Fig. S.4).

b. Number of trains

After the electrification (1992), the number of trains is 100 in the Cikampek - Cirebon seciton and 38 in the Cikamped - Bandung seciton. The figures mean an increase of 52 and 20, respectively, compared with the current number (See Fig. S.5).

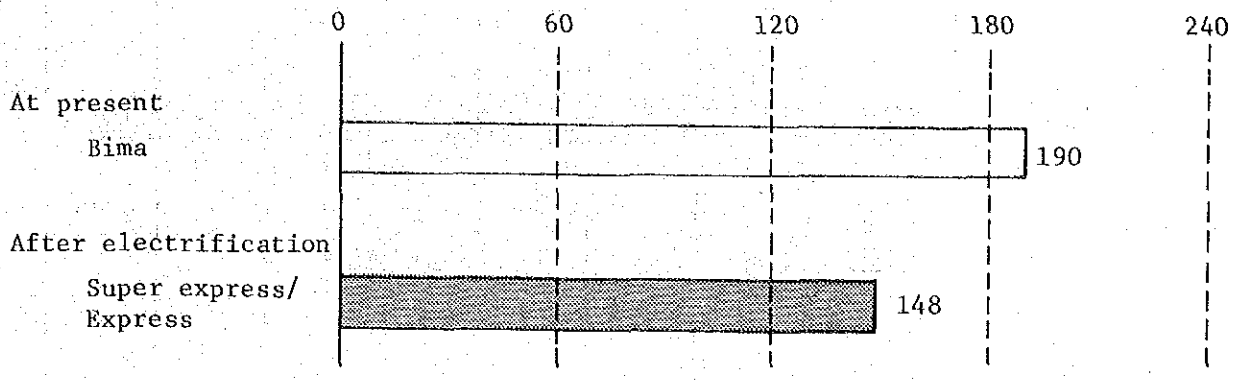
(3) Number of electric locomotives

The required number of electric locomotives is shown in Table S.6.

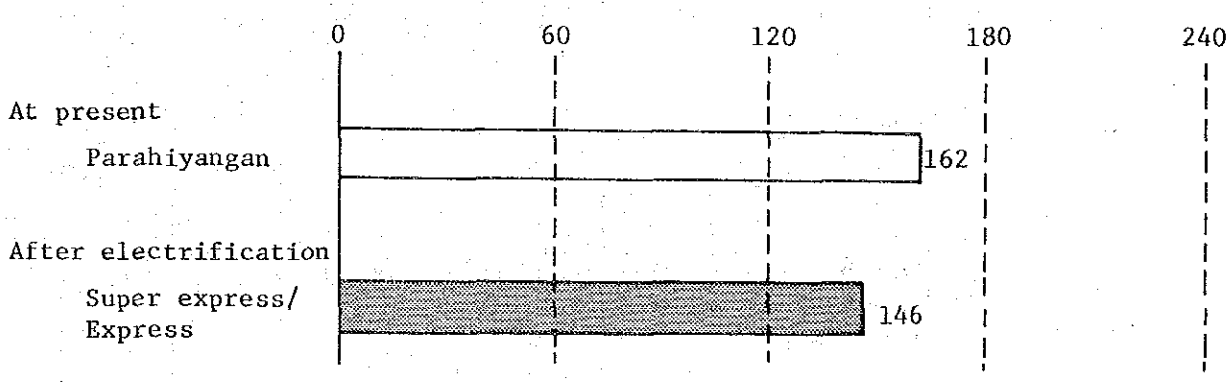
Table S.6 Required Number of Electric Locomotives

1992	1997	2002	2007
58	63	68	71

(1) Jatinegara - Cirebon



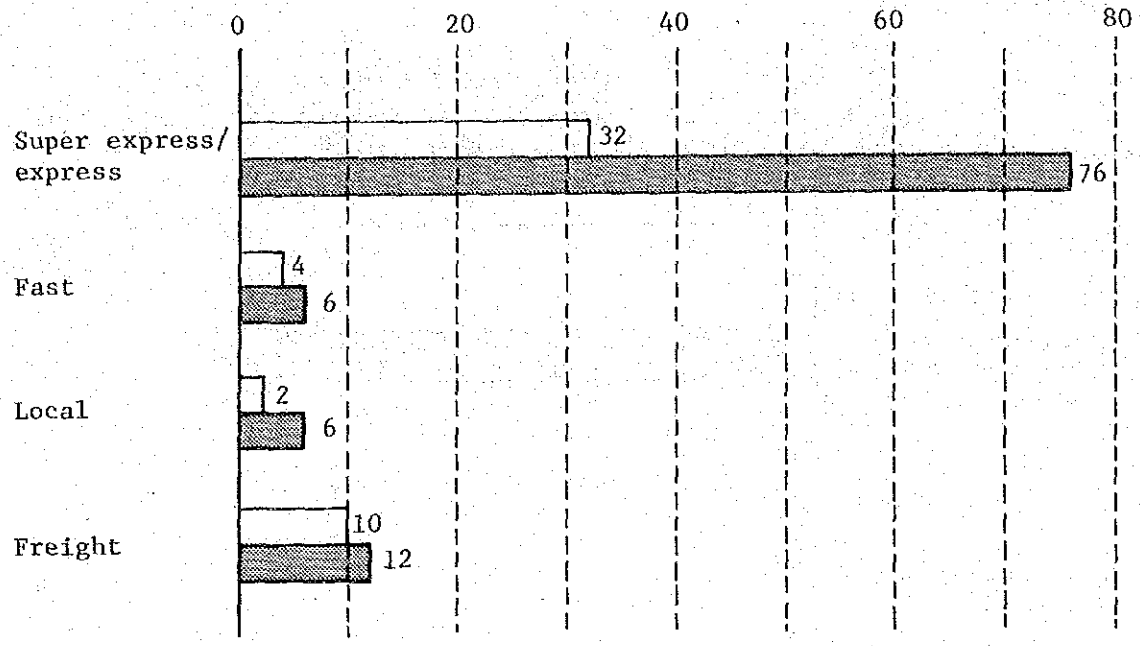
(2) Jatinegara - Bandung



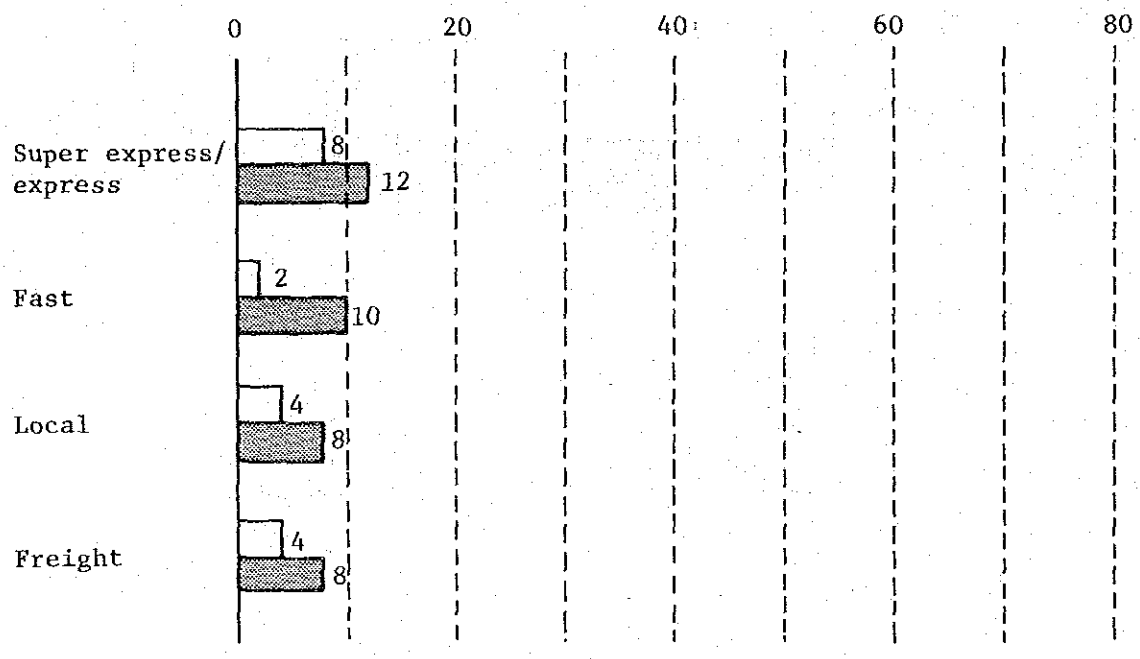
(Unit: minute)

Fig. S.4 Passenger Train Operation Time

1. Cikampek - Cirebon



2. Cikampek - Bandung



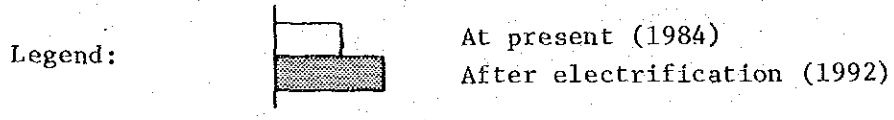


Fig. S.5 Number of Trains by Section

7. Electrification System

(1) The commercial frequency, single-phase, 25 kV AC system is adopted.

(2) As for the feeding system, the autotransformer (AT) system is selected.

(3) The simple catenary system is employed in general, and the direct suspension system is adopted on Purwakarta - Padalarang section where train speed is limited low.

(4) The low frequency (LF) code track circuit is adopted between stations, while the DC single rail track circuit is employed in the station yards.

(5) The overhead open wires along the railway are replaced with underground screened cables to prevent inductive interference caused by AC traction current.

8. Electric Motive Power Unit

Based on comparative study in terms of performance, reliability, maintenance, and economy on given operation conditions, the VVVF control electric locomotive is selected.

The main features of the locomotive are as follows.

Axle arrangement	B-2-B
Weight	70 ton
Size	17.9 m x 2.8 m x 3.6 m
Output	2600 kW
Maximum speed	120 km/h

9. Ground Facilities

(1) Substation

Three railway substations are installed at Kosambi, Padalarang, and Arjawinangun, which are supplied by a two-line system from 70 kV or 150 kV system of PLN.

Their facilities will be of the outdoor type, and are composed of stand-by system. Sectioning posts and sub-sectioning posts will be provided between the substations for the sake of power control and to restrict de-energized sections in the cases of outage and maintenance work.

(2) Overhead line equipment

Standard overhead line equipment consists of messenger, contact, feeder, protective wires and supporting structures. To cope with the high train speed up to 120 km/h, simple catenary hinged cantilever and automatic tensioning device are employed.

(3) Track and structures

a. The existing steel ties at turnouts are replaced with wooden ties in order to introduce the track circuit.

b. The Sasaksaat Tunnel, bridges, road overpasses, and aqueducts that interfere with the electric train operation are modified.

c. Extension of effective track lengths and platforms, and construction of passing tracks are implemented.

(4) Depot and workshop

a. Electric locomotive depots are constructed at Cirebon and Kiaracondong to conduct daily and monthly checks.

b. Yogyakarta workshop is remodeled to facilitate inspection and repair of electric locomotives.

(5) Signalling

a. The Bekasi - Cirebon section, which has the highest traffic, is provided with automatic block instruments with block signals, and relay/electronic interlocking devices.
Furthermore, the centralized traffic control (CTC) system is introduced in the Cikampek - Cirebon section to optimize and improve traffic control efficiency.

b. In the Cikampek - Bandung section, color light signals and the check-in/out block instruments are introduced, which will be further improved to automatic block system and relay/electronic interlocking devices in the future.

(6) Communications

a. The overhead wires along the railway are replaced with underground screened cables.

b. Increase in the capacity of UHF channels, number of automatic exchange telephones, dispatcher telepones, teleprinters, etc., are made to improve information quality and capacity.

10. Organization, Personnel, and Training

(1) Organization and Personnel

Organization for electrification facilities for both field and administration levels must be established together with strengthening of related sectors to facilitate maintenance and operation of the electrification system. Maintenance depots each with a staff of 17 personnel will be posted at every 50 km.

The number of personnel required for this project is shown in Table S.7.

Table S.7 Number of Personnel (in 1992)

Occupation	Number of personnel
Driver/Assistant driver	404
Depot	116
Workshop	70
Electrification	129
Signalling/Communications	Current + 27
Others	Current

(2) Training

Training will be conducted systematically at the training center in two levels, keeping pace with the improvement of the existing training system and facilities as well as implementation of electrification works.

a. Training instructors

Required number of training instructors/technical supervisors will be educated either by training abroad or lectures by foreign experts.

b. Electric locomotive driver and maintenance personnel

Diesel locomotive driver and maintenance personnel will be trained through lectures and practice and converted into those for electric locomotives.

The training program shall be conducted systematically because the number of personnel to be trained is large.

c. Ground facility maintenance/on-duty personnel

The required number will be trained through lecture and engaging in the construction to cope with new facilities and technologies.

11. Investment Plan

(1) Investment

The investment costs are estimated using the price as of March 1985. Inflation factors are not taken into account.

Table S.8 Initial Investment

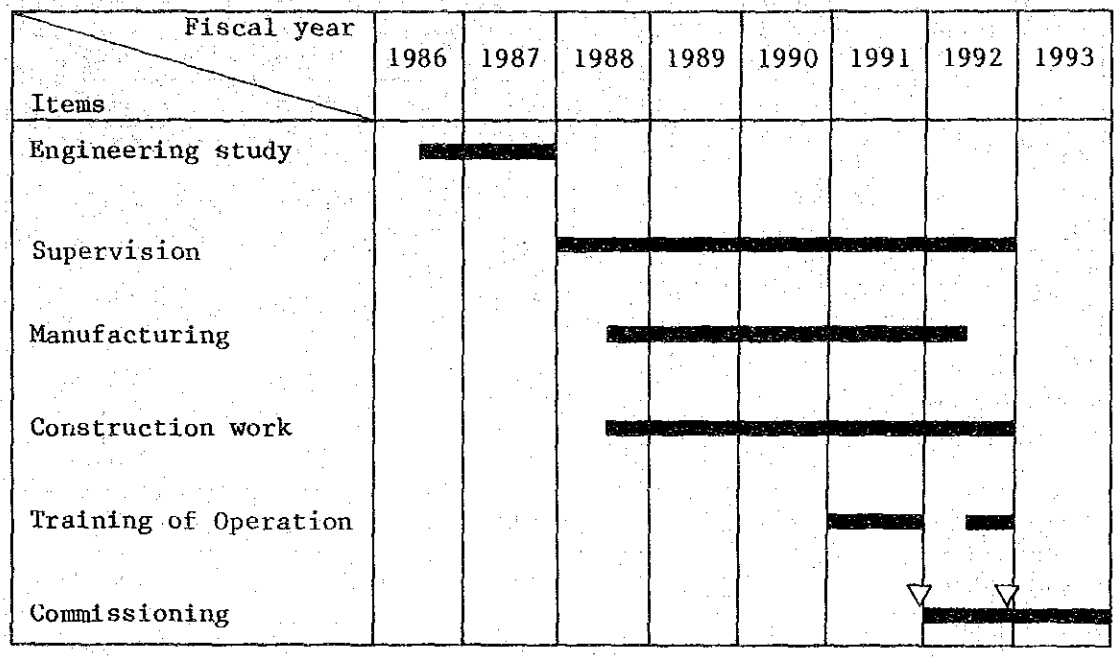
(Unit: million Rp.)

Items	1988 - 1992 (Workshop 1994 - 1996)		
	Local	Foreign	Total
Rolling stock	13,500	98,800	112,300
Electric facilities	15,700	18,600	34,300
Track and structure	7,000	3,200	10,200
Inspection & repair equipment for EL	2,400	8,700	11,100
Signalling and communications	5,000	16,100	21,100
Subtotal	43,600	145,400	189,000
Engineering and training	3,100	12,000	15,100
Contingencies	2,300	2,200	4,500
Total	49,000	159,600	208,600

(2) Construciton schedule

The construciton schedule is prepared assuming 1991 as the completion of electrification in the Bekasi - Cirebon section, and 1992 in the Cikampek - Kiaracondong section.

Table S. 9 Construciton Schedule



12. Economic and Financial Analysis and Environmental Assessment

(1) Economic analysis

a. Method

The Economic Internal Rate of Return (EIRR) is calculated from the differences of the costs and benefits for the "With the Project" and "Without the Project" cases.
Other effects of the project are examined as well.

b. Premises

(a) Benefits

Time saving resulting from implementing the project.

(b) Costs

Investment, maintenance and operating costs of railway, bus and truck.

(c) Project life

30 years

(d) Exchange rate

Japanese Yen 1. = Rp. 4.249
US$1. = Rp. 1,101

(e) Price

Economic price as of March 1985. Inflation is not considered.

c. Results

(a) EIRR

21.0%

(b) Sensitivity analysis

20% traffic demand reduction	16.8%
20% cost overrun	18.4%
20% traffic demand reduction plus 20% cost overrun	14.5%

d. Evaluation

The project has an EIRR of 21%, and therefore, it can significantly benefit the national economy, because it surpasses by far the opportunity cost of the capital in Indonesia (estimated to be 15% in this study).
Furthermore, the result of the sensitivity analysis surpasses the opportunity cost of the capital, evidencing the high degree of safety of this project.

The implementation of this project is expected to bring about the secondary effects mentioned below.

(a) Petroleum saving (crude oil equivalent)

462×10^3 bbl. in 1992

(b) Bus & truck saving
2,202 vehicles/30 years

(c) Mitigation of air pollution, traffic jam, and traffic accident

(d) Promotion of related industries

(e) Technology transfer

(2) Financial analysis

a. Method

(a) The Financial Internal Rate of Return (FIRR) is calculated from the additional investment required for the project, and the additional revenue and increase/reduction of operating cost of the project.

(b) Cashflow in various fund-raising methods is analyzed.

b. Premises

(a) Revenue

Revenue attributed to the diverted traffic from road to rail.

(b) Costs

Investment, maintenance and operating costs.

(c) Price

The market price as of March 1985.

Other premises are the same as in the economic analysis.

c. Results

(a) FIRR

18.5%

(b) Sensitivity analysis

20% revenue reduction	14.7%
20% cost overrun	15.5%
20% revenue reduction plus 20% cost overrun	12.2%

(c) Cashflow analysis

(i) Financing plan

Table S.10 Financing Plan

	Foreign currency portion	Local currency portion
Plan 1	Government-to-government borrowing	Government budget
Plan 2	Ditto	(50%) Government budget (50%) Domestic rupiah borrowing
Plan 3	Official overseas borrowing	Government budget
Plan 4	Ditto	(50%) Government budget (50%) Domestic rupiah borrowing

(ii) Terms and conditions of each financing source

Table S.11 Terms and Conditions of Each Financing Source

	Interest rate (%)	Term (Years)	Grace (Years)	Repay-ment
Government budget	-	-	-	No need to pay
Government to government borrowing	3.5	30	10	Semi-annual instalments
Official overseas borrowing	9.0	15	4	Ditto
Domestic rupiah borrowing	16.5	10	4	Ditto

(iii) Cashflow

Table S.12 Cashflow Summary

(Unit = Mil. Rp.)

Financing Plan 1	1992	2002	2007
Revenue	32,942	39,613	40,877
Operating costs	7,681	10,391	8,199
(Depreciation)	2,947	5,756	3,494
Expensed interest	3,862	4,391	3,366
Net income	21,399	24,831	29,312
Funds from operation	24,346	30,587	32,806
Financing Plan 2			
Net income	17,477	24,575	29,236
Funds from operation	20,424	30,331	32,730
Financing Plan 3			
Net income	14,709	24,991	32,057
Funds from operation	17,656	30,747	35,551
Financing Plan 4			
Net income	10,787	24,735	31,981
Funds from operation	13,734	30,491	35,475

Funds from operation = Net income plus depreciation

(d) Benefit-Cost Ratio (B/C Ratio)

Financing Plan 1	2.8
Financing Plan 2	2.4
Financing Plan 3	2.2
Financing Plan 4	1.9

The discount rate: 15%

d. Evaluation

The FIRR of the base case, 18.5%, shows the project has fairly high profitability. In addition, since the project still has the FIRR of 12.1% in the pessimistic sensitivity case of 20% revenue reduction plus 20% cost overrun, the project assures safety of profitability.

Meantime, from the standpoint of cashflow, the project is expected to be viable in all financing plans, contributing to improving the financial situation of PJKA.

(3) Environmental assessment

As for environmental impact caused by electrification, the following aspects are considered.

a. Air pollution will be significantly reduced.

b. Noise and vibration will not significantly increase.

c. Inductive interference to communication lines can be mitigated.

d. Safety measures against electric shock should be taken.

e. Careful attention should be paid to the noise and vibration during the construction works.

13. Conclusion and Recommendations

(1) Conclusion

Inter-zonal railway transportation demand in Java island was forecast for both "With" and "Without the Project" cases.

This demand forecast was used as the basis for a technical study to formulate the electrification plan in consideration of present conditions. The technical study concludes that the project is technically feasible at the minimum cost.

The investment plan based on the technical study was then made as the basis for the economic and financial analysis. These show that the project would greatly contribute to the economic development of Indonesia, and that it is financially viable for the Indonesian State Railways.

The implementation of the project is therefore highly recommended.

(2) Recommendations

The following recommendations are made to contribute to smooth implementation of this project and to satisfactory operation thereafter.

a. It is necessary to establish efficient and rational criteria and methods, to introduce modern maintenance system, and to level up maintenance personnel capability.

b. The continuous training of related personnel at railway training center is indispensable.

c. During the engineering stage, it is necessary to establish standards of new rolling stock and facilities, considering smooth and efficient construction and maintenance.

d. Double tracking of the Cikampek - Cirebon section should be studied as soon as possible to cope with the expanding traffic demand which is supposed to surpass the track capacity.

e. Pedestrians in railway premises should be prohibited.