REPORT
ON
NATIONAL POWER STUDY
IN
REPUBLIC OF INDONESIA

VOLUME III
APPENDICES

November 1969

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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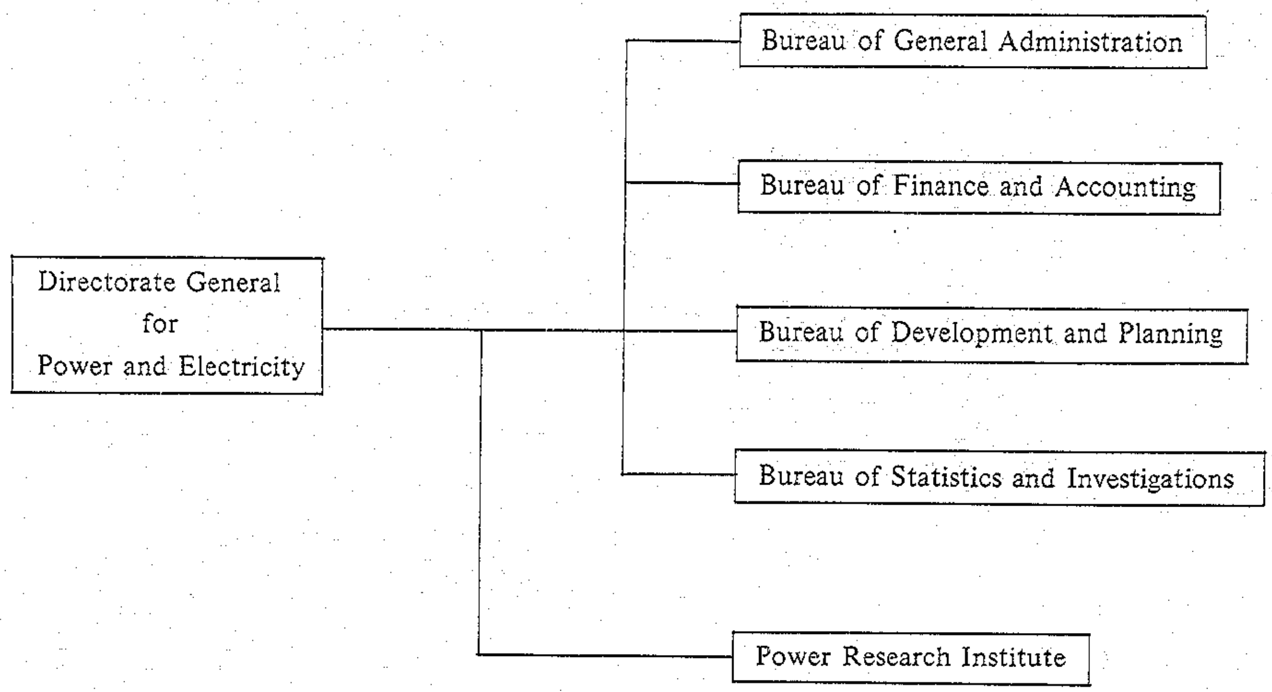
CONTENTS

ORGANIZATION AND DUTY OF DIRECTORATE GENERAL FOR POWER AND ELECTRICITY (TENTATIVE)



BUREAU OF GENERAL ADMINISTRATION

(1) General affairs of the Directorate General for Power and Electricity itself, and adjustment among each Director of Bureau

(2) Adjustment between the government requirements and PLN management policy, procedures for appointment of PLN President, Vice Presidents and approval of Directors for PLN

(3) Secretariate business for the electric power commission

BUREAU OF FINANCE AND ACCOUNTING

(1) Grasp of the financial condition of PLN

(2) Business relating to approval of electric tariff

(3) Supervising on PLN financial and accounting works and auditing

BUREAU OF DEVELOPMENT AND PLANNING

(1) Supporting the introduction of foreign fund, national fund and imported materials for the projects of PLN

(2) Suggestions on the planning of facilities

(3) Inspection of PLN electric power facilities

BUREAU OF STATISTICS AND INVESTIGATIONS

(1) Making statistics for electric power and other energy sources in Indonesia

(2) Investigations on electric power in foreign countries

(3) Investigations on utilization of water resources for power generation and other energy sources

(4) Supervision of electric power facilities not belonging to PLN

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POWER RESEARCH INSTITUTE

(1) Study on the technique for utilization of power

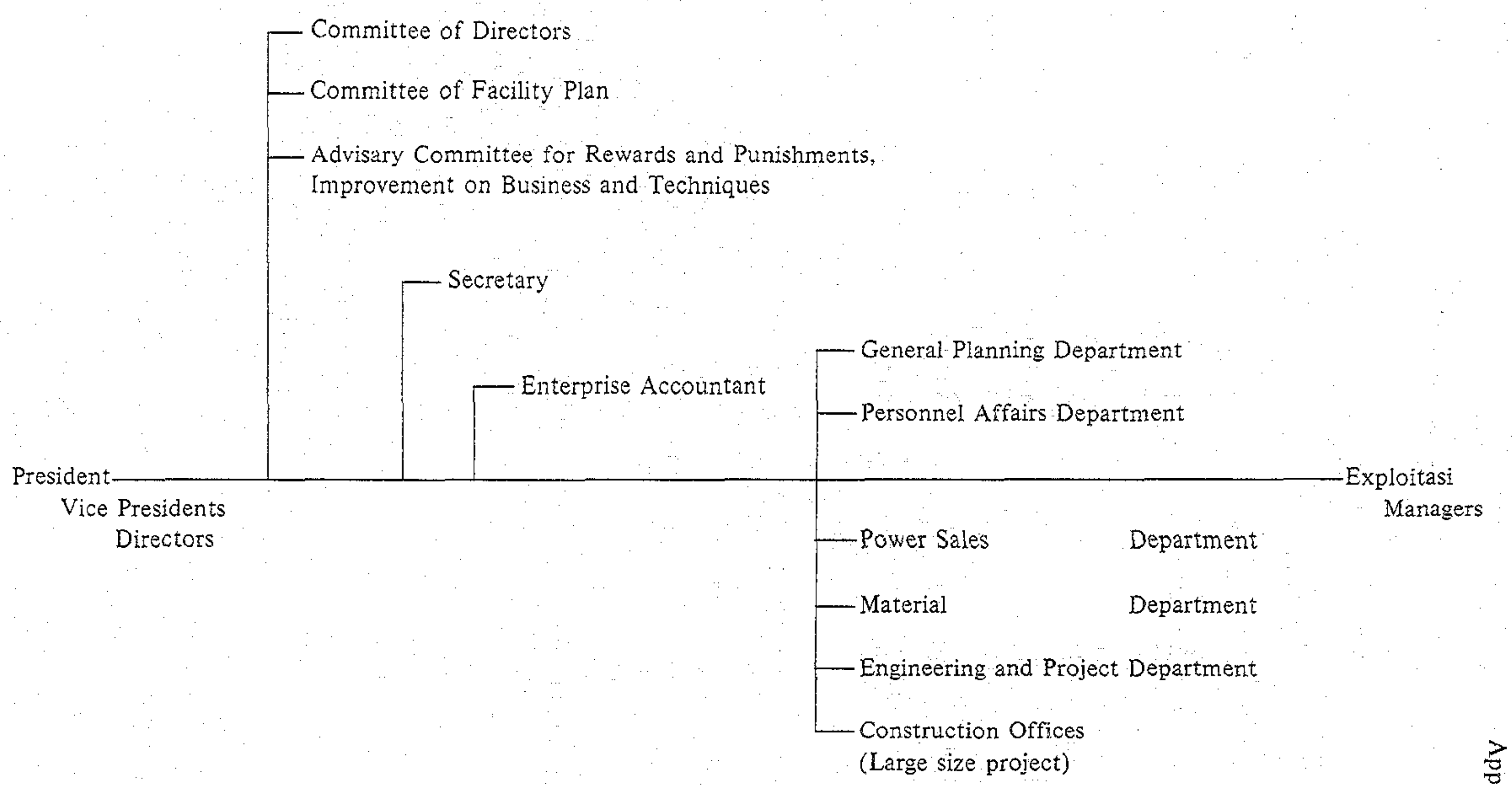
(2) Establishment of safety standards of electric facilities including the facilities of the customers

(3) Maintenance of standards for the electric metering, and approval of electric meters

The above-mentioned duty of the Directorate General for Power and Electricity concerning PLN is also applied to PGN. If the reorganization for PGN is not applied as for PLN, the authority of the Bureaus of General Administration, Finance and Accounting, Development and Planning, Statistics and Investigations should be limited to PLN, and the Bureau of Gas Administration should be established for PGN.

Appendix 1–2

ORGANIZATION AND DUTY OF PLN (TENTATIVE)



PLN head office

PLN HEAD OFFICE

GENERAL PLANNING DEPARTMENT

(1) Giving assistance to the management committee (Planning the draft of management policy and direction of budget)

(2) Overall adjustment on long term planning

(3) Overall control of the whole facilities and works

(4) General Adjustment on overall works

(5) Business concerning organization, structure and authority

(6) Load estimation for the overall enterprise and each exploitasi

(7) Management of budget and finance including raising of fund

(8) Grasp of management results

PERSONNEL AFFAIRS DEPARTMENT

(1) Planning of personnel, transfer of personnel, and rewards and punishments

(2) Labour control

(3) Training and education

POWER SALES DEPARTMENT

(1) Business for power sales, tariff and metering

(2) Business for services

(3) Research for regional development

(4) Rate making

MATERIAL DEPARTMENT

(1) Management of material and material supply

(2) Purchasing (including import materials)

(3) Contract works for projects

(4) Research of fuel sources and purchasing of fuels

ENGINEERING AND PROJECT DEPARTMENT

(1) Investigations of technical development

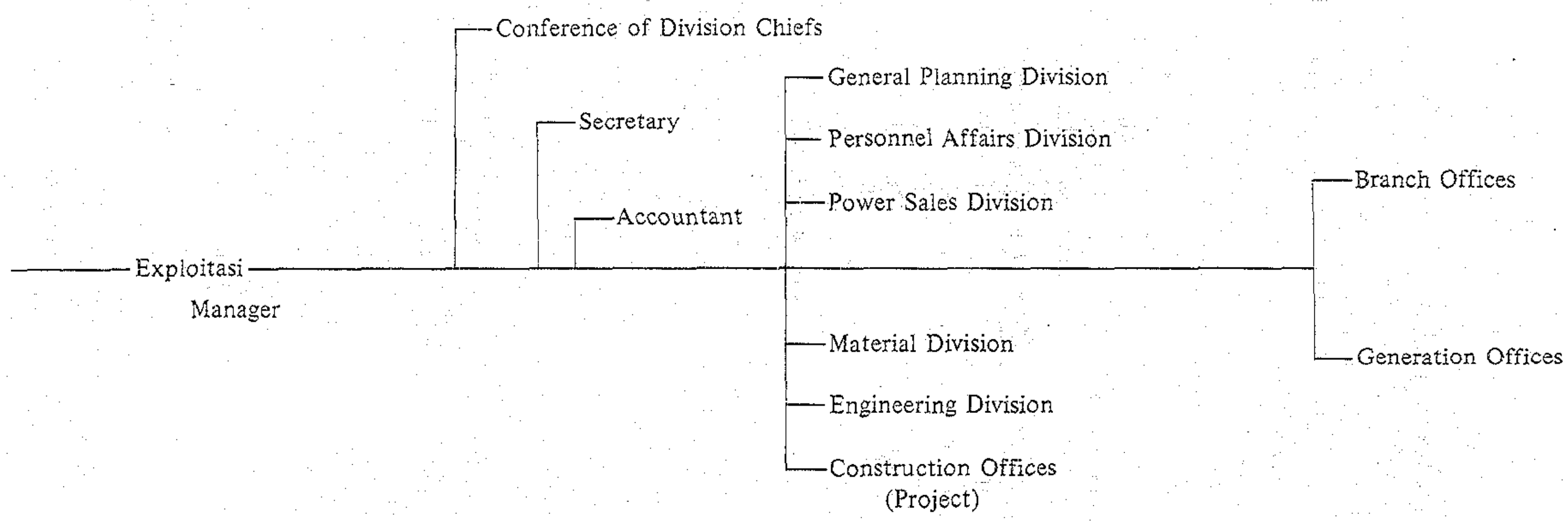
(2) Planning of the facilities and designing of projects including large projects

(3) Management of construction works of entire PLN

(4) Inspections of projects

(5) Management of generation, transmission, substation and distribution

(6) Business of power despatching



Exploitasi offices

EXPLOITASI OFFICE

GENERAL PLANNING DIVISION

(1) Planning the draft of policy and the direction for compilation of budget

(2) Load estimation

(3) Overall adjustment for the long range plan

(4) Plan of facilities and comprehensive planning for overall business

(5) Business with regard to authorization

(6) Budget control and financial control

(7) Gasp of results

PERSONNEL AFFAIRS DIVISION

(1) Planning of personnel, transfer of personnel, rewards and punishments

(2) Labour control

(3) Training and education

POWER SALES DEPARTMENT

(1) Business for power sales, tariff and metering

(2) Business for services

(3) Research for regional development

MATERIAL DIVISION

(1) Purchasing and contract

(2) Materials and storage

(3) Purchasing fuels

ENGINEERING DIVISION

(1) Planning of the facilities for maintenance and projects

(2) Business for construction works and coordination of engineering division

(3) Inspection of projects

(4) Management of generation, transmission, substation and distribution

(5) Business of power dispatching

BASIS OF MANAGEMENT AND ORGANIZATION OF ELECTRIC POWER ENTERPRISE

1. BASIC BACKGROUND

The commodity of electricity differs from other commodities and has no conformation. As it cannot be stored, production immediately converts into consumption.

In other words, electricity is a commodity which should be continuously produced and sold throughout the year, the supply of electricity must be made in good and continuous service which satisfies the qualitative and quantitative requirements.

The following items are considered as the features of the electric power enterprise which constitute the basic background of management and organization.

(1) Production and sales of electric energy are in momentary supply-demand relations. Even if the system is operated by several enterprises, whole electric power industry involving production to sales has the necessity to operate through an exclusive facilities of electric power.

(2) The electric power enterprise has facilities which are large in scale and wide in extent, and needs not only a good maintenance and management, but also the extention and construction of facilities to cope with the increase of new consumers. As a result, such electric enterprise must have a large scale organization which consists of many offices and a large number of employees.

(3) The electric power enterprise having facilities which are large in scale and wide in extent should be rationally organized and managed by making reference to the condition of load demand and conditions of facilities. In addition, it is important to make a fair service for all consumers.

Existance of two or more enterprises in the same territory is hard to satisfy the above-mentioned conditions. As a result, an electric power enterprise is desired to be the monopoly in an area.

(4) An electric power enterprise supplies the power which is indispensable as the basic energy for the development of industries, economy, society, and culture of a nation, as well as for the improvement of nation's life. Therefore, an electric power enterprise is one of the basic industries of public benefit.

(5) It is needless to say that the electric power enterprise, a basic industry of public benefit, must supply plenty of cheap and good quality electric power so as to contribute to the increase of national power through the development of industries and economy, and improvement and stabilization of living conditions. Furthermore, it has the responsibility to make a progress of management by rationalization and modernization leading other industries.

2. BASIC CONDITIONS OF ORGANIZATION AND MANAGEMENT OPERATION FOR THE ELECTRIC POWER INDUSTRY

The activity of electric power enterprise should be based on the organization and management which fit the character of electric power enterprise, and serves to achieve its purpose. In addition, the organization and management is required; 1) to cope with the increasing complexity and expansion in scale, 2) to put several different departments which have the relationship each other 3) and to make possible to provide the continuous enterprise activity which can achieve uninterrupted supply of electric energy. The followings are the major basic conditions required for the organization and the management control for electric power enterprise.

(1) Activity of enterprise should fit the character of the enterprise

From the viewpoint of the character of enterprise mentioned above, the electric power enterprise should be managed by the process of through system from production to sales in each territory to realize its rational activity. Accordingly a reasonable division should be provided to cope with the enterprise activity in each territory, and the activity in each territory should be directly connected to the overall activities of enterprise.

(2) The following managing activities from establishment to target achievement to be accurately operated in each territory by each specialized departments should be integrated and systematized by the enterprise.

(a) A policy of enterprise activity should be made clear.

(b) A program should be previously set up as to what to do in order to achieve the policy.

(c) The organization should play the role of rationally systematizing the personnel who decide the programs, and promoting the cooperation between each departments.

(d) A motivation which displays big effort to realize the programs would be obtained through an organization.

(e) A coordinating function should be exercised to achieve the program by communication which solves opposing opinions and interests occur between each department during the activity.

(f) A control activity should be exercised to make efforts to coincide the programs with the results of activities, and to establish the prompt coordination between two opposite opinions.

(g) And then the managing policy should be achieved most efficiently through the whole activities.

(3) In the management activities, the intentions of higher organs should be promptly and clearly conveyee to lower organs, and the intentions of specialized department and lower organs should be clearly communicated to upper organs without delay. Moreover, a function of overall control is necessary.

An electric power enterprise needs not only the unifications of managing intentions in all divisional activities but also the unification of intentions of specialized departments caused by the multiplex status of the facilities and works. The enterprise consists of complex combinations of organization such as the vertical lined organization and the horizontal staff organization. Such an organization has the trend not only to disturb transmission of intentions, but also to make the overall control difficult.

Special attention should be paid to prevent the occurrence of above-mentioned condition, by the establishment of the line and staff organization in which are clarified the command system and the transmission of instructions and specialized guidances as shown in the attached chart.

(4) Responsibility for the work as well as the obligation and authority due to responsibility should be made clear and should be always reviewed to maintain flexibility.

In case of electric power enterprise, the organization is generally based on the line and staff system. Both of activity of vertical lined organization and activity of horizontal staff organization should be accomplished, and also the integrated management operation should be obtained. Therefore, the inter relationship between the following items should be previously made clear.

(a) Clarification of responsibilities for each division.

(b) Obligation to perform the responsibility and the authority required therefor.

(c) Accountability for fulfilling a responsibility dependent upon the authority.

(d) Liability for the results.

However, if the relationship between above-mentioned items were fixed for a long time, the organization will eventually fall into a rigid and unsuitable status. Especially, in case of the electric power enterprise which has prominent local character in each territory, and which requires the continuous operation, the relationship between above items should be flexible to deel with the situation.

Beside that, the authority should be entrusted as much as possible to the lower organization to make clear the relationship between the accountability for execution and the liability for the result.

(5) To achieve more rationalized and effective activity of enterprise under above-mentioned conditions, the high level management function should be established.

The management can be classified in two systems, one is the partial control, for instance production control, sales control, financial control and labor control, and the other is general control which is common to all the above-mentioned controls.

The power, considering the character and other conditions previously mentioned, the higher level management function covering all the activities of enterprise is necessary. For instance,

(a) The electric power enterprise which can be called a facility industry needs big amounts of an income and expenditure. In addition, it needs a huge amount of funds for construction. Therefore, the establishment of budget system which can joint the management program and the budget, and which can also connect the cost control and the budget is particularly necessary.

(b) Since the nature of the electric power industry calls for a large scale and complex organization, the firm internal reporting system is required for the management to make progress in the overall enterprise activity.

(c) The policy of electric power enterprise does not allow to place priority only on the profit as in other enterprises, but it should aim at the fair service for all customers and the public benefit. Therefore, the management policy of electric power enterprise should be based on the coordination of profit and public benefit.

(d) Beside the excellent organization, prompt and correct activity is required to prevent the partial ceasing of activity. In addition, the efficiency and the rationalization of electric power enterprise are required. Considering the above items, we can say that the electric power enterprise needs the modernization of management. For this purpose, the new management method, especially the modernized control system for office works should be introduced.

(6) <u>The office works should be effectively improved.</u>

The electric power enterprise is characterized by the expansion in scale which should keep pace with the development of industries and the improvement of nation's life. The expansion of the scale of enterprise means;

(a) Expansion of facilities and progress of technical revolution

(b) Increase of customer numbers and routine works

(c) Increase of necessity to make data correctly, speedily and more economically to cope with the higher level of management.

(d) Promotion of more scientific management plan

Therefore, the improvement of office work ability should be attained by the modernization of office management.

Consequently, examining the future aspect of electric power industry, the electric power enterprise needs the adoption of suitable measures for the improvement of office works, such as the introductions of office machinery.

(7) <u>Measures based on the importance of personnel management should be taken</u>

At present, almost every enterprise in the world has the policy: <u>"GOOD MANAGEMENT IS SUSTAINED BY TALENT"</u>, and the personnel management is of controlling importance to the management of enterprises.

Especially, in case of electric power enterprise, severe and exacting measures should be taken in the personnel management, because the electric power enterprise needs a diversity of members who vary in specialized technical fields, knowledges, labor condition, age, sex, and livelihood condition to deel with its multiplex activities which are under the following condition.

(a) Since the enterprise is large in the scale, wide in its activity area, and has close relationship with the regional communities in each territory, the management exerts a large influence on each regional community.

The working condition of electric power enterprise is obliged to influence generally the working condition of other workers in that territory.

(b) In order to maintain the through process from generation to distribution and the close connection with the customers who are located in the wide area, many kinds of offices and many members who are varied in speciality are necessary.

(c) As the quantitative and qualitative requirements in the power demand are increasing due to the development of industries and improvement of living condition of nation, the enterprise should secure not only a sufficient numbers of persons to comply with such requirements but also make efforts to improve the knowledge of members with respect to the techniques of construction facilities and management of enterprise.

(d) In accordance with the increasing dependence on the electric power as an essential energy for the daily life and the industrial activities, the stable power supply and the prompt recovery of accident is required. Consequently, the enterprise should secure a sufficient manpower to deal with dangerous and fatiguous works, and establish suitable working conditions.

(e) The members of electric power enterprise which has the character of both the public utility and the basic industry should be conscious of their duty to serve the society and support the enterprise. Measure for personnel management which include the following items should be positively taken with the full knowledge of individual aptitude, ability and achievement.

Consequently, the electric power enterprise should grasp the aptitude, ability, and results of each person to realize the following items.

(a) Improvement of labor power

(b) Making exactitude of personnel management from the viewpoint of long range plan based upon the overall coordination of future prospect of the enterprise and the measures planned therefor.

(c) Realization of the right person in the right place

(8) Human development should be positively executed

Generally, the purpose of the training and education in the enterprise is as follows.

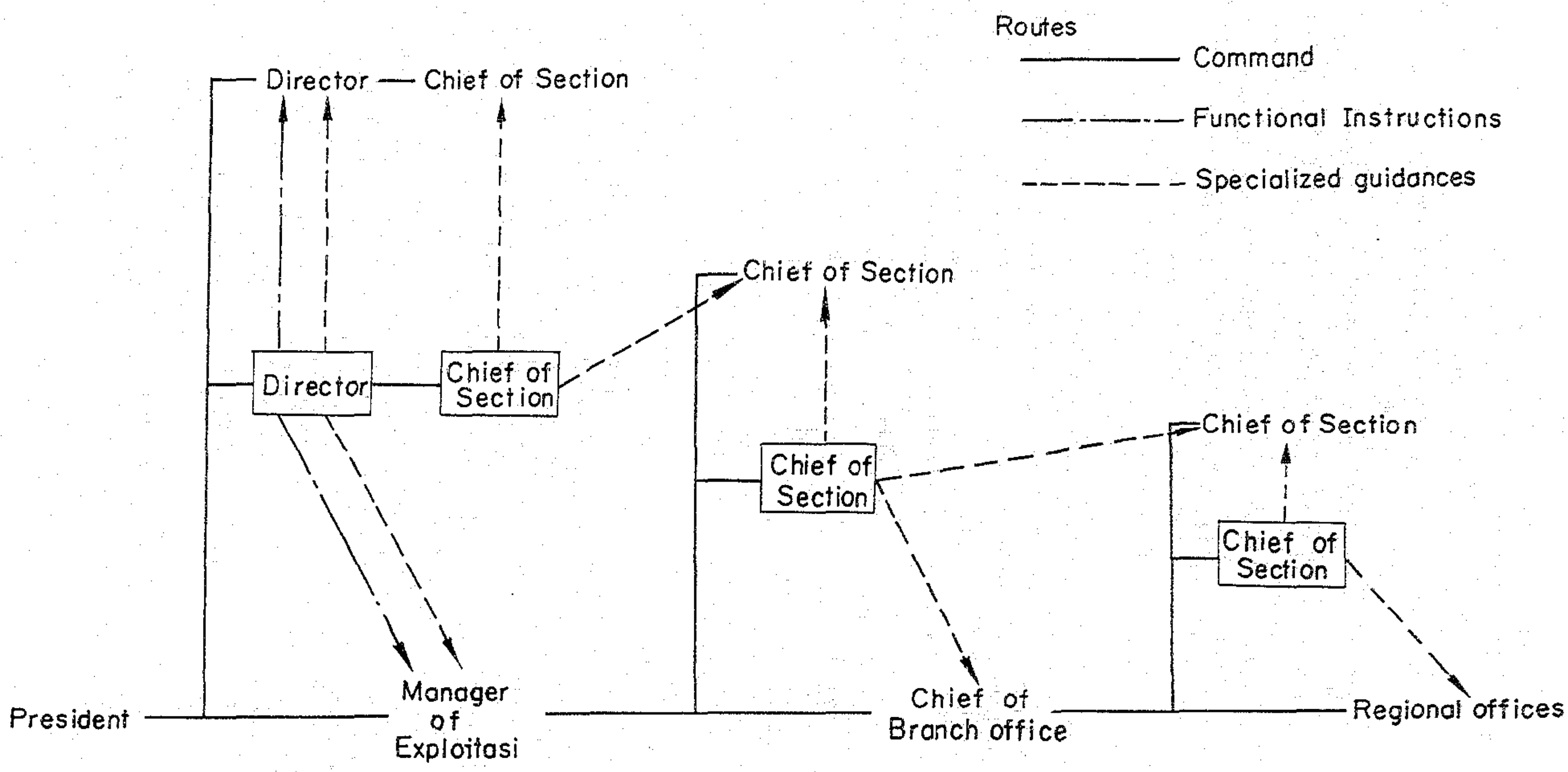
(a) Giving a motivation and foundation for self development, by which the members can develop themselves to be worthy members of the enterprise.

(b) By providing the members with knowledges and techniques demanded by the enterprise which are essential in the fulfilment of their present duties, they will express their self-consciousness and obligation that they are the members of enterprise.

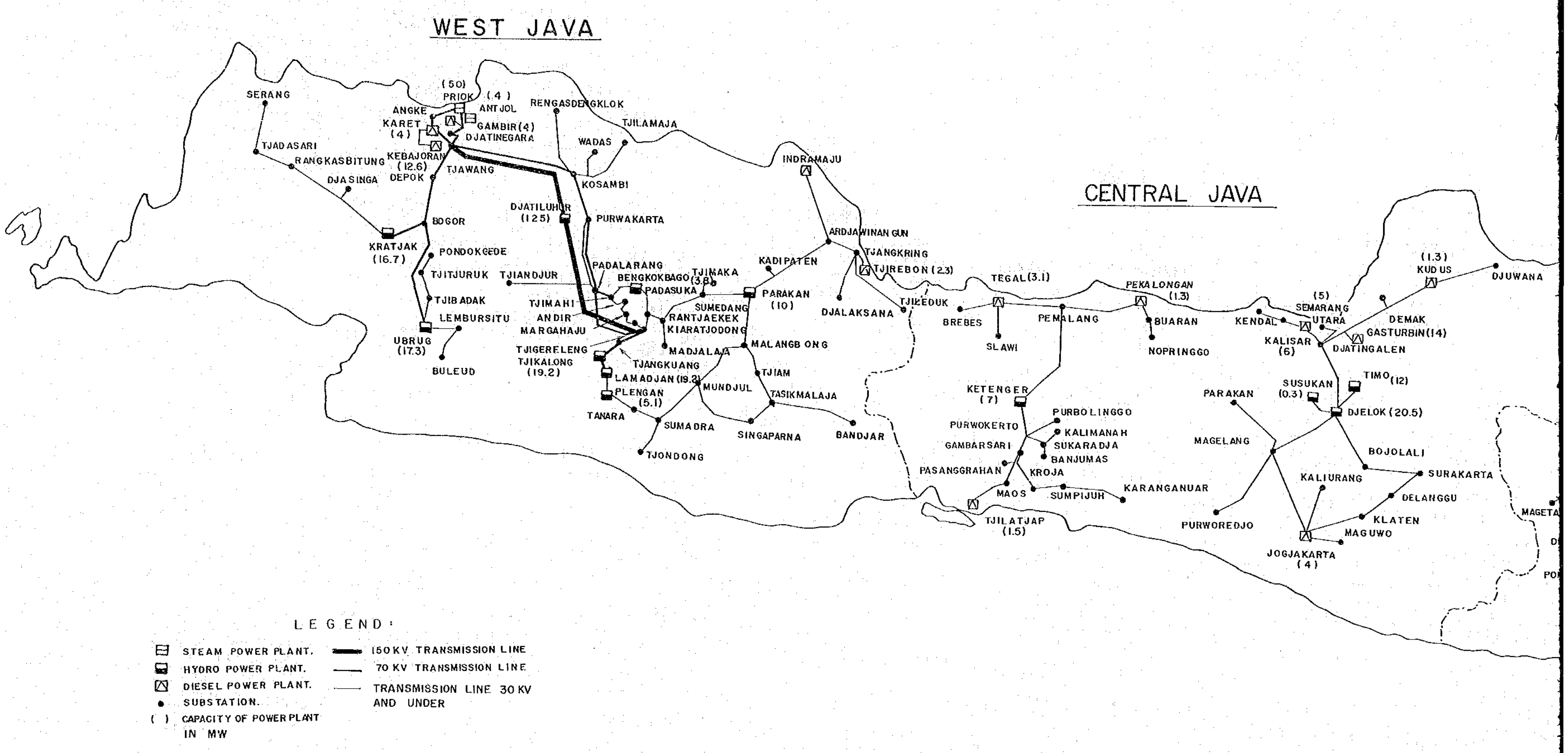
(c) Securing a minimum required number of qualified personnel to comply with the future demand through the development of individual abilities in order that their future responsibility may be fulfilled in the developing enterprise.

Considering the above-mentioned purpose of the training and education, we can say that a great importance must be attached to the training and education in the enterprise particularly when we make a reviewal on the basic conditions which are necessary for the future progress in the activity of electric power enterprise. Above all, the member of electric power enterprise needs a training and education which will provide him with the ability to reach the reasonable point of view, attain an equitable way of thinking and realize how he should behave as a member of the enterprise, with full recognition of his status of a member of society engaged in a public utility.

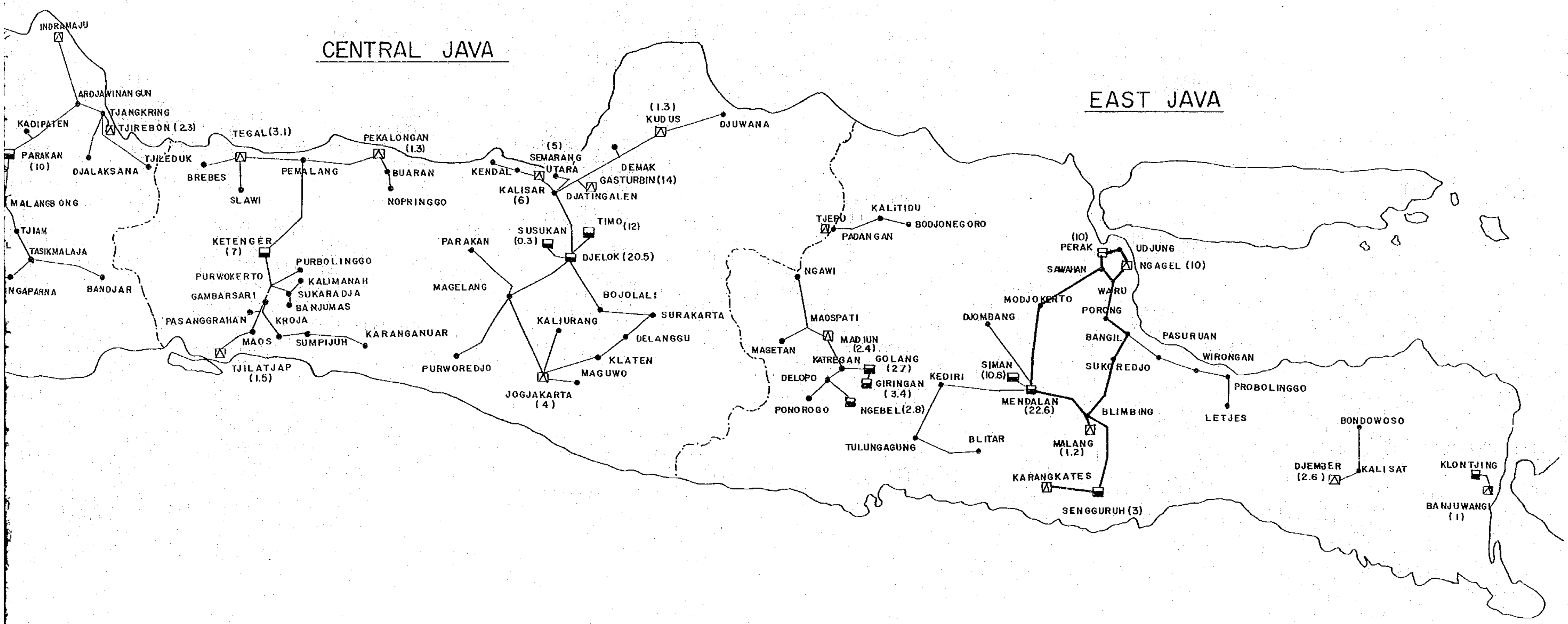
RELATIONSHIP OF COMMAND. FUNCTIONAL INSTRUCTIONS AND SPECIALIZED GUIDANCES



TRANSMISSION LINE MAP (Java, Mar. 19

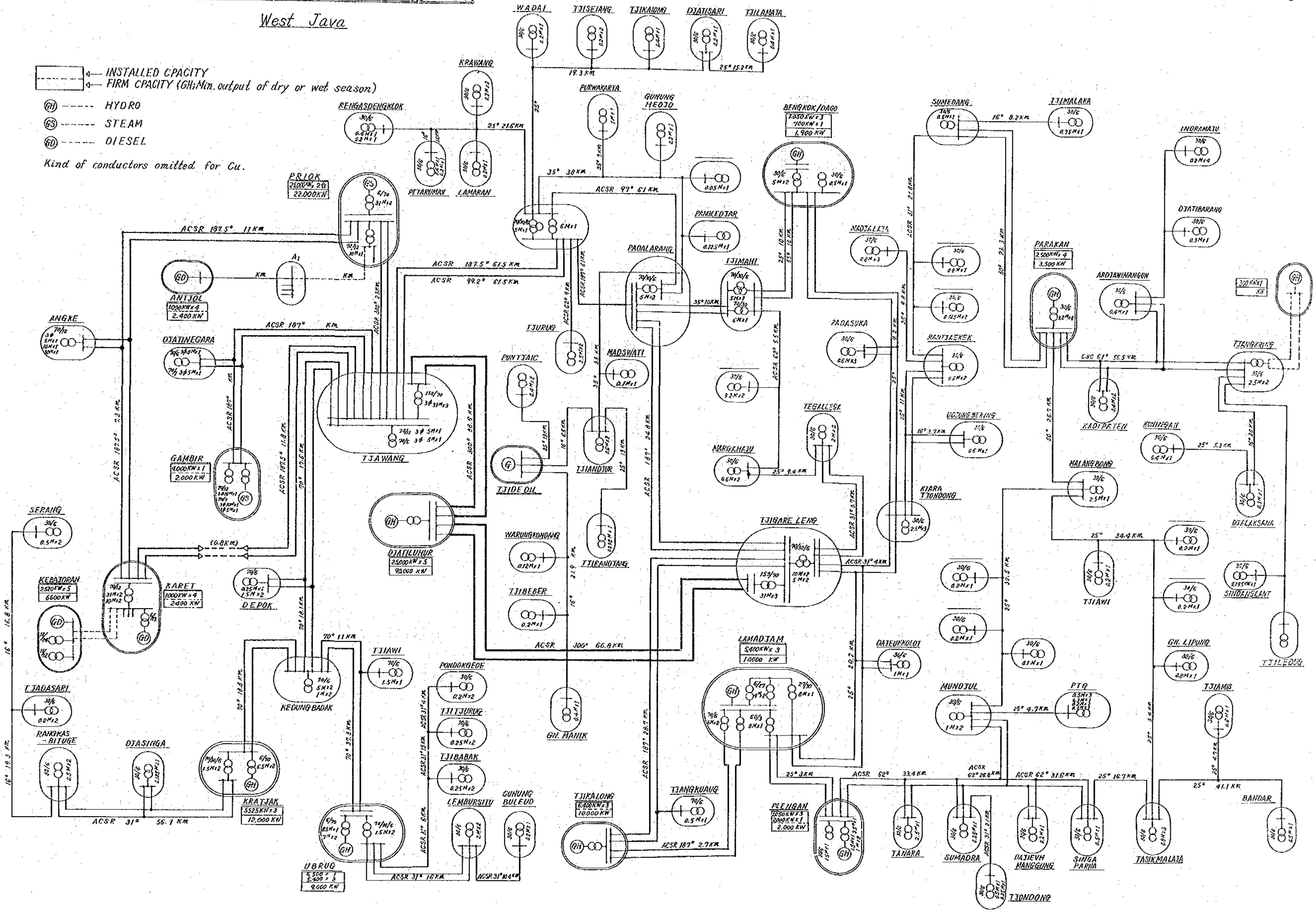


TRANSMISSION LINE MAP (Java, Mar. 1969)

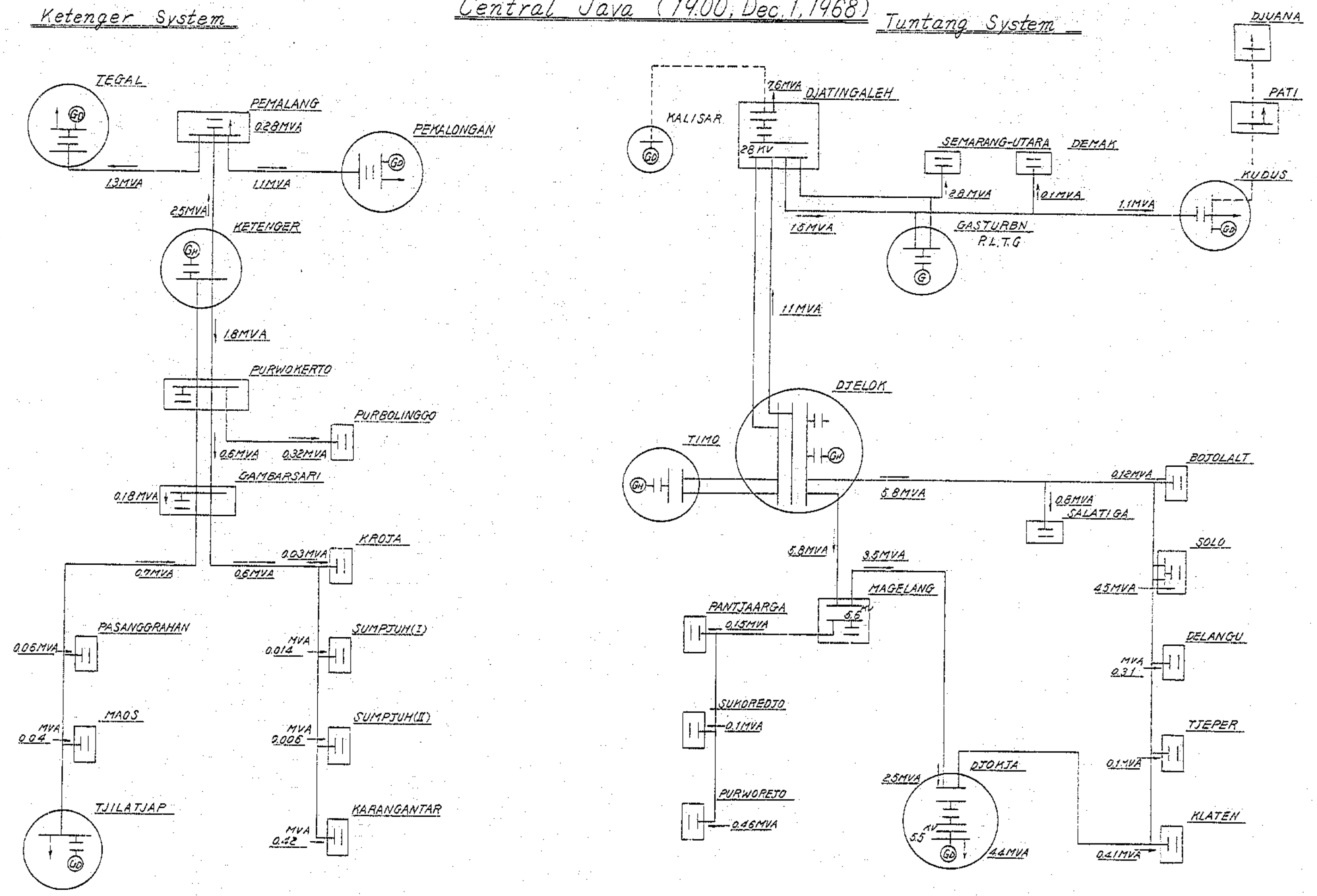


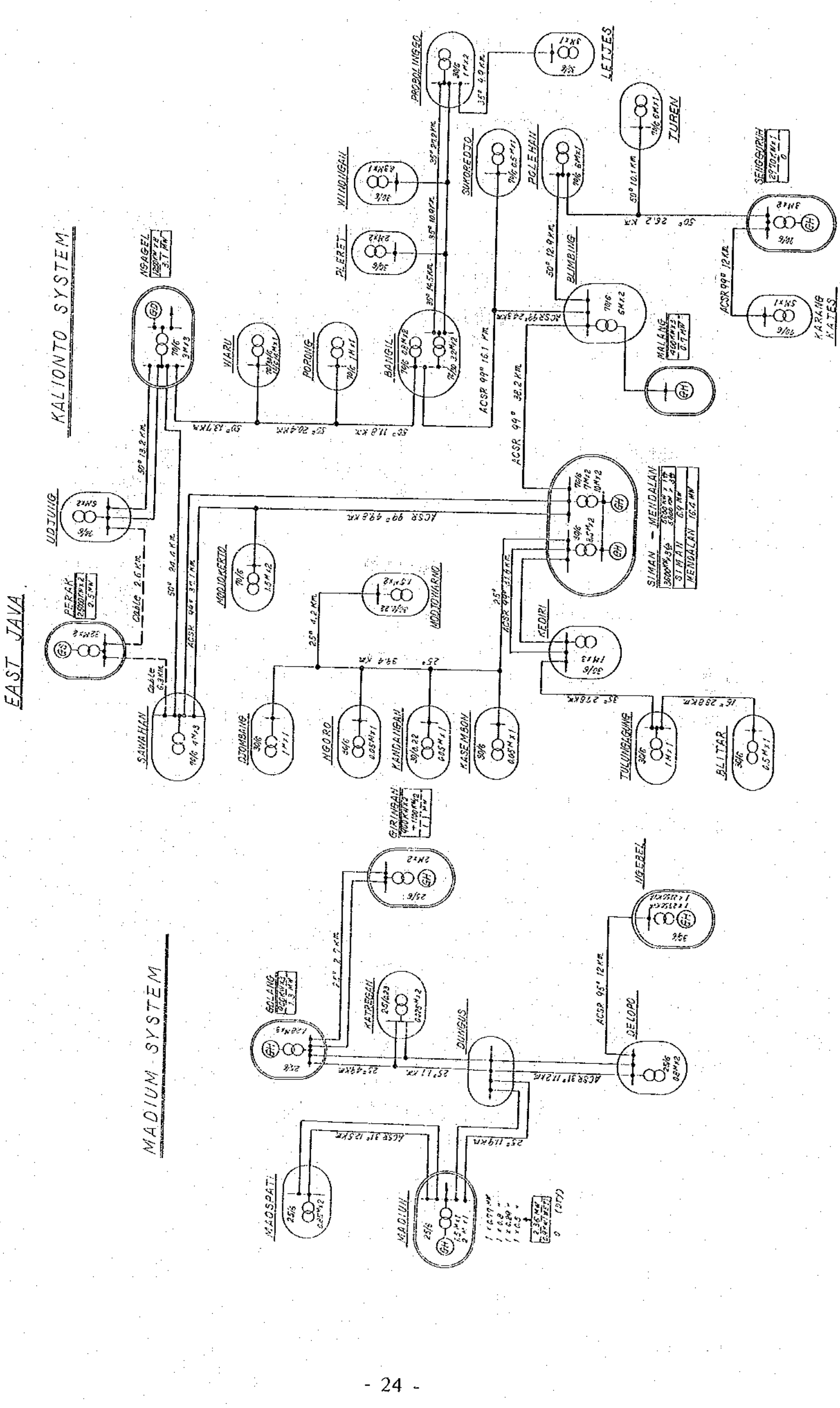
TRANSMISSION SYSTEM DIAGRAM (APRIL 1969)

West Java



Central Java (19.00, Dec.1,1968)

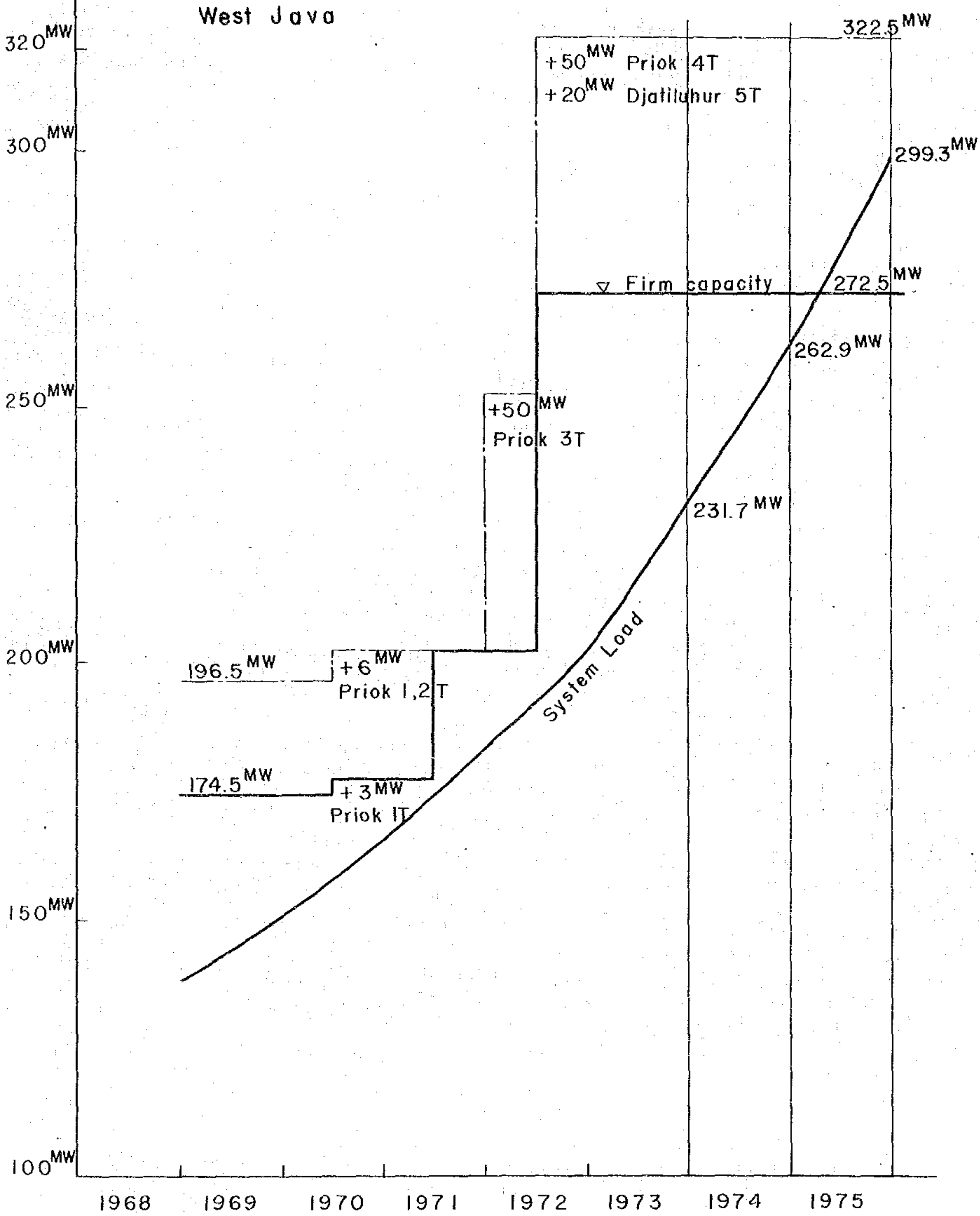


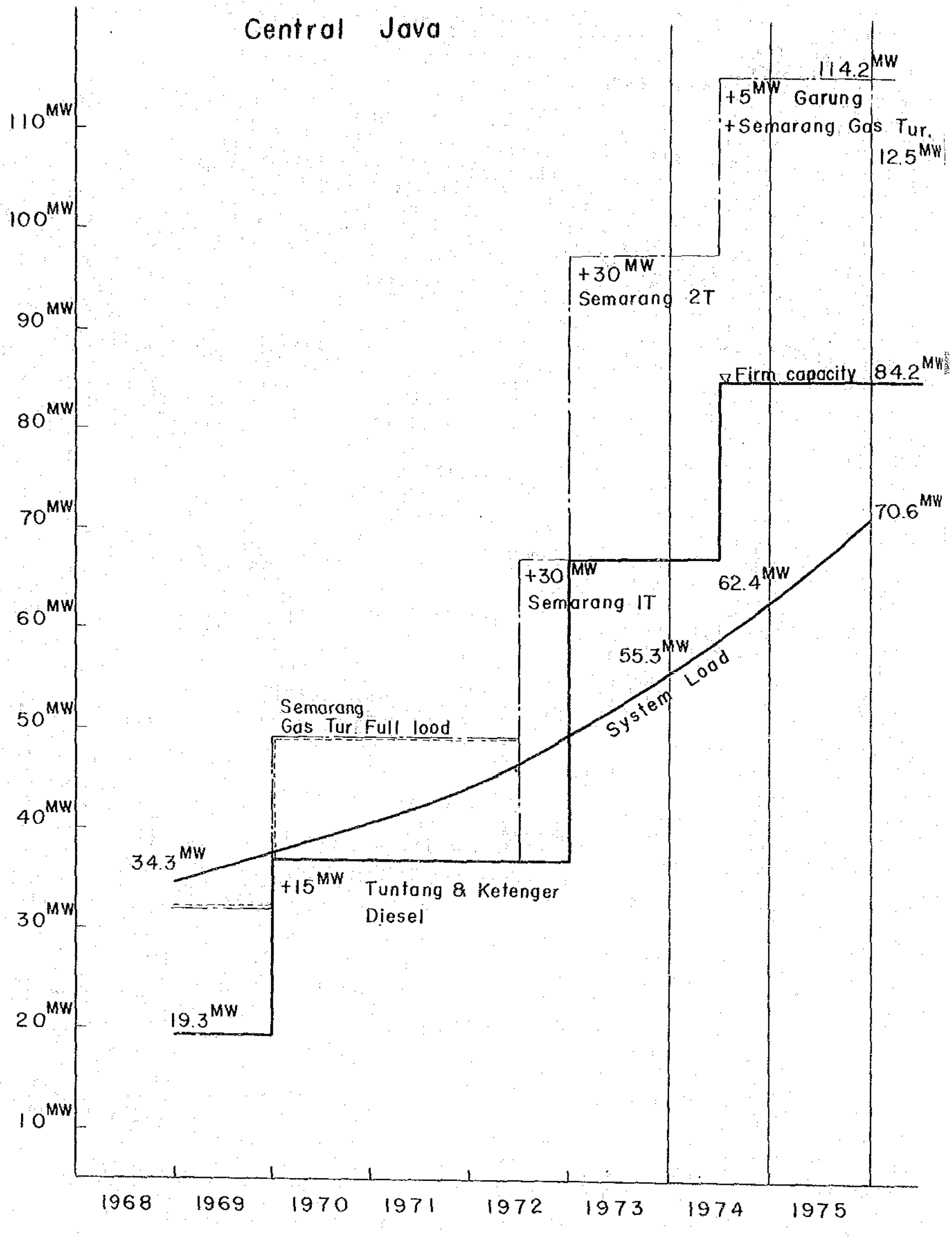

EAST JAVA
KALIONTO SYSTEM
MADIUM SYSTEM
PROBOLINGGO
LETJES
TUREN
SENGGURUH
KARANG KATES
WINONGAN
PLERET
SUKOREDJO
POLEHAN
BLIMBING
MALANG
NGAGEL
WARU
PORONG
BANGIL
UDJUNG
PERAK
SAWAHAN
MODJOKERTO
MODJOWARNO
SIMAN - MENDALAN
KEDIRI
DJOMBANG
NGORO
KANDANGAN
KASEMBON
TULUNGAGUNG
BLITAR
GIRINGAN
NGEBEL
GOLANG
KATREGAN
DUNGUS
DELOPO
MAOSPATI
MADIUN

Load Estimation for Java

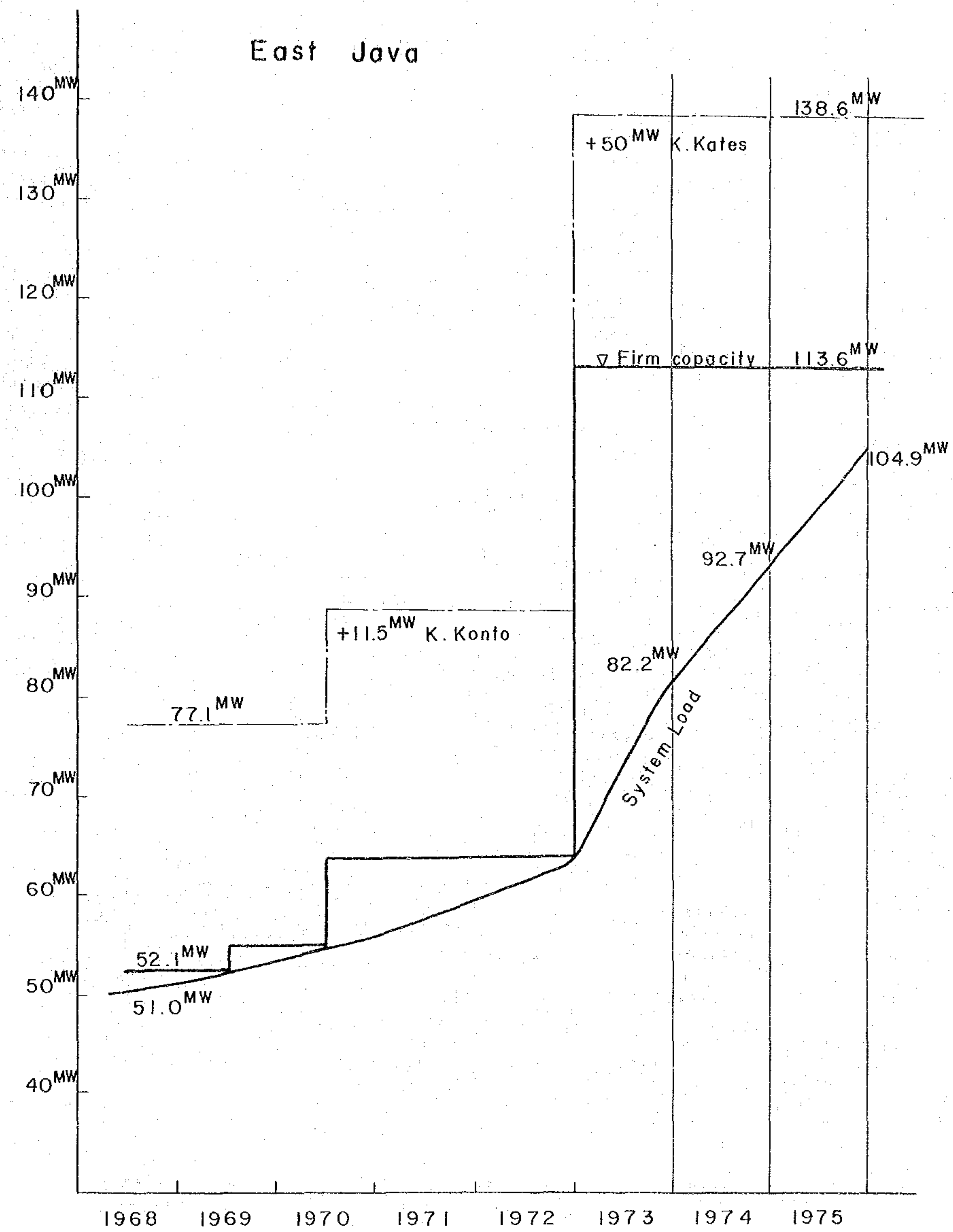
	Area		1968 (Actual)	1969	1970	1971	1972	1973	1974	1975	Average Rate of Increase par Year 1968 ~ 1973	1973 ~ 1975
Maximum Load at Generating End (MW)	West	XII	84.0 MW	(10.5%) 92.7 MW	(10.5%) 102.5MW	(11.8%) 114.6MW	(12.7%) 129.1MW	(13.0%) 145.9MW	(13.8%) 166.1 MW	(14.2%) 189.7 MW	11.7 %	14.0 %
	West	XI	53.3	(8.5) 57.8	(8.5) 62.7	(10.0) 69.0	(11.2) 76.7	(11.9) 85.8	(12.8) 96.8	(13.2) 109.6	10.0	13.0
	West	Sub-total	137.3	(9.7) 150.5	(9.7) 165.2	(11.1) 183.6	(12.1) 205.8	(12.6) 231.7	(13.5) 262.9	(13.8) 299.3	11.0	13.6
	Central	X	39.3	(7.9) 42.4	(7.8) 45.7	(10.1) 50.3	(11.3) 56.0	(11.8) 62.6	(12.8) 70.6	(13.2) 79.9	9.8	13.0
	East	IX	59.3	(4.4) 61.9	(5.7) 65.4	(7.3) 70.2	(7.5) 75.5	(25.8) 95.0	(12.8) 107.2	(13.2) 121.4	9.9	13.0
	Total		235.9	(8.0) 254.8	(8.4) 276.3	(10.1) 304.1	(10.9) 337.3	(15.4) 389.3	(13.2) 440.7	(13.6) 500.6	10.5	13.4
Energy Production (10^6 kwh)	West	XII	514.2 10 kwh	(10.5%) 568.2 10^6kwh	(10.5%) 627.9 10^6kwh	(11.8%) 702.0 10^6kwh	(12.6%) 790.5 10^6kwh	(13.0%) 893.5 10^6kwh	(13.8%) 1016.8 10^6kwh	(14.2%) 1161.2 10^6kwh	11.7 %	14.0 %
	West	XI	327.4	(8.5) 355.2	(8.5) 385.4	(10.0) 424.1	(11.2) 471.4	(11.8) 527.2	(12.8) 594.7	(13.2) 673.2	10.0	13.0
	West	Sub-total	841.6	(9.7) 923.4	(9.7) 1013.3	(11.1) 1126.1	(12.1) 1261.9	(12.6) 1420.7	(13.4) 1611.5	(13.8) 1834.4	11.0	13.6
	Central	X	217.0	(7.9) 234.1	(7.8) 252.4	(10.1) 277.9	(11.3) 309.3	(11.8) 345.7	(12.8) 390.0	(13.2) 441.5	9.8	13.0
	East	IX	363.5	(4.4) 379.5	(5.6) 400.9	(7.3) 430.2	(7.5) 462.5	(25.8) 581.8	(12.8) 656.3	(13.2) 742.9	9.9	13.0
	Total		1 422.1	(8.0) 1537.0	(8.4) 1666.6	(10.1) 1 834.2	(10.9) 2 033.7	(15.5) 2 348.2	(13.2) 2657.8	(13.6) 3018.8	10.5	13.4

Firm Capacity and System Load



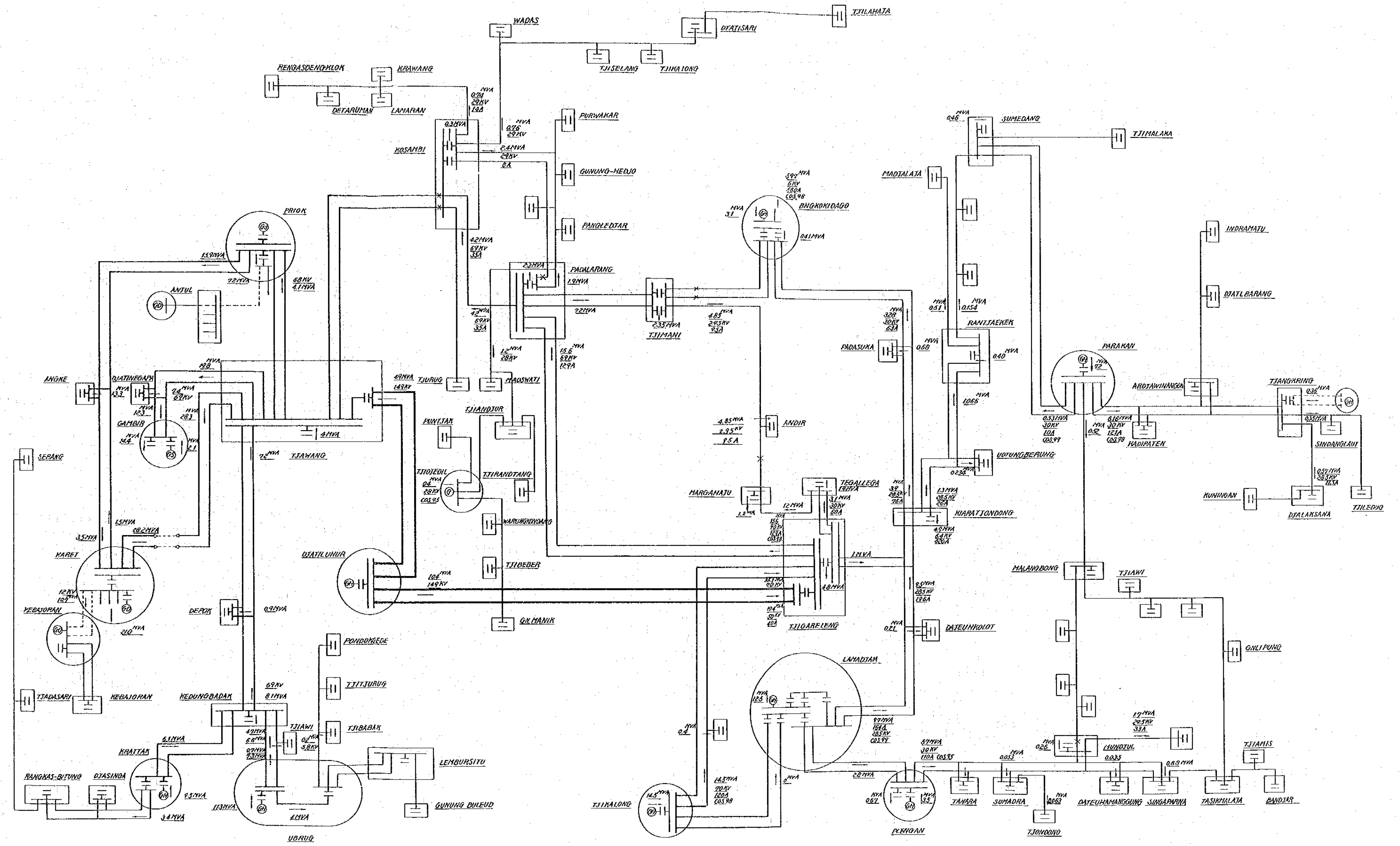


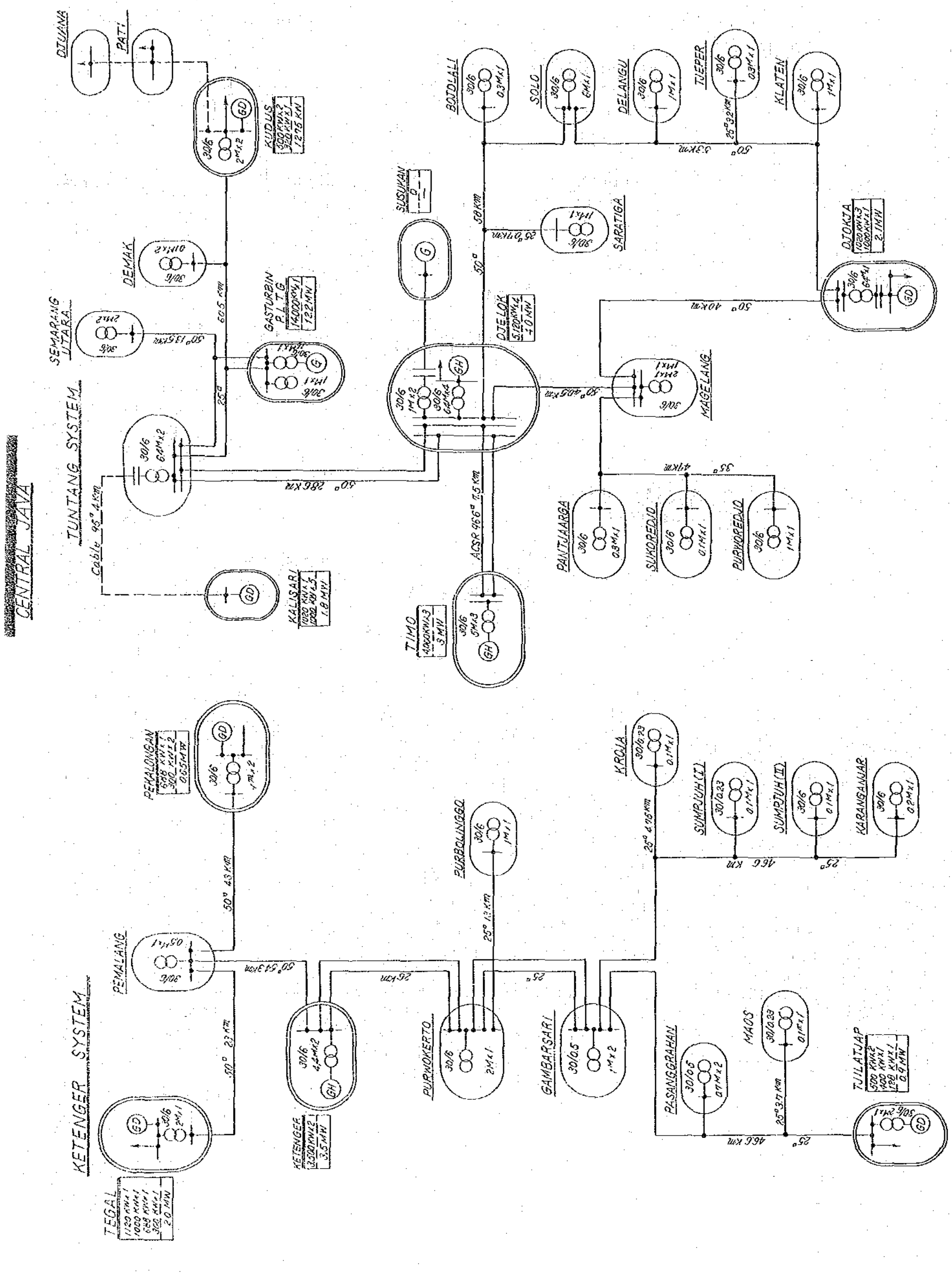
Central Java
110MW
100MW
90MW
80MW
70MW
60MW
50MW
40MW
30MW
20MW
10MW
114.2MW
+5MW Garung
+Semarang Gas Tur.
12.5MW
+30MW
Semarang 2T
Firm capacity 84.2MW
70.6MW
+30MW
Semarang IT
62.4MW
55.3MW
System Load
Semarang
Gas Tur. Full load
34.3MW
+15MW
Tuntang & Ketenger
Diesel
19.3MW
1968
1969
1970
1971
1972
1973
1974
1975


East Java
140MW
130MW
120MW
110MW
100MW
90MW
80MW
70MW
60MW
50MW
40MW
138.6MW
+50MW K. Kates
▽ Firm capacity 113.6MW
104.9MW
92.7MW
+11.5MW K. Konto
82.2MW
77.1MW
System Load
52.1MW
51.0MW
1968
1969
1970
1971
1972
1973
1974
1975

Power Flow Diagram (Actual)

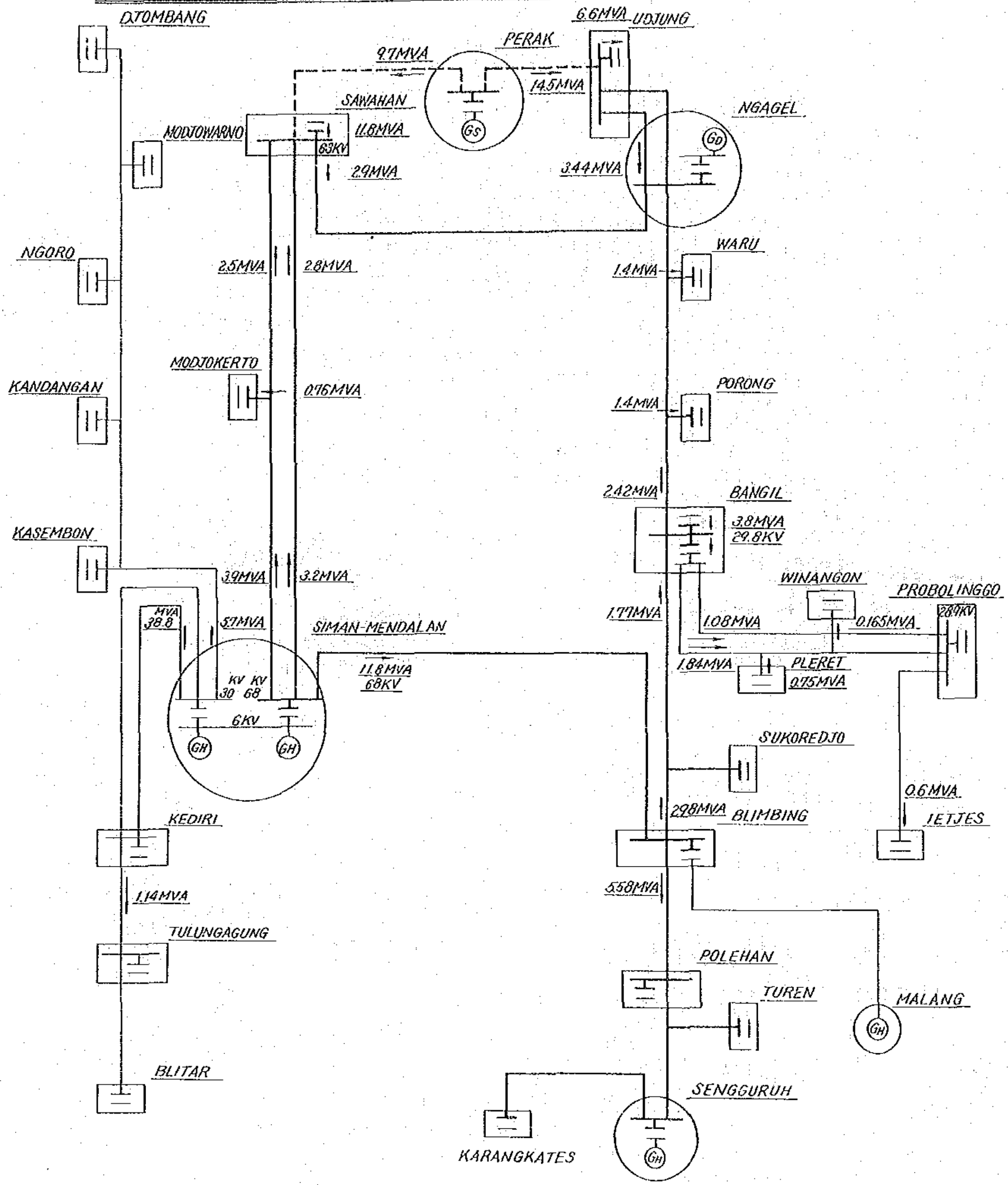
West Java (19.00, Oct. 26, 1968)





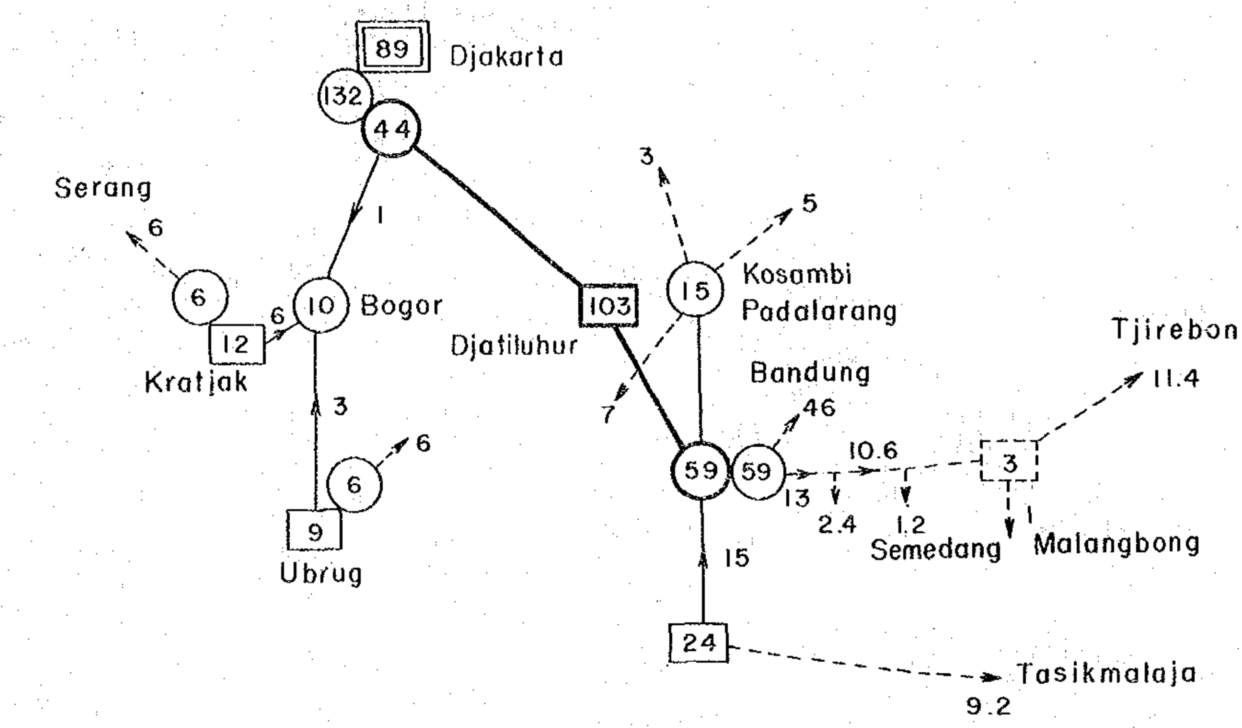
CENTRAL JAVA
TUNTANG SYSTEM
KETENGER SYSTEM
DJUANA
PATI
KUDUS
DEMAK
SEMARANG UTARA
GASTURBIN
KALISARI
TIMO
DJELOK
SUSUKAN
SARATIGA
BOJOLALI
SOLO
DELANGU
TJEPER
KLATEN
DJOKJA
MAGELANG
PANTJAARGA
SUKOREDJO
PURWOREDJO
TEGAL
PEKALONGAN
PEMALANG
KETENGER
PURWOKERTO
PURBOLINGGO
GAMBARSARI
KROJA
SUMPJUH (I)
SUMPJUH (II)
KARANGANJAR
PASANGGRAHAN
MAOS
TJILATJAP

East Java, Kalikonto System (19.00, Dec. 10, 1968)

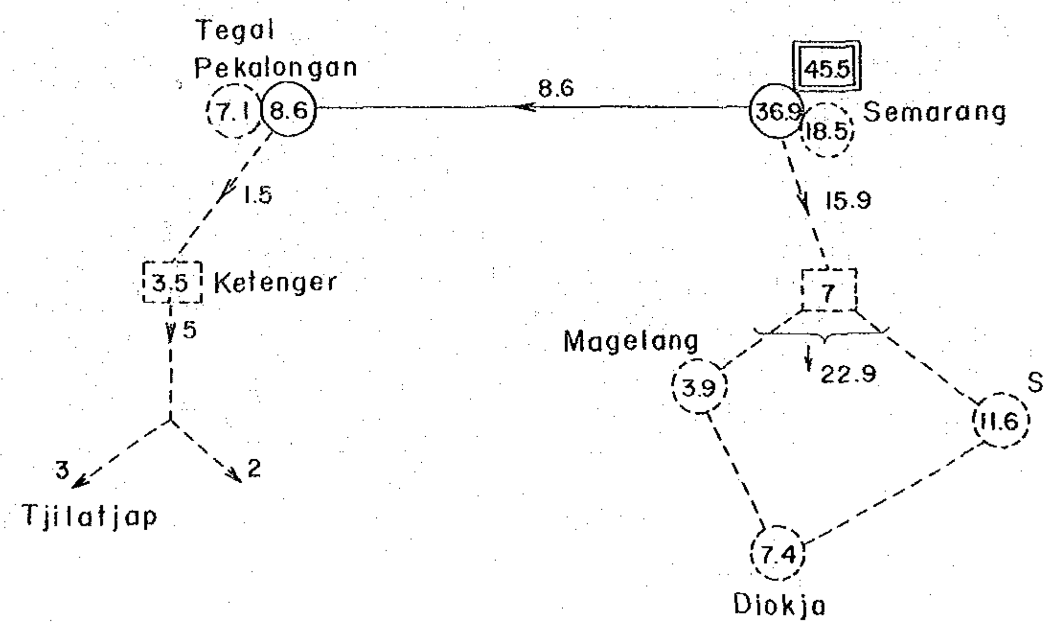


Power Flow Diagram (1973 Estimated)

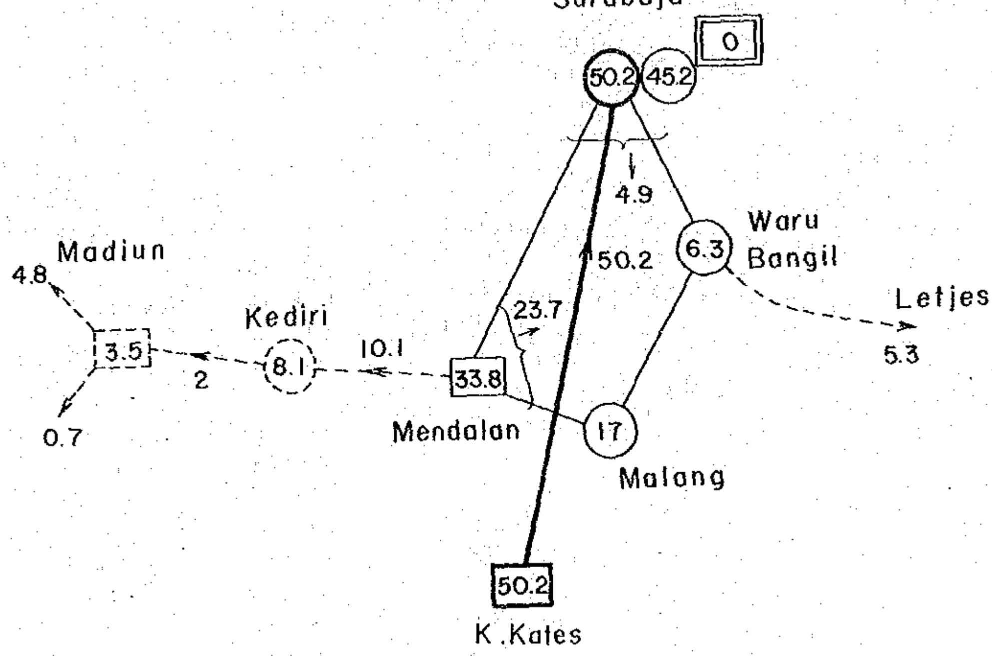
West Java (Dry Season) (Unit : MW)



Central Java (Dry Season)



East Java (Wet Season)



Notes; 1. The system structures are based on system existing in 1969 excepting Tuntang - Ketenger and Kalikonto - Madiun inter-connections and the transmission line for Karangkates.

2. The loads are calculated assuming the uniform growth rate for areas in a power system in 1968.

Loading Condition of Distribution Substations

Expl.	Area	1968 Load (MW)	1968 Capacity (MVA)	1968 Loading factor (%)	1969 Load (MW)	1969 Capacity (MVA)	1969 Loading factor (%)	1970 Load (MW)	1970 Capacity (MVA)	1970 Loading factor (%)
XII	Djakarta	76.2	187	42	84.3	230	37	94	230	41
	Bogor	5.6	15.3	36	6.2	25.3	25	6.9	25.3	27
	Others	6.8	9.4	72	7.5	10.9	69	8.1	10.9	74
	Total	88.6	211.7	42	9.8	266.1	37	109	266.1	41
XI	Bandung	28.4	2) 40.5	70	30.9	3) 65.5	47	33.6	65.5	51
	Others	24.9	2) 43.5	57	27.1	43.5	62	29.4	43.5	68
	Total	53.3	83.5	64	58	109	53	63	109	58
X	Semarang	4) 11.5 / Δ1.2	17.8	58	12.5 / —	17.8	70	13.6	17.8	76
	Others	4) 23.3 / Δ6.1	36.1	48	5) 25.1 / Δ6.1	42.1	45	5) 27.3 / Δ6.1	42.1	50
	Total	34.8 / Δ7.3	53.9	51	37.6 / Δ6.1	59.9	53	40.9 / Δ6.1	59.9	58
IX	Surabaja	28.1	33	85	29.4	53	56	30.7	53	58
	Others	26.3	49	53	31.6	49	65	33.7	49	69
	Total	54.4	82	66	61	102	60	64.4	102	63

Notes;
1. Local loads are calculated assuming the uniform rate of load growth for areas in a power system.
2. Capacities at 6^{KV} sides of $70/30/6^{KV}$ transformers are assumed as 20% of the rated capacities.
3. Capacities of East and West substation are regarded as 10^{MVA} each.
4. Minimum MW generated during the peak hours by diesels connected to 6^{KV} side.
5. Minimum MW generated by diesels may be increased in and after 1969 but the same figure is taken for 1969 and 1970 taking to safety side.

INVESTMENT PROGRAM FOR FISCAL YEAR 1970–1971 (JAVA)

Unit: Million Rp

	1970 Program of Five Year Plan (a)	Proposal by The Directorate General (b)	Our Proposal (c)	Difference	
				(c)–(a)	(c)–(b)
Power Plants	7,758	5,409	7,473	△ 285	2,064
Transmission Lines and Substations	1,625	1,835	1,687	+ 62	△148
Distribution	5,361	5,705	5,508	+147	△197
Diesel Stations	228	759	228	0	△531
Total	14,972	13,708	14,896	△ 76	1,188

Note: *Investment in the electric power sector as whole will be 26,010 Million Rp. 26,010 Million Rp. if our proposal is adopted for Java and Proposal by the Directorate General for other areas. It will be 24,262 Million Rp. if our proposal is adopted for Java and 1970 Program of Five Year Plan for other areas.*

Investment for Distribution Facilities in 1970 ~ 71

Extension and Reinfercement of High Tension Line in Major Cities

Exploitasi	Outline of Works	Materials	Investment (Million Rp)	Explanation
XII	(1) 12^{KV} loop system (2) Reinforcement of existing 12^{KV} system	——	978	See "Rehabilitation and Extension of Distribution System in Djakarta City"
XI	(1) Extension and reinforcement of 6^{KV} high tension lines	36 km	270	(1) Installation of 2 circuits from a $20^{KV}/6^{KV}$ small substation. (2) Replacement of 40% of existing cable including further deterioration by new cable along with the reinforcement of existing 6^{KV} system during five years. In 1970, the replacement is mainly for the central area of the city.
X	Same as above	14 km	115	Same as above (2).
IX	(1) 20^{KV} distribution system	6 km	66	(1) Installation of 6^{km} 20^{KV} cable between Sawahan and Pesapen for construction of 20^{KV} loop system.
	(2) New construction of Gemblongan sub-station		80	(2) Replacement of existing 19 oil circuit breakers with metal clad types and new installation of 4 circuit breakers. (3) New installation of 4 distribution feeders from Gemblongan Substion.
	(3) Extension and reinforcement of existing 6^{KV} high tension lines	36 km	302	(4) Same as Explanation (2) for Expl. XI

Extension and Reinforcement of Low Tension Line in Major Cities

Unit : Million Rp.

Item / City	Installing new transformers		Extension of low ten. lines		Replacement of low ten. wires by larger size wires		Total	Standard pattern of low tension system
	Number	Investment	Route length (km)	Investment	Length (km)	Investment		
Djakarte	238	1,022	75.5	226	296.4	40	1,288	(1) Unit capacity of transformer, 150^{KVA} (2) Size of wires for main low ten. lines, 50^{mm^2} (3) Loading factor of new transformers, approx. 70%
Bandung	72	292	48.9	105	62.5	4	401	(1) Unit capacity of transformer, 100^{KVA} (2) Size of wires for main low ten. lines, 25^{mm^2} (3) Loading factor of new transformers, approx.75%
Semarang	39	156	31.1	66	43.8	1	223	(1) Unit capacity of transformer, 75^{KVA} (2) Size of wires for main low ten. lines, 25^{mm^2} (3) Loading factor of new transformers, approx.75%
Surabaja	74	303	41.5	89	41.5	2	394	(1) Unit capacity of transformer, 100^{KVA} (2) Size of wires for main low ten. lines, 25^{mm^2} (3) Loading factor of new transformers, approx.75%

Note : 1. It is assumed to rehabilitate most of low tension systems during five years.

2. In 1970, the rehabilitation is mainly for the centrel area of the cities.

Improvement of Low Tension Line in Major Cities

Expio-itasi	Item	Materials	Investment (Million Rp)
XII	Cable	6.5 km	27
	Transformer	26	73
	Total		100
XI	Cable	1.8 km	4
	Transformer	22	56
	Total		60
X	Cable	2.4 km	5
	Transformer	12	30
	Total		35
IX	Cable	1.7 km	4
	Transformer	20	53
	Total		57

Notes; 1. It is assumed to replace 40% of existing low tension cables including further deterioration by new cables during five years.

2. In 1970, the replacement is mainly for the central area of the cities.

Rehabilitation and Extention
outside Major Cities

Exploi-tasi	Increase of demand (KW) (a)	Construction cost per kW [Thousand Rp/KW] (b)	Total cost [million Rp] (a) x (b)
XII	2,700 ($1.5 \times 10^3 \times 1.8$)	80	216
XI	4,140 ($2.3 \times 10^3 \times 1.8$)	80	331
X	2,700 ($1.5 \times 10^3 \times 1.8$)	80	216
IX	4,700 ($2.6 \times 10^3 \times 1.8$)	80	376
total	14,240	——	1,139

Notes; 1. Inerease of demand

= Increase of peak lood of power system

x diversity factors.

2. Assumed diversity factor covers from the generating end to customer's entrance

Rehabilitation and Extension of Distribution System in Djakarta City

Unit ; Million Rp.

	Item		Materials	Investment
Extension	Switching stations		1	48
	Loop feeders		3 loops 25.3 km	255
	Express feeders		14.4 km	158
	Sub-switching stations		16	240
	Transformers		238	1,022
	Low ten. lines	New installation	1,888 poles	226
		Wire replacement by larger size wires	296.4 km	40
Reinforcement and replacement	High ten. cables		53.4 km	277
	Low ten. lines	Cables	6.5 km	27
		Transformers	26	73
Total				2,366

Note ; 1. It is assumed to rehabilitate most of distribution system in Djakarta city during five years.

2. In 1970, the rehabilitation is mainly for the central area of the city.

Economic Comparison of Low Tension System Patterns in Djakarta City

Capacity of transformer (KVA) (a)	Number of poles supplied from one transformer (b)	Distance of one direction $(c)=(\frac{b}{4})\times 40$ (m)	Size of wire: Resistance (Ω/km) (d)	Size of wire: Size	Construction cost per pole (Thousand Rp): Transformer	Construction cost per pole (Thousand Rp): High ten. cable	Construction cost per pole (Thousand Rp): Low ten. cable	Construction cost per pole (Thousand Rp): Total cost
1. 300KVA (phase current $A=\frac{300\times10^3}{\sqrt{3}\times 220}$ = 790 (A))	54.7	504 (ℓ = 12.6 × 40)	0.0805 ($\frac{2\times127\times0.1\times10^3}{A\ell}$)	about 200mm²	62.3 ($\frac{3,410\times10^3 Rp}{60}$)	6.1 ($\frac{330\times10^3 Rp}{100m}$)	341	409.4 (wire & pole = 324×10³ Rp/pole, cable = 17×10³ Rp/pole)
2. 200KVA (A = 52.6 (A))	36.4	318	0.169	100mm²	82.5 (3,010×10³)	13.6 ($\frac{495\times10^3}{150m}$)	204.5	300.6 (wire & pole = 187.5×10³, cable = 17×10³)
3. 150KVA (A = 395 (A))	27.4	252	0.332	50mm²	102.4 (2,810×10³)	24 ($\frac{660\times10^3}{200m}$)	134.6	260.0 (wire & pole = 119.6×10³, cable = 15×10³)
4. 100KVA (A = 263 (A))	18.2	174	0.715	25mm²	143 (2,610×10³)	54.4 ($\frac{990\times10^3}{300m}$)	100.6	298.0 (wire & pole = 85.6×10³, cable = 15×10³)

Note: 1. Number of poles supplied from a transformer = Maximum load / total number of poles.

2. Assumptions for calculation of resistances of wires.

a. Allowable line voltage drop is 10%.

b. Load is uniformly distributed.

COMMUNICATION SYSTEM IN CENTRAL JAVA

SCOPE

The scope of specifications covers construction of telephone and telemetering facilities required for the power supply system control in the central Java island.

1. BASIC SPECIFICATIONS

1.1 COMMON ITEMS

(i) To install telephone system in each power plant and power station.

(ii) To install telemetering systems to transmit voltage, power output, and frequency, in major power plants.

(iii) To use existing power lines to transmit telephone and telemetering signals.

(iv) To install a load dispatching desk, a load dispatching board and telemetering receivers, in the load dispatching office.

1.2 KETENGER SYSTEM (Refer to Fig. 1)

o Telephone Circuit

Except two stations below, ali the power plants and power stations will be through connected to the load dispatching desk, and communication between plants and stations will be connected through the exchange installed in the command desk.

To provide system economy, the Tjilatjap and Gambarbar stations will be connected in a two-party line, and will be individually called by dialing. Mutual communication of the Gambarbar and Tjilatjap stations will be made by dialing.

o Telemetering Circuit

Voltage, power output, and frequency of Tegal, Pemalang, and Ketenger stations will be transmitted to the power supply command station, and will be indicated in the receiver indicators (voltage) and receiver recorder (power output and frequency).

1.3 TUNTANG SYSTEM (Refer to Fig. 3)

o Telephone Circuit

An automatic exchange will be installed in the load dispatching office to provide dial connection of desired plants, station and an other load dispatching office. In an emergent case, the Load dispatching office will interrupt the conversation between plants and stations, at will.

o Telemetering Circuit

The telemetering circuit in this system will be the same to that in the Ketenger system.

2. SUMMARY OF FACILITIES

2.1 KETENGER SYSTEM

Classification	Type of Device To Be Installed	Q'ty	Remarks
Power Supply Command	Load dispatching desk for 20 lines	1	Refer to Fig. 3
	Power System Panel	1	
Carrier Transmission	Power Line Carrier Terminal Equipment (Including Relay Panel & CB Sheet)		
	2 Channel Type	4 pairs	
	3+1 Channel Type	2 pairs	
Telemetering	Telemetering Terminal Equipment	2 routes	
	Telemeter Primary Transducer (Thermal Converter)	4	
	Telemeter Primary Transducer (VF PU)	3	
	Telemetering Receiver Indicator	4	
	Telemetering Recorder	4	
Power Source	Automatic Float Changing Rectifire 37V 20A	3	Refer to Fig. 3
	Storage Battery 24V 120AH	3 sets	
Telephone set	Automatic Telephone Set	4	
	Common-battery Telephone set	4	
Coupler	Line Trap	16	Refer to Fig. 4
	Coupling Capacitor	14	
	Coupling Filter EF	14	
	Coupling Filter MF	2	
	Coaxial Cable TC2V-0	1,200m	

2.2 TUNTANG SYSTEM

Classification	Type of Device To be Installed	Q'ty	Remarks
Power Source Command	Load dispatching desk for 20 lines	1	Refer to Fig. 5
	Power System Panel	1	
Carrier Transmission	Power Line Carrier Terminal Equipment (Including relay panel and CB sheet)		
	2 Channel Type	5 pairs	
	3+1 Channel Type	1 pair	
	6 Channel Type	1 pair	
Telemetering	Telemeter Terminal Equipment	6 routes	Refer to Fig. 5
	Telemetering Primary Transducer (Thermal Convertor)	18	
	Telemetering Primary Transducer (VF RU)	7	
	Telemeter Receiver Indicator	6	
	Telemeter Receiver Recorder	9	
Power Source	Float-Charging Rectifier 37V 40A	2	
	Float-Charging Rectifier 90V 20A	1	
	Storage Battery 24V 210VA	2 sets	
	" " 60V 130VA	1 set	
Telephone Set	Automatic Telephone Set	42	
Coupling	Line Trap	29	Refer to Fig. 6
	Coupling Capacitor	20	
	Coupling Filter EF	20	
	" " MF	6	
	Coaxial Cable 7C2V-0	1,400m	

3. SPECIFICATIONS FOR INDIVIDUAL DEVICES

(Refer to Table of Device Specifications, Figs. 7 to 12)

3.1 LOAD DISPATCHING DESK

Type	One-position, desk type Pushbutton System
Capacity	20 Lines (10 automatic lines and 10 common battery lines.)
Power Source Voltage	DC 60V for Tuntang System DC 24V for Ketenger System

3.2 POWER SUPPLY SYSTEM PANEL

Type	Multi-hole Type w/Instrument Panel for Panel for Telemetering (two-sides)
Dimensions	4,000 x 1,500mm for Tuntang System 3,000 x 1,500mm for Ketenger System

3.3 POWER LINE CARRIER TERMINAL EQUIPMENT

Transmission System	SSB System
Active Parts	All Transistorized
Number of Channels	Three types; 2, 3 + 1, and 6 channels. The auxiliary channel in the 3 + 1 channel system will use the narrow band system.
Transmission Bandwidth	2 Channel Type; 300 to 2,000 Hz 3 + 1 Channel Type; 300 to 2,300 Hz and 300 to 1,450 Hz 6 Channel Type; 300 to 2,300 Hz

Signalling System	Frequency shift signalling to use continuously transmitted two frequencies (out of the voice frequencies)
Line Impedance	High Frequency Side 75 ohms Voice Frequency Side 600 ohms
Carrier Output Level	2 Channel Type 31 dBm or more 3 + 1 Channel Type 31 dBm or more 6 Channel Type 29 dBm or more
Carrier Input Level	+ 10 dBm/ch for test tone (equivalent to 0.8 kHz)
Standard Voice Input and Output Levels	– 8 dBm and 0 dBm
Power Source	DC 24V Two sets, with and without internal floating charger. (For details, refer to the Standard Specifications for Multi-channel Power Line Carrier Telephone Equipment)

3.4 TELEMETERING TERMINAL EQUIPMENT MODULATION SYSTEM

Modulation System	Frequency Shift (FS) System
Active Parts	All transistorized
Frequency Shift Width	±35 Hz
Transmission Speed	Nominal 50 bauds Maximum 60 bauds
Carrier Input and Output Impedance	Within 600 ohms ±20%
Power Source	External DC 24V Source (For details, refer to the Specifications for Signal Transmission Equipment)

3.5 TELEMETERING PRIMARY TRANSDUCER

Type	Power Transmitter (Thermal Convertor)	
Ratings	Maximum Input Power	AC-110V 5A
	Output Voltage	DC-0 to ±30mV
Type	Voltage and Frequency Transmitter (VF-PU)	
Ratings	Input Voltage	AC 110V
	Output Voltage	DC 0 to 110mV (Voltage)

3.6 TELEMETERING RECEIVER INDICATOR (Recorder)

Type	Receiver Indicator Receiver Recorder	
Ratings	Input Frequency	20 to 30 Hz
	Input Level	+ 10 dBm
	Response	Against input transient from 0 to 90% of input transient, indication or recording responds within 7 second.

3.7 AUTOMATIC FOLATING CHARGER

Type	Automatic Constant Voltage Floating Charger	
Ratings	Input Voltage	AC 200V 50/60 Hz
	Output Voltage	37V (90V)
	Output Current	40A (20A)

3.8 STORAGE BATTERY

Type	Clad Type Lead Storage Battery	
Ratings	Nominal Voltage	24V (60V)
	Capacity (10 hour rate)	210 AH (130AH)

3.9 TELEPHONE SET

Type	NTTPC Type 600 Automatic and Common Battery Types

3.10 LINE TRAP

Type	Exposed Type, for out-of-Door Use. May be hanged down, or installed upright.
Rated Current	300A (6KA for short time)
Inductance	300 μH
Blocking Method	Filter Type

3.11 COUPLING CAPACITOR

Type	Out-of-door Type, Oil-filled, and Insulated Terminals.	
Ratings	Nominal Voltage	30kV
	Class of Insulation	No. 30
	Capacitance	0.002 μF
	Operational Frequency	450kHz or lower
	Current Capacity	2A (r.m.s.)
	Structure	Will install the blockin blocking coil (300 μH, 300A) on the capacitor top.
	Auxiliary Devices	A switch to ground low voltage side output terminal. Coupling filter box Angle type mounting frame

3.12 COUPLING FILTER

Type	Earth Return Type Type (EF)

Ratings	Transmission Loss	0.5 dB or less in the rated frequency bandwidth
	Impedance Ratio	Line to Feeder, 500 ohms Co-axial Cable to 75 ohms
	AC Current Capacity	2A or more
Type	Balanced Type Repeating Filter for Metalic Return (MF)	
Ratings	Trnasmission Loss	0.3 dB or less in
	One-arm Grounded Loss and Open Time Loss	4 dB or less
	Impedance Ratio	EF to Co-axial cable sides, 150 ohms to 75 ohms
	AC Current Capacity	2A or more

3.13 COAXIAL CABLE

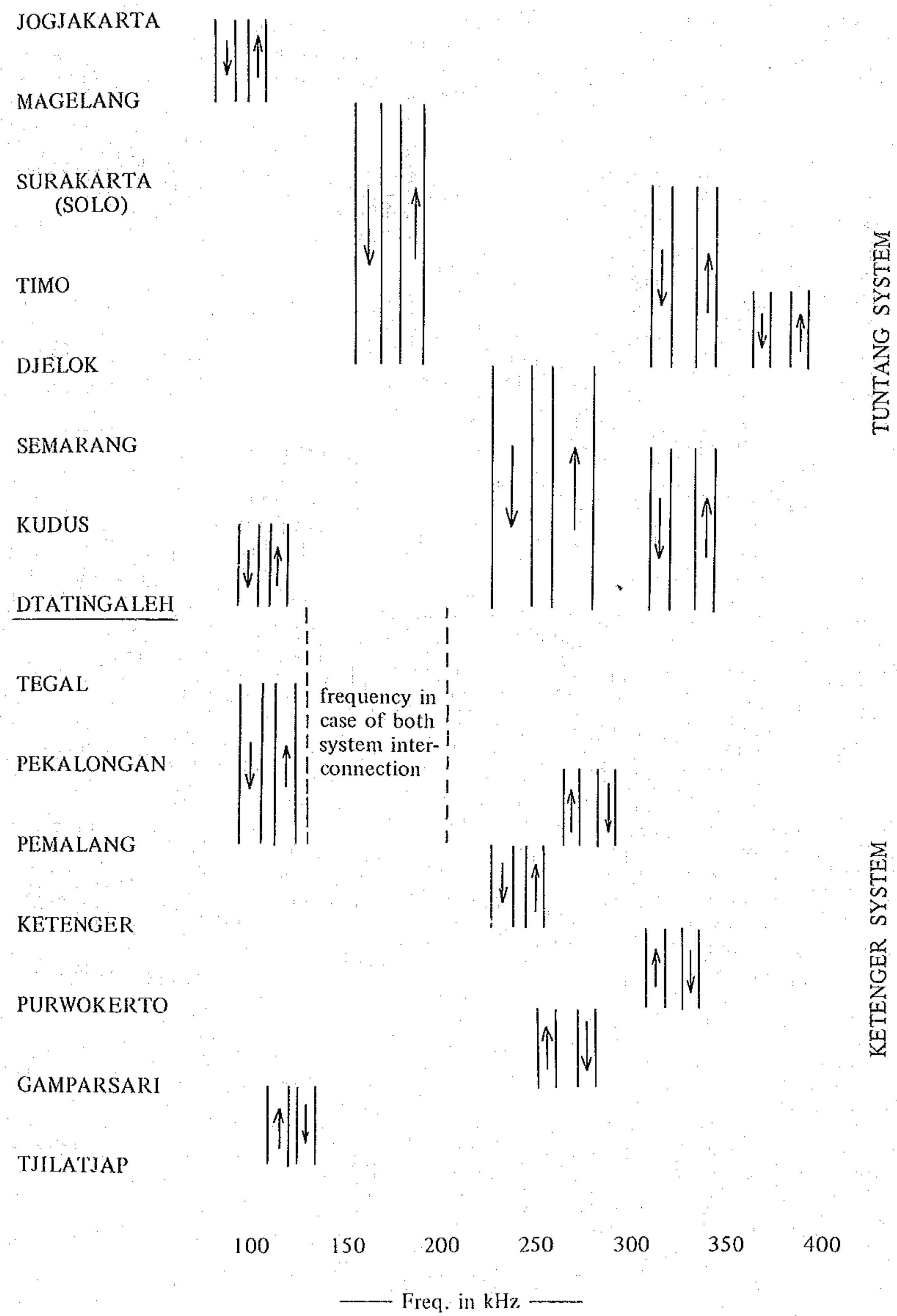
Type	7C2V-0	
Ratings	Electrical Characteristics	Identical to 7C2V
	Outer Insulator	Polyethylene, 3mm in thickness.

4. OTHER

4.1 FREQUENCY ALLOCATION

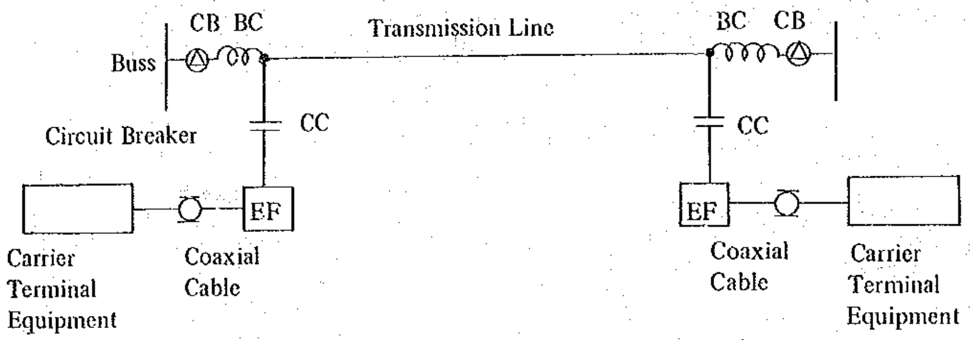
The frequency allocation for the power line carrier system is shown in the following figure.

Table of Frequency Allocation

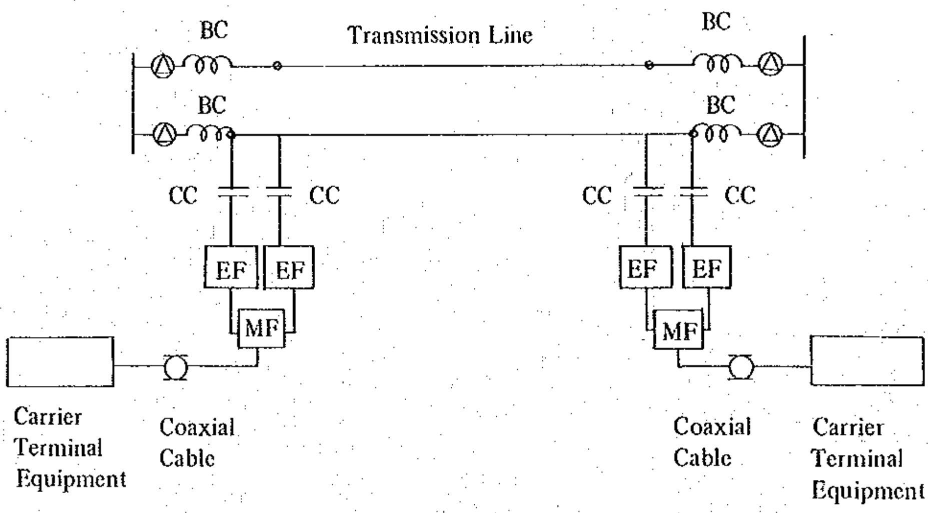


4.2 ON THE TRANSMISSION PASS OF THE POWER LINE CARRIER SYSTEM

The power line carrier system will be used for transmission of telephone and telemetering signals. The system is composed, as shown below, of the terminal equipment and the power line coupling devices.



For Earth Return Operation

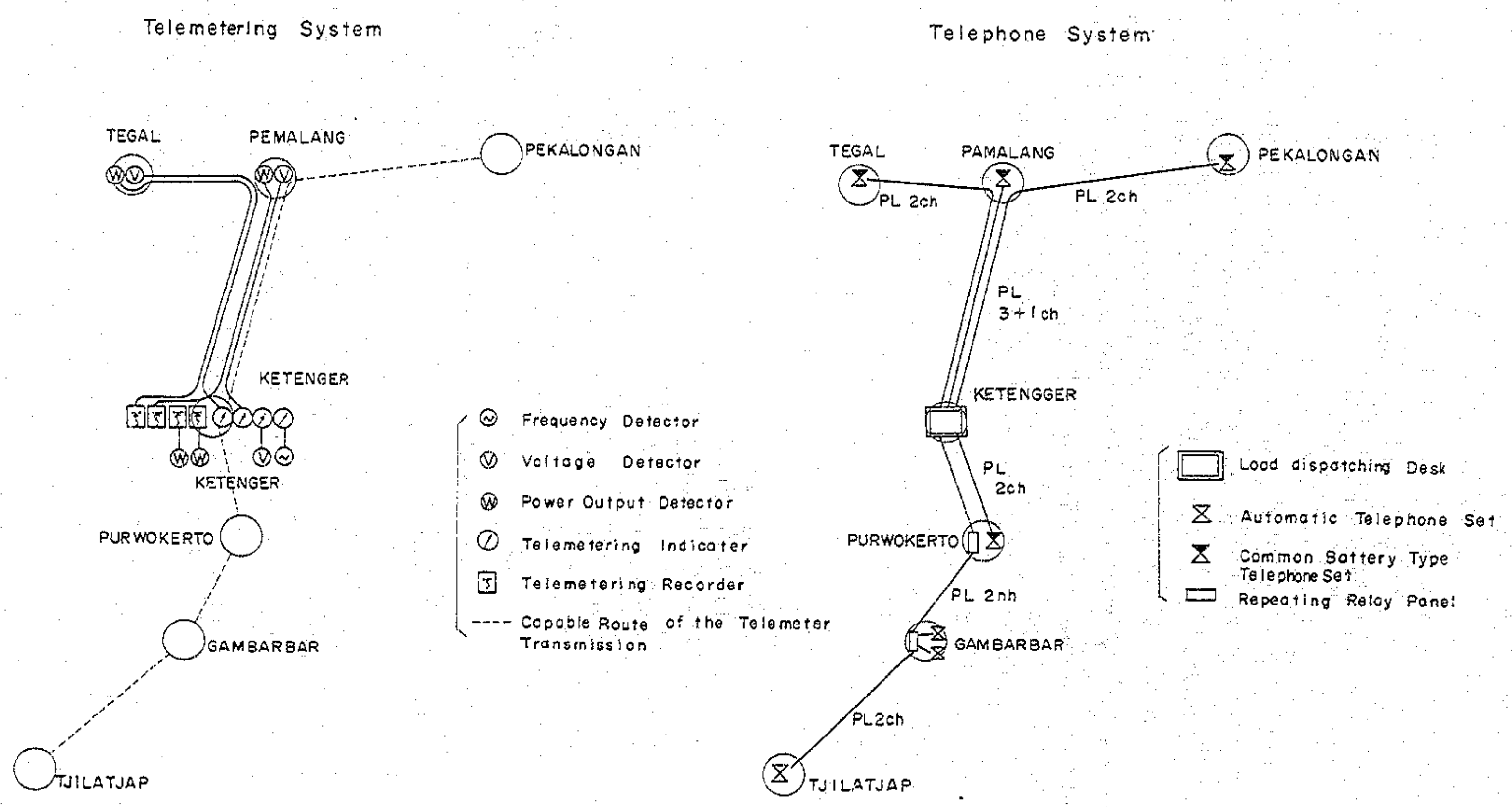


For Metalic Return Operation

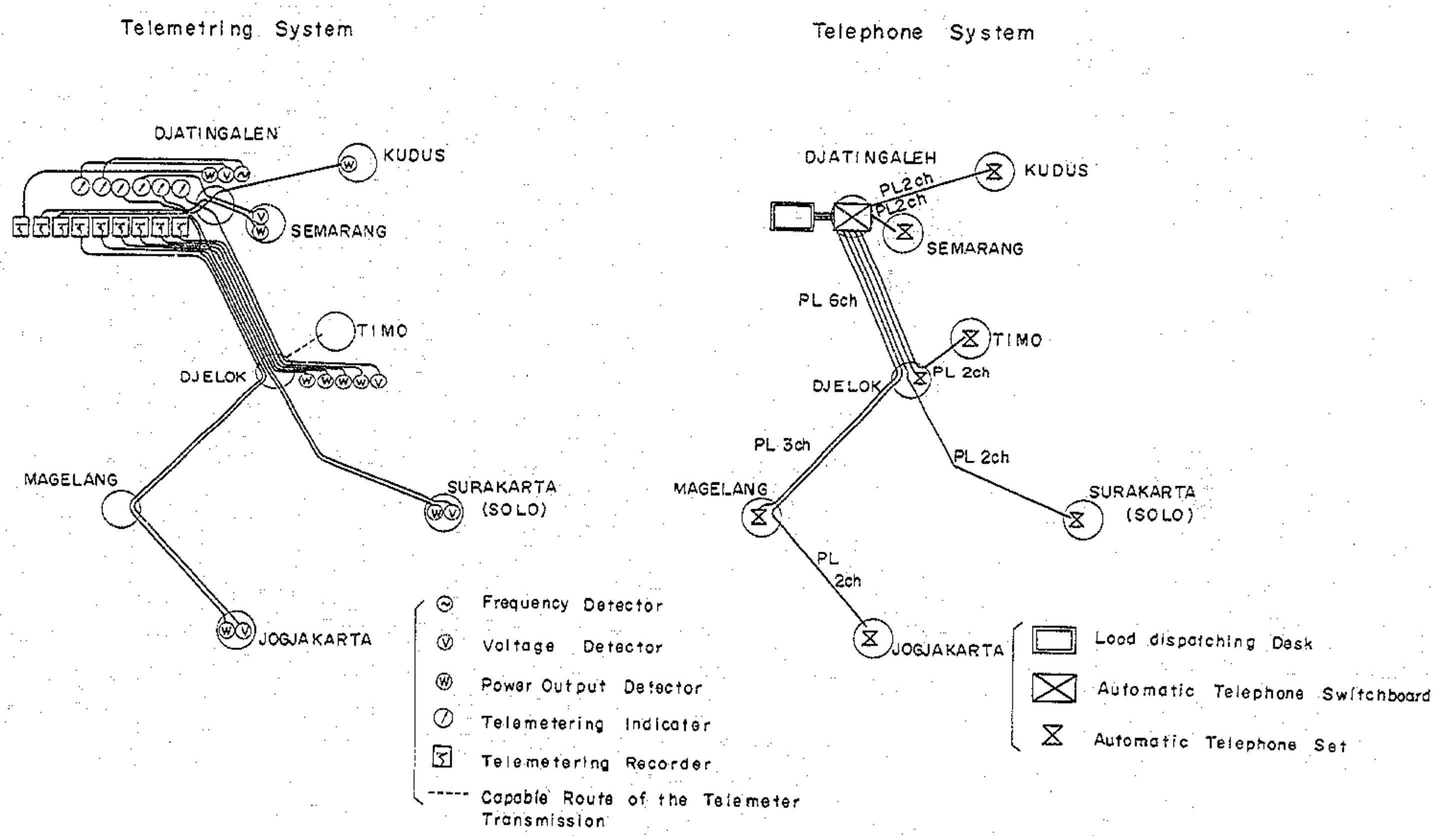
Symbol	BC:	Line Trap (Wave Trap)	
	CC:	Coupling Capacitor	0.002 μF
	EF:	Earth Return Coupling Filter	
	MF:	Metalic Return Coupling Filter	
	—⦶—	Coaxial Cable, 7C2V-0	

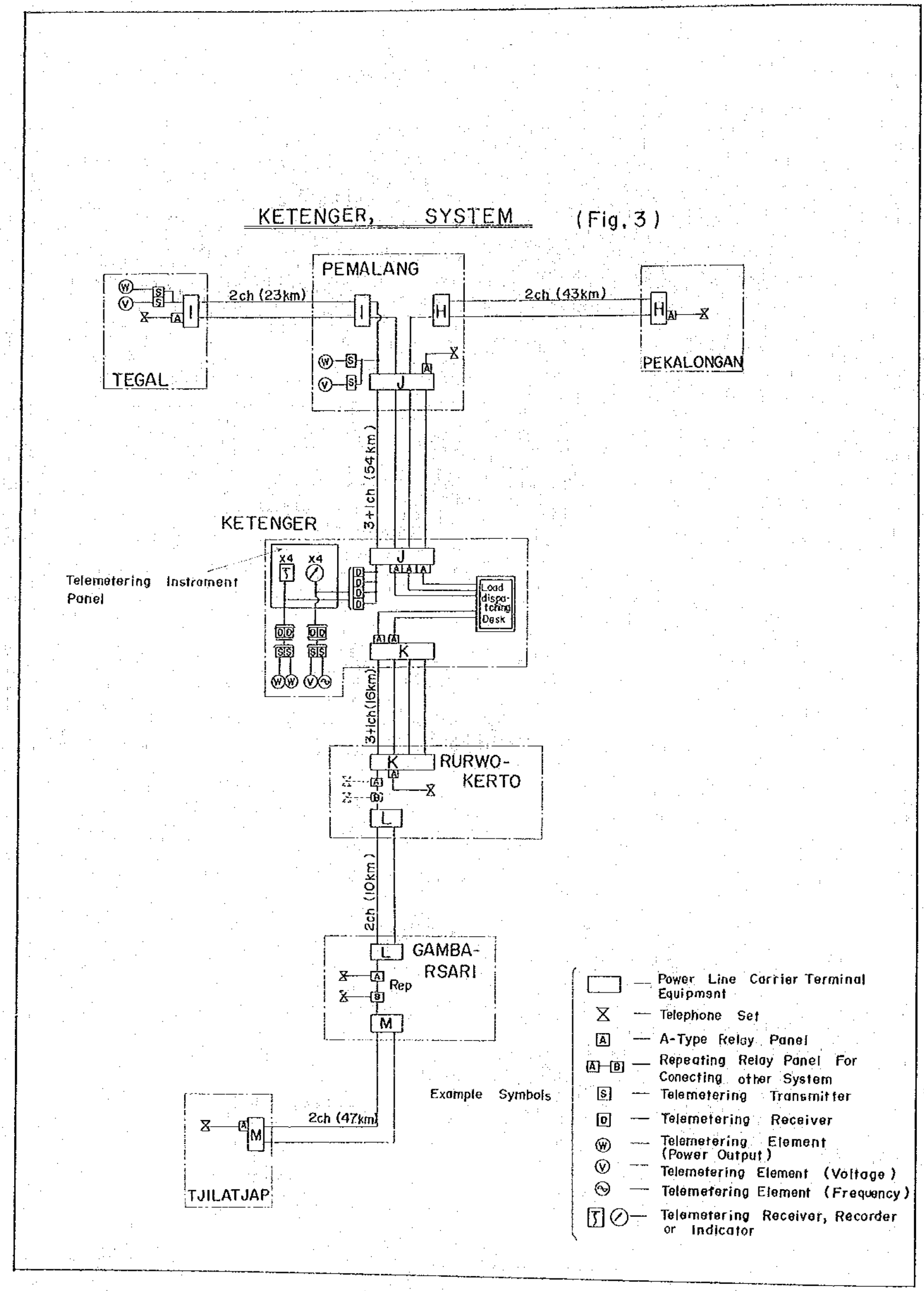
The coupling devices will normally be installed at the transmission line inlet of the power plants or stations. At the branching of power feeding liens, only the Line Trap will be installed at the side to be blocked. The Earth return and the metalic return will be selectively used with span of the Transmission line. In other words, the Earth return type will be used in the lines 50km or less, and the metalic return will be used, in order to reduce line loss, in the lines longer than 50km.

KETENGER SYSTEM (Fig, 1)



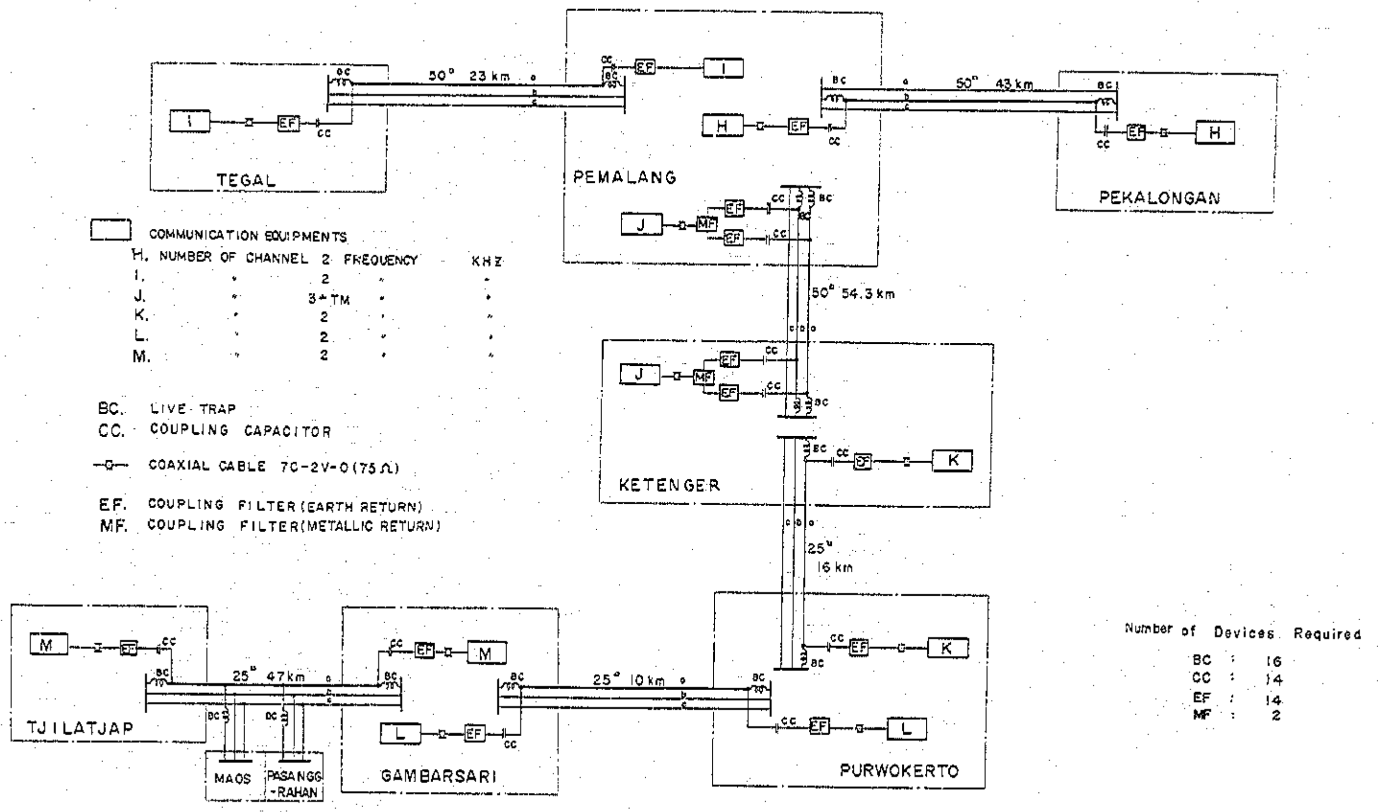
TUNTANG SYSTEM (Fig,2)



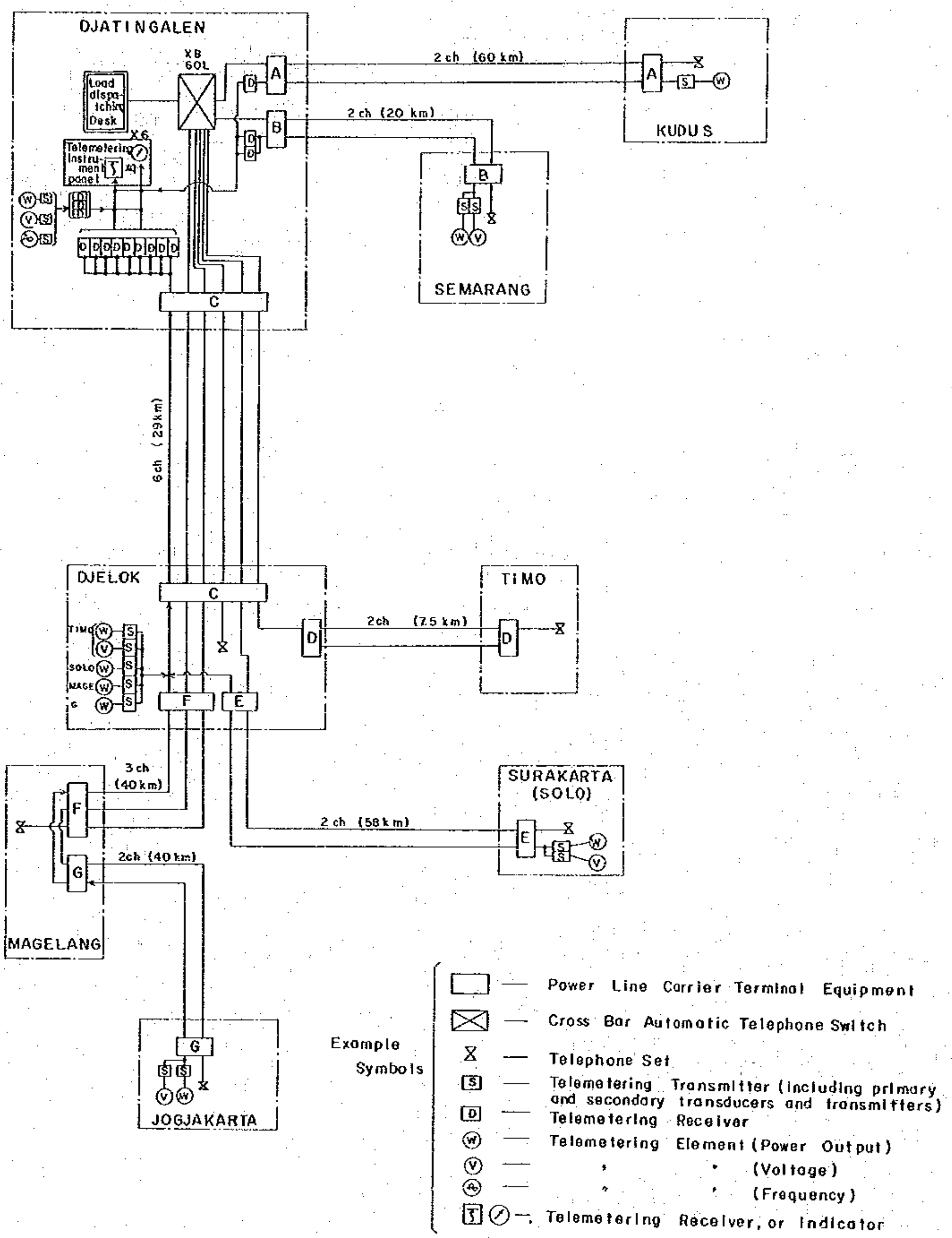

KETENGER, SYSTEM (Fig. 3)
PEMALANG
TEGAL
2ch (23km)
2ch (43km)
PEKALONGAN
3+1ch (54km)
KETENGER
Telemetering Instrument Panel
Load dispatching Desk
3+1ch (16km)
RURWO-KERTO
2ch (10km)
GAMBA-RSARI
Rep
2ch (47km)
TJILATJAP
Example Symbols
Power Line Carrier Terminal Equipment
Telephone Set
A-Type Relay Panel
Repeating Relay Panel For Conecting other System
Telemetering Transmitter
Telemetering Receiver
Telemetering Element (Power Output)
Telemetering Element (Voltage)
Telemetering Element (Frequency)
Telemetering Receiver, Recorder or Indicator

Systematic Diagram for Power Line Carrier Telephone Coupling (Fig 4)

KETENGER SYSTEM



TUNTANG SYSTEM (Fig 5)



Systematic Diagram for Power Line Carrier Telephone Coupling (Fig 6)

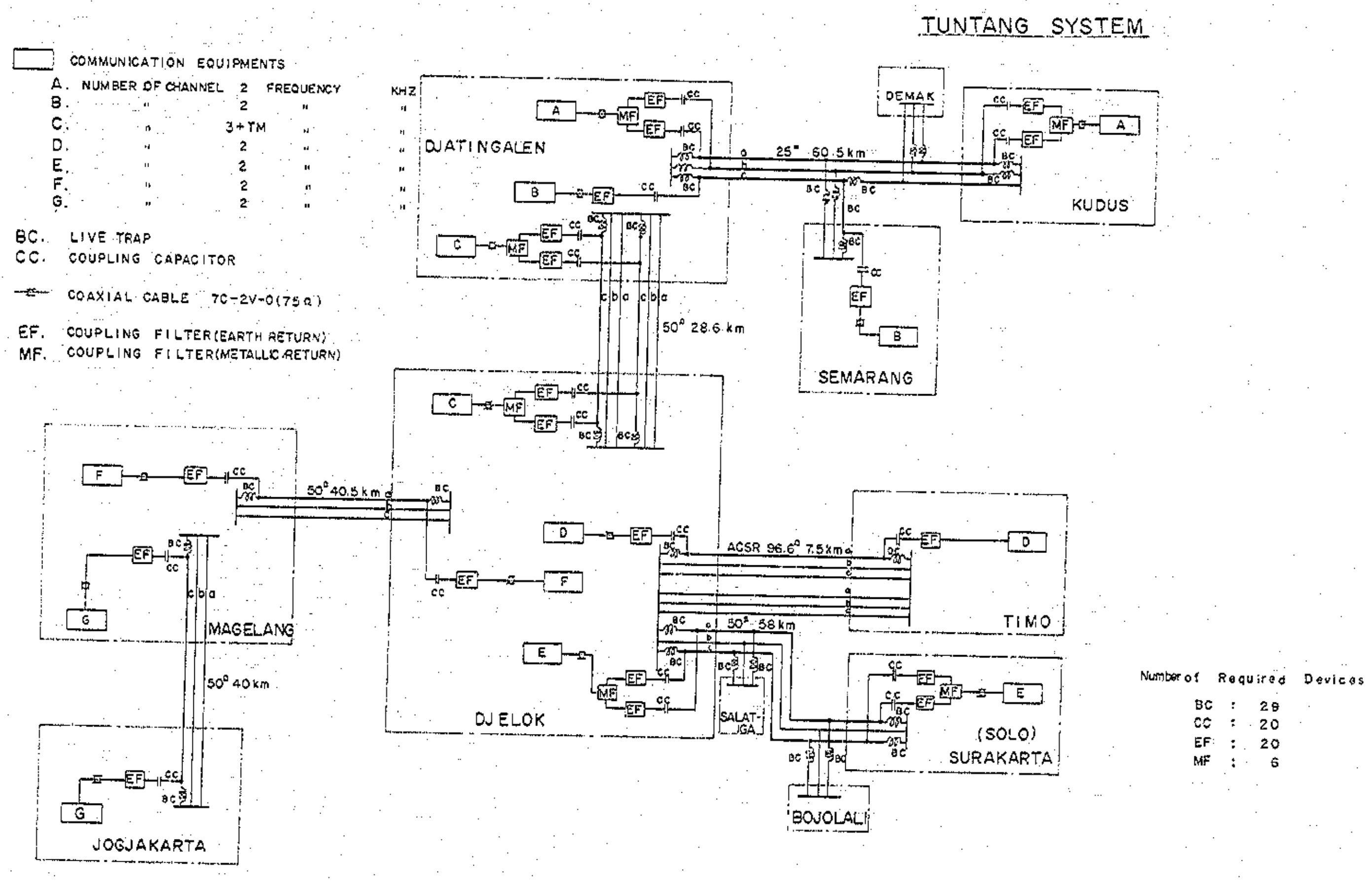


Table of Specifications for Equipment KETENGER · SYSTEM No. 1 (Fig 7)

Plants or Stations To Be Installed	Name of Transmission Lines	Phase	Line Trap				Coupling Capacitor	Earth Return Coupling Filter (EF)	Metalic return Coupling Filter (MF)	Storage Battery	Battery Charger	Load dispatching desk	System Panel
			Frequency (KHz)	Inductance (μH)	Rated Current (A)	Short-circuit Current (KA)	Class of Insulation : No. 30 Capacitance : 0.002 μF Frequency : 10 ~ 450 KHz Current Capacity : 2 Amp. Line trap Mounting Type, Angle Frame	500Ω : 75Ω 90~450 KHz Installed Under the Coupling Capacitor	150Ω : 75Ω 90~450 KHz Out door Type	Clad Type, Styrole Battery Jar, W/Frame	Input 200V 3φ Self Support Type Noise Output : less than 2mV Automatic Equalized Charge System		
										Voltage (V) and Capacity (AH)	Rated Output Voltage (V) and Current (A)		
PEMALANG	PEKALONGAN Transmission Line	b	450-220	300	300	6	○	○		24V · 130AH	37V · 20A		
	KETENGER Transmission Line	a	270-165	〃	〃	〃	○	○	○				
		b	〃	〃	〃	〃	○	○					
	TEGAL Transmission Line	a	120-95	〃	〃	〃	○	○					
PEKALONGAN	PEKALONGAN Transmission Line	b	450-220	〃	〃	〃	○	○					
TEGAL	TEGAL Transmission Line	a	120-95	〃	〃	〃	○	○		24V 130AH	37V 20A		
KETENGER	KETENGER Transmission Line	a	270-165	〃	〃	〃	○	○					
		b	〃	〃	〃	〃	○	○	○	24V 130AH	37V 20A	One Position Desk Type, Capacity : 20 Lines (10 Automatic, and 10 CB Lines) Power Source : DC24V,	Multi-hole Type With Telemeter Instrument Panels (Two Sides), Dimensions : 3,000 x 1,500 mm,
	PURWOKERTO Transmission Line	a	450-220	〃	〃	〃	○	○					
PURWOKERTO	〃	a	〃	〃	〃	〃	○	○					
	GAMBARSARI Transmission Line	a	〃	〃	〃	〃	○	○					
GAMBARSARI	〃	a	〃	〃	〃	〃	○	○					
	TJILATJAP Transmission Line	a	145-110	〃	〃	〃	○	○					
TJILATJAP	〃	a	〃	〃	〃	〃	○	○					
PASANGG-RAHAN Branch	〃	a	〃	〃	〃	〃							
MAOS Branch	〃	a	〃	〃	〃	〃							
Total			16				14	14	2	3 sets	3 sets	1	1

Table of Specifications for Equipment KETENGER SYSTEM No.2 (Fig 8)

Station or Plant to be Installed	Power Line Carrier System	Carrier Terminal Equipment			Telemetering Equipment							Automatic Telephone Switch	
		SSB System Carrier Input Level: 10dBm/CH at 0.8KHz Crosstalk Attenuation: 50 dB or more. Carrier Side Impedance: 75 ohms. Voice Side Impedance: 600 ohms. Line Loss: 42 dB (max) 29 dB (nominal). Automatic Gain Control: Compression Ratio 20% against line loss variation ± 10% and power supply fluctuation ± 5% Carrier Frequency Stability: With 0.01%. Distortion: 30dB or more at 0.8 KHz. Telephone Bandwidth: 300 to 2,300 Hz. TM Bandwidth: 300 to 2,700 Hz.			Thermal Convertor	Voltage /Frequency Transducer	Frequency Transmission Convertor	Transmitter	Detector Amplifier	Recorder	Indicator	Crossbar Type. Capacity 60 lines /1 marker Refer to attached specifications for detail.	
		2CH Type (31dB/CH) Working Frequency (KHz)	3+1CH Type (31dB/CH) Working Frequency (KHz)	6CH Type (29dB/CH) Working Frequency (KHz)	Input: AC110V/5A Output: DC 0 to 30mV 2 Power Meter Method	Input: AC 0 to 110V Output: DC 0 to 110mV	Output Level: +10 dBm Impedance: 600 ohms	50 bauds FS Type Input Level: 5 dBm	50 bauds FS Type Output Level: +10 dBm	Input Frequency: 20 to 30 Hz Input Level: +10 dBm Chart Width: 150 mm 1 Pen Type	Input Frequency: 20 to 30 Hz Input Level: +10 dBm Electronic Type		
PEMALANG	H	260 ~ 286											
	I	104 ~ 120			2	1	2	2					
	J		220 ~ 250										
PEKALONGAN	H	260 ~ 286											
TEGAL	I	104 ~ 120			2	1	2	2					
KETENGGER	J		220 ~ 250		4	2	4	4	8	4	4		
	K		294 ~ 320										
RURWOKERTO	K		294 ~ 320										
	L	254 ~ 280											
GAMBARSARI	L	254 ~ 280											
	M	114 ~ 130											
TJILATJAP	M	114 ~ 130											
Total		4 systems, 8 sets	2 systems, 4 sets		8	4	8	8	8	4	4		

Table of Specifications for Equipment, TUNTANG System No. 1 (Fig 9)

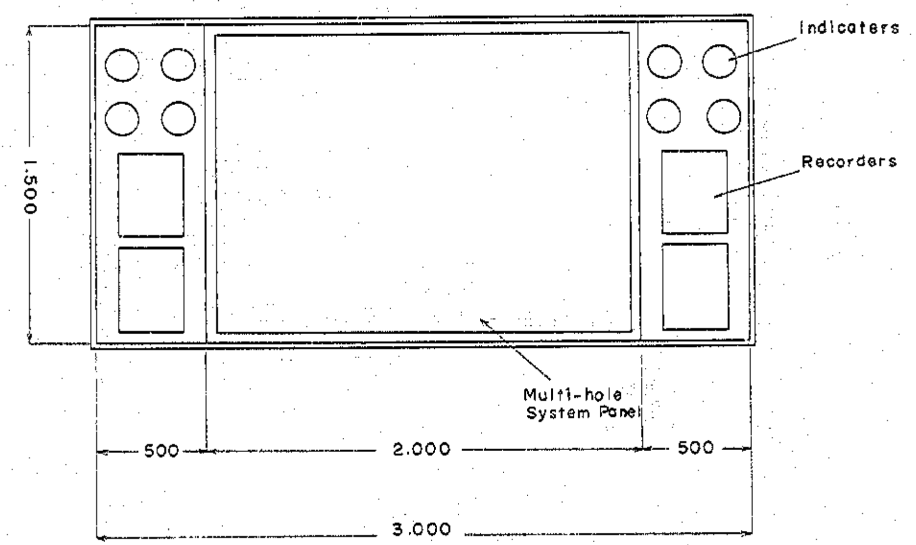
Plants or Stations To Be Installed	Name of Transmission Lines	Phase	Line Trap: Frefuency (KHz)	Line Trap: Inductance (μH)	Line Trap: Rated Current (A)	Line Trap: Short-circuit Current (KA)	Coupling Capacitor	Earth Return Coupling Filter (EF)	Metalic return Coupling Filter (MF)	Storage Battery	Battery Charger	Load dispatching desk	System Panel
							Class of Insulation: No. 30 Capacitance: 0.002 μF Frequency: 10 to 450 KHz Current Capacity: 2 Amp. Type Line trap Mounting Angle Frame	500Ω:75Ω 90~450 KHz Installed Under the Coupling Capacitor	150Ω:75Ω 90~450KHz Out-of-door Type	Clad Type, Styrole Battery Jar, W/Frame Voltage (V) and Capacity (AH)	Input 200V 3φ Self Support Type Noise Output: less than 2mV Automatic Equalized Charge System Rated Output Voltage (V) and Current (A)		
DJATINGALEN	KUDUS Transmission Line	a	120 - 95	300	300	6	○	○	○	24V · 210AH	37V · 40A	One Position Desk Type Capacity: 20 Lines (10 Automatic Line and 10 CB Lines) Power Source: DC 60V	Multi-hole System Panel With Telemeter Instrument Panels (Two Sides) Dimensions: 4,000 x 1,500mm
		b	〃	〃	〃	〃	○	○					
		c	450-220	〃	〃	〃	○	○					
	DJELOK Transmission Line	1c	270-165	〃	〃	〃	○	○		60V · 130AH	90V · 20A		
		2c	〃	〃	〃	〃	○	○					
SEMARANG Branch	KUDUS Transmission Line	a	120 - 95	〃	〃	〃							
		b	〃	〃	〃	〃							
		c	450-220	〃	〃	〃							
SEMARANG	KUDUS Transmission Line SEMARANG Branch		〃	〃	〃	〃	○	○					
DEMAK Branch	KUDUS Transmission Line	a	120 - 95	〃	〃	〃							
		b	〃	〃	〃	〃							
KUDUS	KUDUS Transmission Line	a	〃	〃	〃	〃	○	○	○				
		b	〃	〃	〃	〃	○	○					
DJELOK	DJELOK Transmission Line	1c	270-165	〃	〃	〃	○	○	○	24V · 210AH	37V · 40A		
		2c	〃	〃	〃	〃	○	○					
	TIMO Transmission Line	1a	450-220	〃	〃	〃	○	○					
	SURAKARTA Transmission Line	a	〃	〃	〃	〃	○	○	○				
		c	〃	〃	〃	〃	○	○					
	MAGELANG Transmission Line	a	270-165	〃	〃	〃	○	○					
TIMO	TIMO Transmission Line	1a	450-220	〃	〃	〃	○	○					
SALATIGA Branch	SURAKARTA Transmission Line	a	〃	〃	〃	〃							
		c	〃	〃	〃	〃							
BOJOLALI Branch	SURAKARTA Transmission Line	a	〃	〃	〃	〃							
		c	〃	〃	〃	〃							
SURAKARTA (SOLO)	SURAKARTA Transmission Line	a	〃	〃	〃	〃	○	○	○				
		c	〃	〃	〃	〃	○	○					
MAGELANG	MAGELANG Transmission Line	a	270-165	〃	〃	〃	○	○					
	JOGJAKARTA Transmission Line	c	120 - 95	〃	〃	〃	○	○					
JOGJAKARTA	JOGJAKARTA Transmission Line	c	〃	〃	〃	〃	○	○					
Total			29				20	20	5	3 sets	3 sets	1	1

Table of Specifications for Equipment, TUNTANG System No. 2 (Fig 10)

Station or Plant to be Installed	Power Line Carrier System	Carrier Terminal Equipment			Telemetering Equipment							Automatic Telephone Switch
		SSB System Carrier Input Level: 10dBm/CH at 0.8KHz. Crosstalk Attenuation: 50 dB or more. Carrier Side Impedance: 75 ohms. Voice Side Impedance: 600 ohms. Line Loss: 42 dB (max) 29 dB (nominal) Automatic Gain Control: Compression Ratio 20%, against line loss variation ±10% and power supply fluctuation ± 5% Carrier Frequency Stability: With 0.01%. Distortion: 30dB or more at 0.8 KHz. Telephone Bandwidth: 300 to 2,300Hz. TM Bandwidth: 300 to 2,700Hz.			Thermal Convertor	Voltage /Frequeney Transducer	Frequency Transmission Convertor	Transmitter	Detector Amplifier	Recorder	Indicator	Crossbar Type Capacity 60 lines /1 marker Refer to attached specifications for detail
		2CH Type (31dB/CH) Working Frequency (KHz)	3+1CH Type (31dB/CH) Working Frequency (KHz)	6CH Type (29dB/CH) Working Frequency (KHz)	Input: AC110V/5A Output: DC 0 to 30mV 2 Power Meter Method	Input: AC0 to 110V Output: DC 0 to 110mV	Output Level: +10dBm Impedance: 600 ohms	50 bauds FS Type Input Level: 5dBm	50bauds FS Type Output Level: +10dBm	Input Frequency: 20 to 30Hz Input Level: +10dBm Chart Width: 150mm 1 Pen Type	Input Frequency: 20 to 30Hz Input Level: +10dBm Electronic Type	
DJATINGALEN	A	104 ~ 120			2	3	3	3	15	9	6	1
	B	294 ~ 320										
	C			220 ~ 270								
KUDUS	A	104 ~ 120			2		1	1				
SEMARANG	B	294 ~ 320			2	1	2	2				
DJELOK	C			220 ~ 270	8	1	5	5				
	D	334 ~ 360										
	E	294 ~ 320										
	F		170 ~ 220									
TIMO	D	334 ~ 360										
SURAKARTA (SOLO)	E	294 ~ 320			2	1	2	2				
MAGELANG	F		170 ~ 220									
	G	104 ~ 120										
JOGJAKARTA	G	104 ~ 120			2	1	2	2				
Total		5 systems, 10 sets	1 systems, 2 sets	1 systems, 2 sets	18	7	15	15	15	9	6	1

Sketch of Load Dispatching Office's System Panel (with TM panel) (Fig. 11)

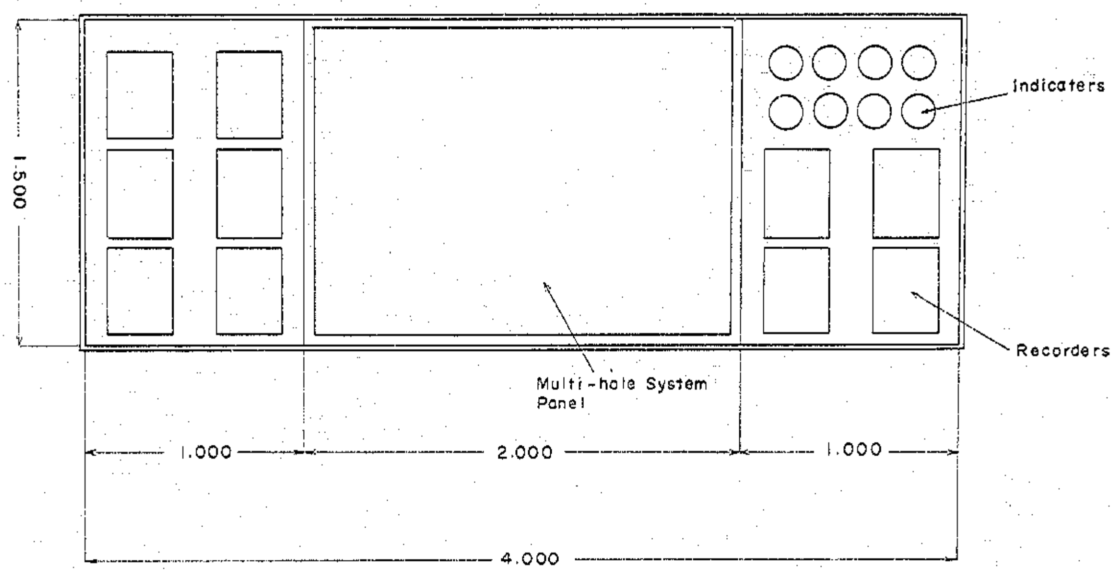
KTENGER · SYSTEM



(Fig. 12)

Sketch of Load Dispatchig Officers System Panel (with TM panel)

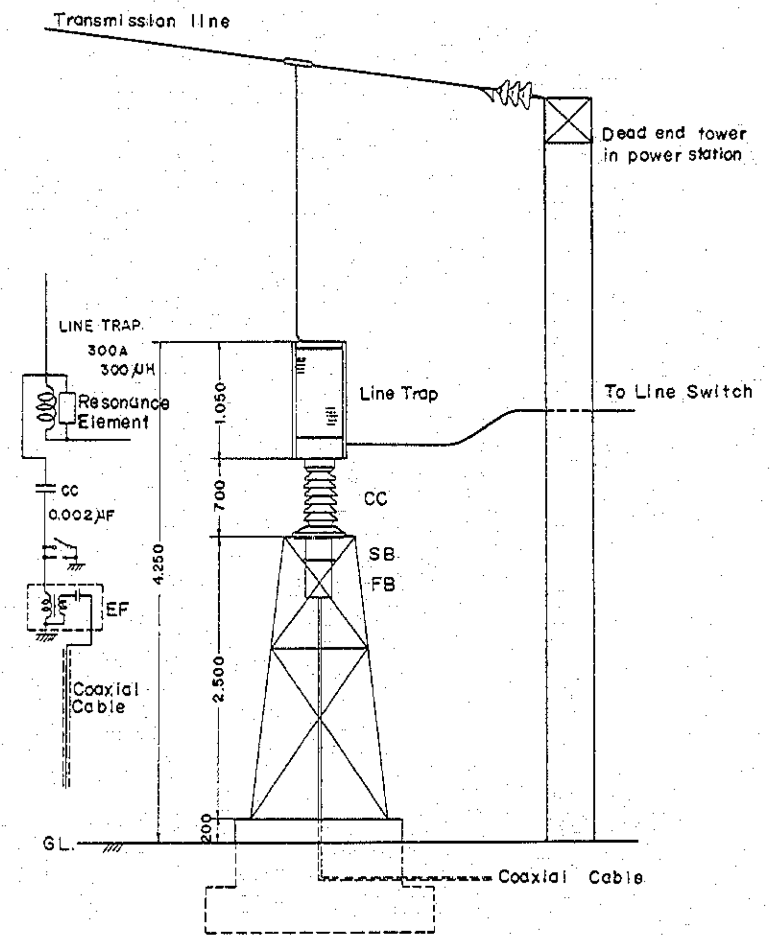
TUNTANG · SYSTEM



(Fig 13)

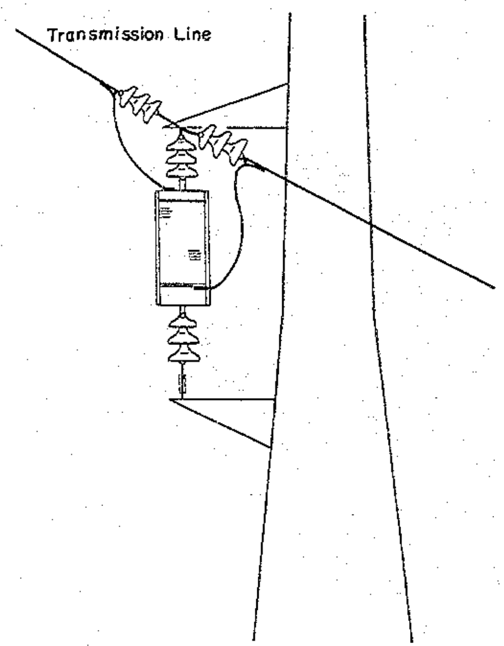
Installation of Line Trap and CC

(To be installed in plants or stations)



Installation of Line Trap on Tower

(To be installed at branching point)



Appendix 2–11

MEMORANDUM

ON THE INVESTMENT PROGRAM FOR FISCAL YEARS 1969–1970 and 1970–1971 in Exploitasi II and XIV

June 16, 1969

Japanese Study Team
of National Power
in Indonesia.

1. In Expl. II & XIV, due to the shortage of power, the load increase has been suppressed for several years especially in the main cities, and the scheduled service interruptions are still continued in Padang.

2. Therefore, the priority of investment should be given to the expansion of generating facilities.

   It is recommended that the addition of diesel unit for Padang should be advnaced from original 1970 to 1969, whereas small diesel units to small cities can be postponed if the available fund is not enough.

   Other power plant projects in The Five Year Development Plan, especially the construction of a steam power plant in Palembang needs to be positively carried out as programmed.

3. The investment in distribution facilities should be considered gradually in pace with the expansion of generating facilities, as the condition of generation is far worse than that of distribution.

   For the fiscal years 1969 and 1970, the investment should be limited to the areas where generating capabilities will be increased.

4. As a basis for the programming of the rehabilitation and the expansion of distribution facilities as well as for the planning of power sources in the future, it is very important to estimate the demand by analyzing the financial capabilities of waiting consumers and studying the possibilities of the expansion of industries.

Also, it is essential to know the actual condition of consumers and generation/ distribution facilities which do not belong to PLN.

5. According to the master plan of transmission and distribution for Palembang in connection with the new steam power plant, distribution voltage is going to be changed to 12 KV from present 6KV.

However, it is questionable to change the voltage in view of the load density and the possibility of installing overhead high tension lines.

As for the transmission, the original plan should be pushed forward.

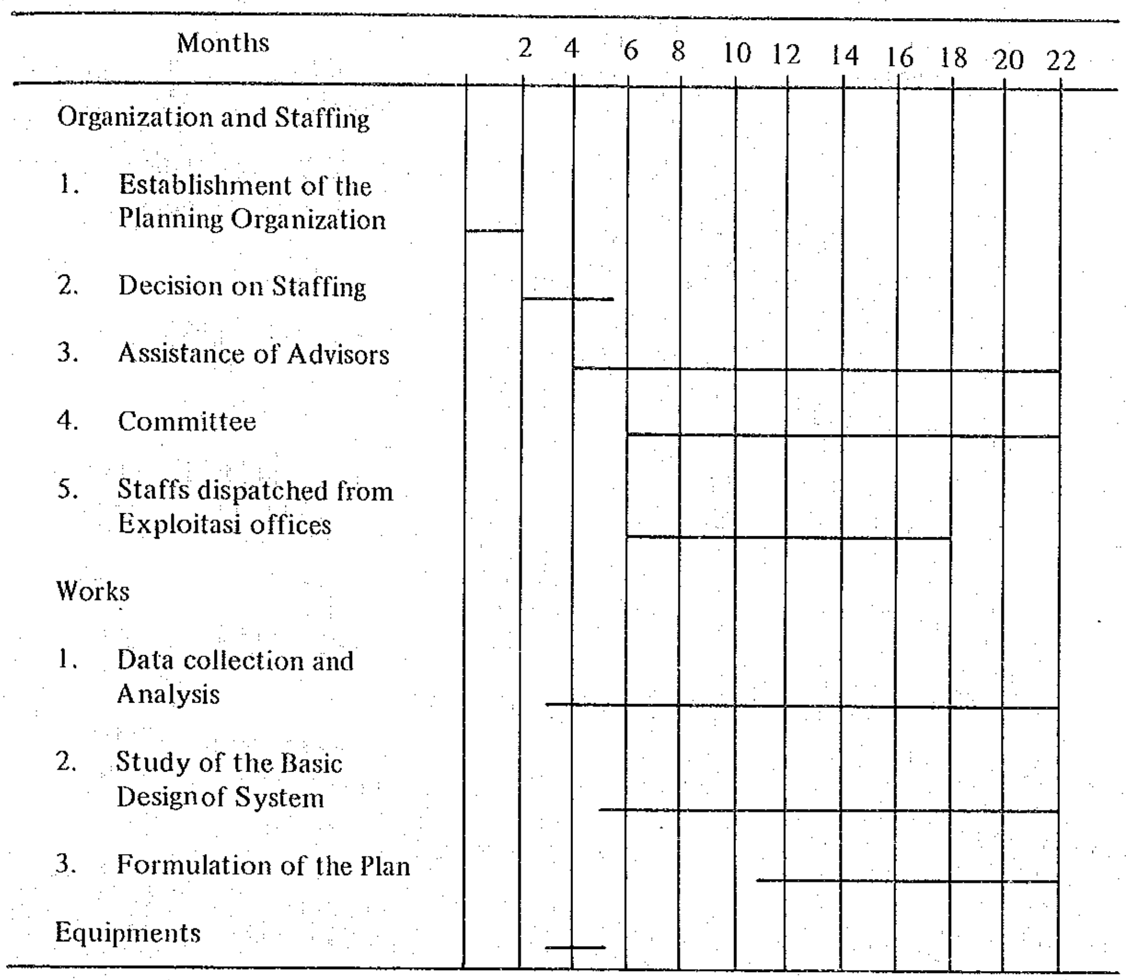
6. It is commendable that the overhead high voltage lines have been largely adopted in Expl. II & XIV.

7. Bt. Agam Project is originally planned in anticipation of the development of local industries in the Bukittinggi area, but it will take years for this development. In order to avoid the low utilization of plant capacity for some years, the reduction in capacity or the transmission of surplus power to Padang by a long distance line can be considered. But both measures will raise the energy cost (even though this energy cost will be still cheaper than that of diesel or steam plant.)

On the other hand, this province has many lakes and rivers, and it is expected that the various types and scales of hydro sites can be found.

Therefore, as to Bt. Agam Project, more efforts should be made in increasing the economic value of the project along with effective transmission planning, and it is more desirable to carry out a comparative study with other possible sites.

PHASING FOR FORMULATION OF FIRST LONG-TERM PLAN



Note: *(1)* *First of all, the planning organization is established.*

(2) *Major staffing works are completed before advisors arrive.*

(3) *Preparations for data collection are started soon.*

METHOD OF LOAD ESTIMATION

There is no single method that fully satisfies the purpose of load estimation. Load estimation should therefore be made using a number of different methods whose results should be checked and compared with each other. Methods applicable to load estimation can be broadly grouped into the following three.

(1) Estimation based on the past or future trends — Macroscopic estimation

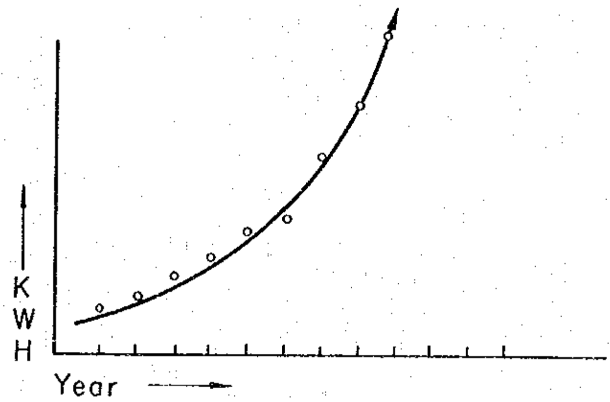
(2) Estimation based on category of contract ⎫
(3) Estimation based on cross-section data ⎭ — Microscopic estimation

1. ESTIMATION BASED ON PAST OR FUTURE TRENDS

(1) Simple application of past trends

This is the simplest and most basic method in which the past trends are applied for the future by means of the running average method[1], arithmetical progression, geometrical progression or method of least squares[2].

Application of these methods results in the plotting illustrated in the graph below.



It is to be noted that this method, which resorts to the past trends, demands that data on KWH sales by categories and other elements are compiled in good order for several years or months in the past. Further, its application is limited to the case where consistency is considered existent in the economic conditions and supply conditions that affect the trends of power demand.

Note 1 and 2 – For the running average method and the method of least squares, refer to a pertinent textbook of statistics.

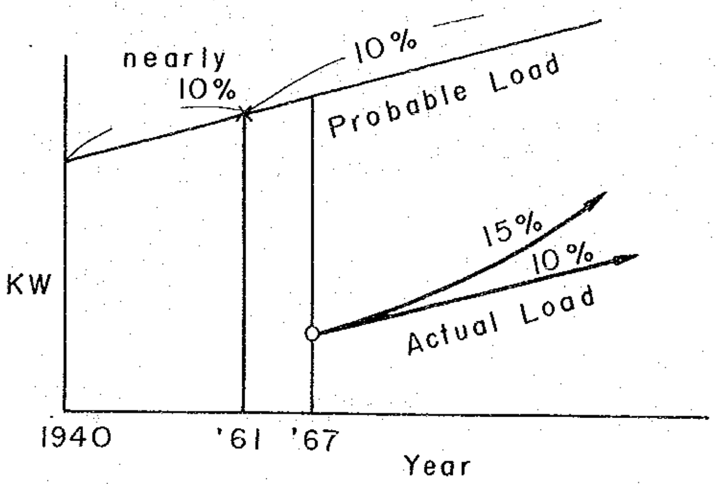
The curve obtained by least squares method can be represented, as occasion demands, by the linear equation ($y = ax + b$), quadratic equation ($y = ax^2 + bx + c$), logarithmic equation ($\log y = a \log x + \log b$), or Gompertz curve.

(2) Estimation based on future vision

In this method, estimation is made for a certain period from the present time (e.g. from the present time to 10 years ahead or A.D. 2000) in which the envisaged target, such as attainment of the prevailing level in European countries, is assumed to be achieved. This method is generally applied to envision the rate of electrification or the average power consumption per household. Method employed in the French Green Book and by Exploitasis XI and XII falls under the category of this method.

Being based on a vision in the remote future, this method is suited to making an estimation for a prolonged period. However, since it is apt to be based on an implicitly intentional or discretionary vision, it should preferably be employed combinedly with other methods.

① French Green Book Method



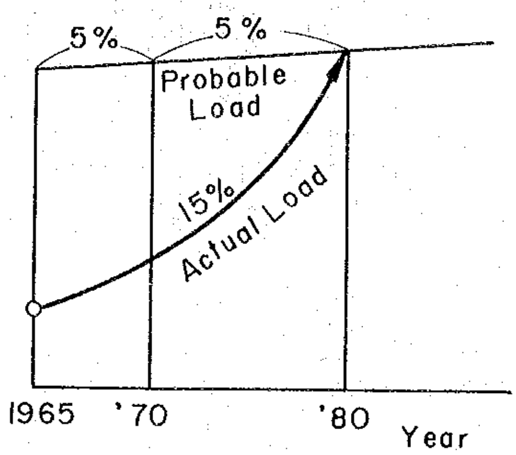
(factors considered)

a. Population (Number of Houshold)

b. Ability of Payment

c. Ratio of Actual Load Increase in FCAFE Region

② The Method used by Exploitasi



a. Population (Number of Houshold)

b. Waiting Consumer

c. Target of Saturation factor 100%

2. ESTIMATION BASED ON CATEGORY OF CONTRACT

(1) Estimation based on factors of demand trends

In case where changes are expected in the future demand structure, trends of such changes should be estimated on the basis of demand factors by categories and industries.

In the event where the required statistical data are not available in good order, or the minimum demand in future is to be estimated, it may be justified to make an estimation by considering the load increase in terms of the following two categories, one proportionate to the economic growth rate and the other exceeding it.

a. Load increase proportionate to economic growth

There exists a close relationship between the rate of economic growth and the load increase rate in any country of the world irrespective of the stage of its development. Especially in Indonesia, which is one of the developing countries of the world, growth of economy directly enhances the paying ability of general consumers.

As regards the domestic electric lights, the increase in per capita income brings about increased power consumption for the following reasons.

(a) Power consumption of those households already using electric lamps increases in proportion to the increase in income, causing additional use of electric equipment and apparatus.

(b) Households which hitherto had no paying ability become financially capable of using electric lights, adding to the total number of consumers.

The increase in the number of consumers should be correspondent at least to the population growth rate. Otherwise, the overall electrification rate of the country must be considered to be in regression.

The economic growth rate is the sum of the rate of population growth and that of per capita income. From the above explanation, it may be safely deduced that the future power demand will increase at least in proportion to the rate of population growth and of per capita income. In this sense, the 5% growth rate envisaged in the Five Year Development Plan can be construed as the basic increase rate of load.

b. Load increment surpassing economic growth, or electrification

In any country of the world, the rate of load increase surpasses that of economic growth. In other words, the elasticity value of load increase (load increase rate/economic growth rate) never fails to exceed 1.0. The increment of load exceeding that correspondent to economic growth rate is caused chiefly by the changes in the structure of industries and by the use of new or additional electrical equipment and apparatus. In case of the present-day Indonesia, however, this is due predominantly to the enhanced electrification of existing households (precluding new households created by population increase) resulting from the expanded supply capacity of PLN. To be more precise, this sort of load increase is covered, insofar as Indonesia is concerned, by the progress of electrification of existing households which is realized in proportion to the expansion of the distribution networks.

This load increment can be calculated as follows on the basis of the estimated long-term electrification, present population and future reduction in the unit size of families.

(a) $$\frac{\dfrac{\text{Population in 1968}}{\text{Future unit size of families}} \times \text{Estimated electrification rate}}{\text{Number of contracted households as of the end of 1968 (S + R)}}$$

(b) The increase rate obtained by the above calculation is to be applied as the average compound increase rate[2].

Assuming that the family size, averaging at present 10 in urban areas and 20 in rural districts, will be reduced to an average of 5 and the electrification rate will be 25% in A.D. 2000, the load increment due to electrification will be 3%. When this is taken into account, the elasticity value will be 1.6 (= (5 + 3%)/5%).

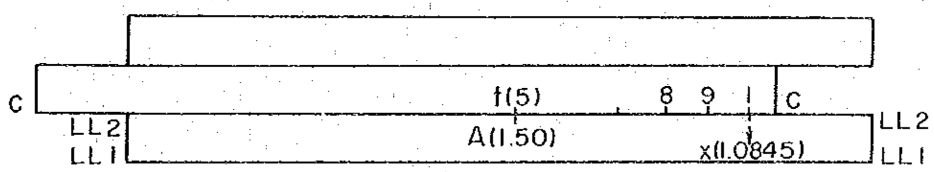
Note 1 – In the above method, the load increase due to population increase is necessarily calculated as the load increase proportionate to the economic growth.

Note 2 – How to obtain the average compound increase rate using a slide rule.

The relationship between the term (t), total increase (A) and increase rate per annum (x) can be expressed by the following equation.

$$x = A^{1/t}$$

On a slide rule, this equation can be represented as follows.



In the above example, A appears on LL scale (or on LL2 scale if A is 1.5), and by setting t (e.g. 5 years) lying on C scale to A by means of the cursor, x (1.0845 on LL1 scale in this case... 8.45% per annum) can be obtained immediately under 1 on C scale.

In general, if t is a one-digit numeral (1 - 10), x can be obtained on -

(i) the same LL scale on which A appears (e.g., LL2 scale) if C scale is drawn to the right, or

(ii) on LL1 scale if C scale is drawn to the left and A lies on LL2 scale.

Where t is a two-digit numeral (10 - 100), x can be located on LL scale less 1 in order than the scale on which A lies.

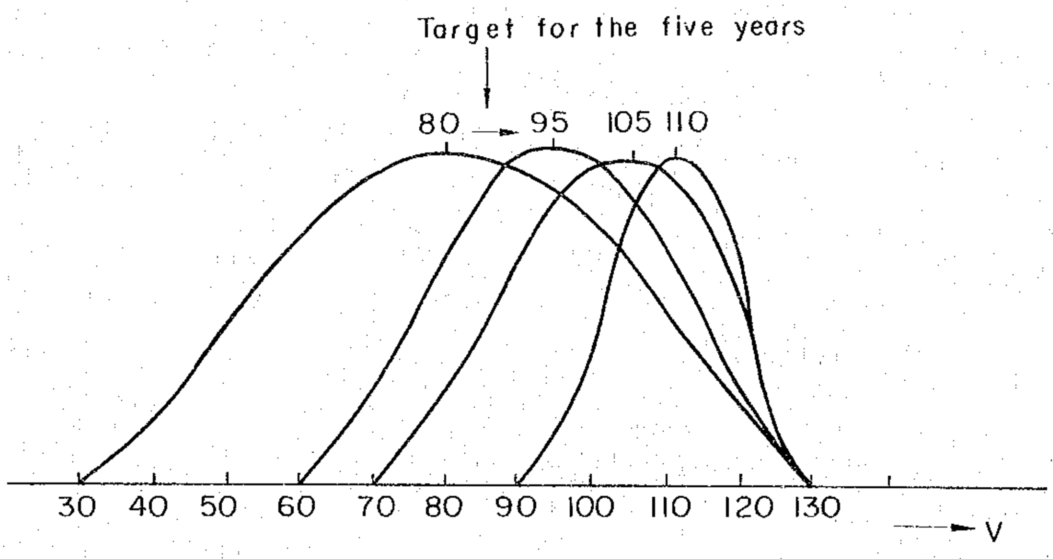
c. Load increase by voltage improvement

In the present stage of development of the electric power industry of Indonesia, the load increase due to voltage improvement is quite considerable.

The load increase by voltage improvement during the coming few years can be obtained, as illustated below, from the voltage level in the existing distribution networks and from the improvement target for the coming five years.

(a) Present condition and target of improvement

Present condition & target of voltage improvement



The elasticity value and the load increase rate with respect to the current voltage level and voltage improvement rate given in the above table are more or less influenced by implicit intentions. Revisions based on investigations of actual conditions in each region should therefore be effected to both elasticity and load increase rate.

(b) Load increase by voltage improvement

Categories	Weight	Purpose	Present voltage	Voltage after improvement	Up rate (A)	Elasticity of load increase (B)	Rate of load increase (A) x (B)	Average increase rate for 5 years
S	35	Lighting	75 (70 – 80)	90	20%	1.0	20%	3.7%
R	20	Fluorescent lamps and motors	75 (70 – 80)	90	20%	0.8	16%	3.0%
K	10	Fluorescent lamps and heaters	80 (75 – 85)	95	19%	0.7	13%	2.5%
U	15	Ditto	90 (85 – 95)	100	11%	0.6	7%	1.4%
P	20	Ditto	90 (85 – 95)	100	11%	0.6	7%	1.4%
TOTAL	100		80	95				2.6%

d. Supply-demand balance

When considered from the short-term viewpoint, the load increase in any specific region will be brought to a halt if there exists a shortage of power source in that region.

Load increase attributable to the foregoing four factors discussed in Description Section 2 can be summarized as follows.

	Rate of load increase	Total rate of increase	Elasticity against economic growth rate
o Economic growth	5%	5	1.00
o Electrification	3	8	1.60
o Improvement of supply conditions			
Voltage improvement	2.6	10.6	2.12
Shortage of power source	Δ 0.1	10.5	2.10

The elasticity value noted above is substantially higher than the average value of 1.5 in advanced countries. It will be understood from the above table that this high elasticity value is due to the improvement of supply conditions. The actual elasticity value in the past would surpass the above value if privately-owned generators are taken into account.

3. ESTIMATION BASED ON CROSS-SECTION DATA

This method is employed to estimate the future trends of Indonesia using data of foreign countries to make up for the lack of data in time series.

(1) Estimation based on the Five Year Development Plan

If estimation is to be made based on data of economic growth and load increase in foreign countries, the following two points must be considered as variables.

(a) Effect of investment ratio on the rate of economic growth and of load increase (Economic growth rate as a variable)

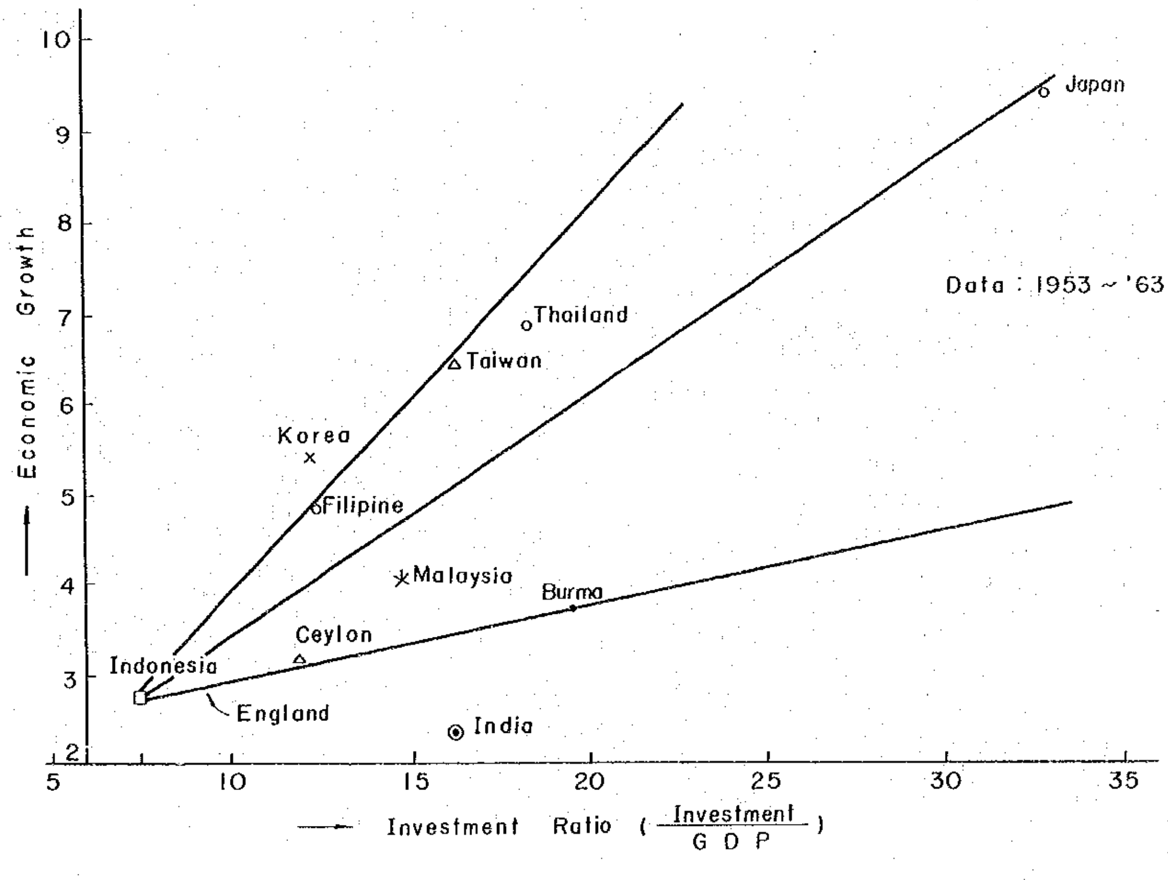
(b) Significance of make-up of industries and privately-owned generators in achieving a desired economic growth rate (Elasticity value and privately-owned generators as a variable)

The above two variable points are discussed below with respect to the Five Year Development Plan.

a. Investment ratio and economic growth rate

The graph below illustrates the relationship between the investment ratio (investment/GNP) and the economic growth rate in countries located mostly within the ECAFE region.

Note: GNP means Gross National Product



Investment in facilities is the largest factor that affects economic growth over a long period of time. In this respect, the above graph is indicative of the fact that the low investment ratio is responsible for the low economic growth rate sustained by Indonesia in the past.

Generally, the relationship between the investment ratio and the economic growth rate can be expressed by the following equation in which the yield coefficient expressing the investment efficiency ($\frac{\Delta Y}{I}$ = ratio of investment in a certain year to the increment of GNP in the following year) is a parameter.

Economic growth rate = Investment ratio x Yield coefficient

$$\left(\frac{\Delta Yt+1}{Yt} = \frac{It}{Yt} \times \frac{\Delta Yt+1}{It} \right)$$

Applying the above equation to the Five Year Development Plan, we obtain the following rough relationship.

$$5\% = 9\% \times 0.55$$

(average growth rate for 1958 - 1966 = 7.3 x 0.34)

It will be understood that the Five Year Development Plan is intended to achieve a 5% growth rate at an approximately 9% of investment ratio (aggregate investment amount = 1420 billion Rp).

It is expected that approximately 80% of the above investment amount will be covered by foreign investment and foreign aids.

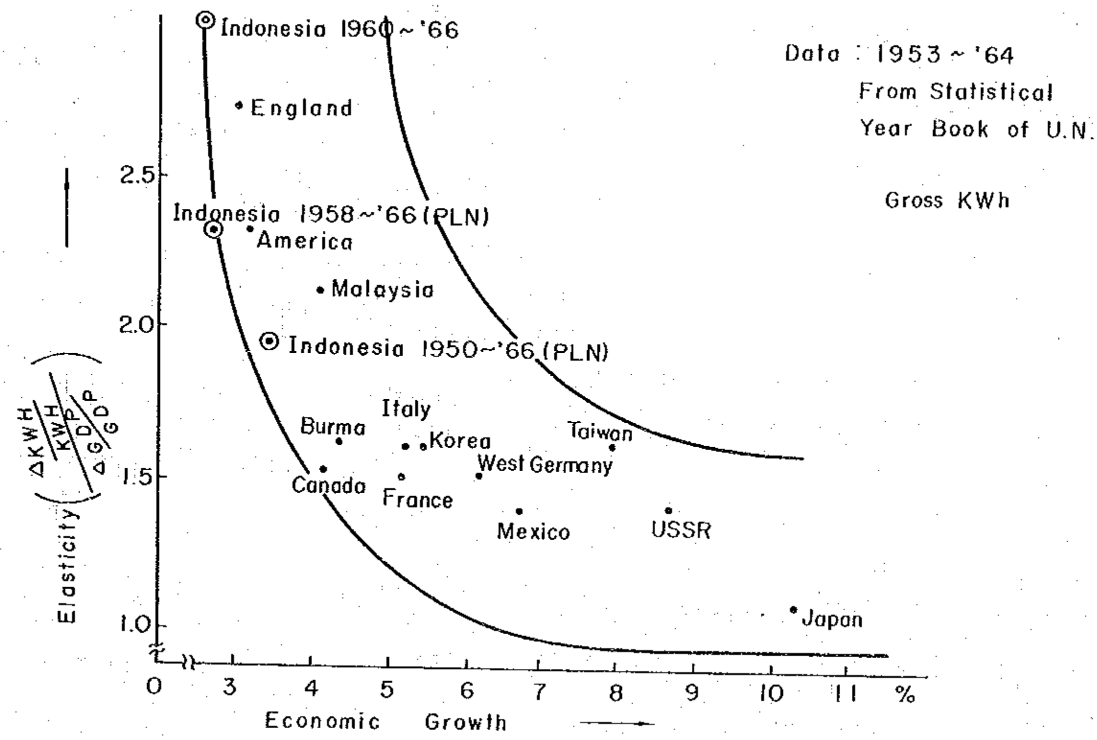
b. Economic growth rate and load increase rate

The graph below shows the elasticity curves representing the relationship between the economic growth rate and the load increase rate in countries located mostly in the ECAFE region.

Economic growth generally accompanies a decline of elasticity value, and this is consequent upon the changes in the structure of industries and consumers that take places with the growth of economy.

The elasticity value corresponding to a 5% economic growth rate appears to be within the neighbourhood of 2.0. When this is taken granted, it would be justified to estimate the load increase rate at about 10% (5% x 2.0).

Relation between Economic Growth and Elasticity



Source: Statistical Year Book of UN, 1953 - 1964

c. Considering the foregoing factors, a high load increase rate of 15% to 20%, if attainable in Indonesia, would be possible in the case where -

(a) A substantially high investment ratio and a consequently high economic growth rate are realized by the introduction of foreign capitals exceeding the planned amount. It deserves attention that countries having a load increase rate of nearly 15% within the ECAFE region are such countries as Thailand, Ceylon and Taiwan where the industrialization is in progress by virtue of an investment ratio ranging from 15% to 20%.

(b) Elasticity value rises up to 2.5 - 3.0 at an economic growth rate of about 5%. This is possible if power-oriented industries are developed as a result of the transformation of industrial structure and such transformation is quite feasible in Indonesia provided that efforts are directed towards efficient utilization of locally available resources.

(c) Estimation given above relates to overall load including the load of privately-owned generators. In estimating the load incumbent upon PLN, therefore, load estimation for privately-owned generators should not be neglected.

It is to be noted that the load estimation involving privately-owned generators should be based on a justifiable policy established for the future management of PLN.

It is recommended that PLN makes load estimation with the primary concern for its system coordination and economic justifiability rather than include all the industries having generators in PLN systems. Hence, it is desirable to establish, in addition to a supply programme for individual plants, a long term supply programme in which the ratio of privately-owned generators is taken into account from the macroscopic viewpoint.

(2) Estimation based on relationship between investment by industries and average contracted KVA based thereon.

Estimation by industries is essential if the structure of industries and consumers undergoes a rapid change.

If a systematic and planned investment by industries can be expected in Indonesia from the socialistic orientation of national policies, the following method would be effective.

Namely, rough estimation of load at the time of completion of the Five Year Development Plan is made for each industry involved in the Plan by multiplying the contracted KW per unit investment by the total investment in each industry.

The following table gives the total investment amount by industries involved in the Five Year Development Plan and the ultimate load by industries as obtained by the above method. The contracted KW per unit investment amount shown in the table has been determined based on the examples in Japan after making necessary adjustment of land appraisement and other factors.

Total Investment Amount and Ultimate Load by Industries Involved in the Five Year Development Plan

Industry		Investment amount (100 million Rp)	Contracted KW per unit investment of 1 million Rp	Contracted KW	Peak load (KWH sold)	Remarks
Agriculture	Rice processing	10^6Rp –	– KW	27.5 MW	11.0 MW (26 million KWH)	250 KW per plant; 110 plants in total.
Mining & Manufacturing Industry	Exploitation, transport & processing of petroleum and natural gas	1,300	0.3	39.0	15.6 (37)	
	Fertilizer	540	1.6	86.4	34.6 (81)	Land appraisement has been set at 1/10 of that in Japan; contracted KW per 1 million yen has been adopted.
	Cement	186	2.6	48.4	19.4 (45)	
	Chemicals & textiles	1,289	0.5	64.5	25.8 (61)	
	Light industry, handicraft, etc.	250	0.3	7.5	3.0 (7)	
	Metal processing, machinery, etc.	235	0.8	18.8	7.5 (18)	
	Sub-total	2,500		225.6	90.3 (212)	
	Ports & Harbours			44.7	1.9 (5)	5.250 KVA adopted for Expansion Programme
Total		3,800		336.8	118.8 (2 80)	

Note:

1) *An allowance of one year from the time of investment to full-scale commissioning has been made for the peak load and KWH sold.*

2) *The diversity factor of peak load against the contracted demand has been set at 0.5 following the example set by exploitasis.*

3) *The annual load factor against the contracted demand has been set at 13.4% (actual value : 12.4%).*

4) *The contracted demand per unit investment amount has been determined on the basis of data of major Japanese plants selected from each field of industry. The data include the fixed assets of these plants appearing in the portfolios, and the sum of the capacity of their privately-owned generators and their contracted KVA.*

(3) Estimation based on geometrical mean values obtainable from detailed and systematically compiled data

a. Estimation based on the output of major industrial products and the power consumption per unit output.

In this method, load estimation is made by first obtaining, from the production plans, respective industrial outputs (which are expressed, for instance, in tons), and then multiplying the outputs thus obtained by the unit power consumption (KWH).

An Example of Power Consumption per Unit Output

Unit: KWH
Values are actual results recorded in 1968

Ammonia (gas process method)	1,736 per ton
Caustic soda (electrolytic method)	3,617 per ton
Oil refinery	12 per kl
Cement	116 per ton
Pig iron	15 per ton
Converter steel ingot	13 per ton
Rolled steel materials	186 per ton
Aluminum	16,634 per ton

b. Estimation based on correlation with production indices

If the production indices of mining industry and manufacturing industries can be obtained from the gross national product or other data, load estimation can be made from the correlation between the production indices and the power demand.

c. Estimation based on the number of consumers and power requirement per consumer

In this method, the long-range transition is calculated for the number of consumers by categories (S, R, K, etc.) and for the power requirement (KWH) per consumer and the load estimation is made by multiplying the number of consumers by the power requirement per consumer.

As regards the domestic electric lamps, KWH requirement per household is estimated, on certain occasion, from the number of respective major apparatus multiplied by their working hours.

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ON LOADING FACTOR

1. DEFINITION OF LOADING FACTOR

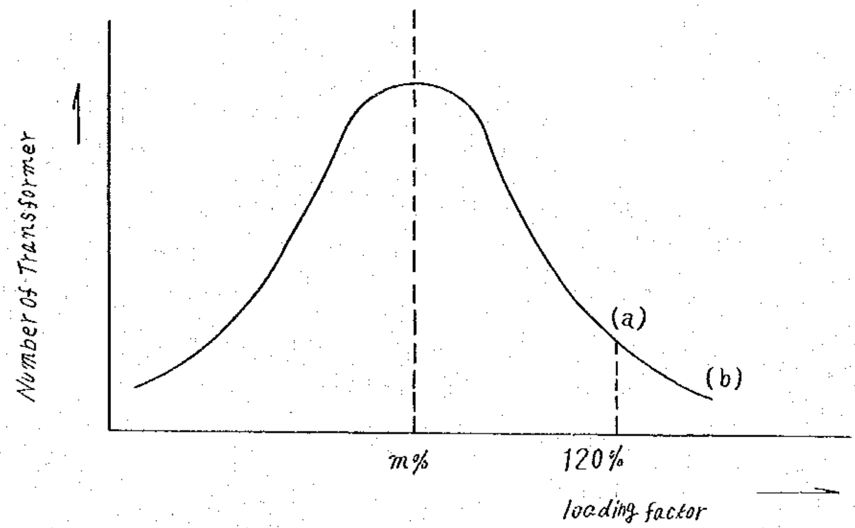
$$\text{Loading factor} = \frac{\text{Load on facility}}{\text{Rated capacity of facility}}$$

2. EXPLANATION ON THE LOADING FACTOR OF DISTRIBUTION TRANSFORMER

(1) It is common to allow blackouts in case of distribution transformer faults.
Then, assuming that the allowable maximum load on a transformer is 120 percent of its rated capacity, we can get

Proper loading factor of a transformer = 120%

(2) It is usual that transformers installed in a certain area are not always fully loaded, loading factors of these transformers form a distribution curve.



Consequently, the proper mean loading factor for a group of transformers is the loading factor m% in the above figure which gives an allowable number of transformers having loading factors larger than 120% (integration from (a) to (b) in the figure).

(3) A calculation of the required increase of capacity.
Assumption;

the present mean loading factor 98%

the desirable mean loading factor after 5 years 70%

Calculation

	Present	After 5 years
Load (MVA)	P_1	P_2
Loading factor (%)	98	70
Total capacity (MVA)	$P_1/0.98 = A$	$P_2/0.7 = B$
Increment (MVA)	B - A	

3. EXPLANATION ON THE LOADING FACTOR OF FEEDER

(1) Assuming that the whole load on a feeder is to be transferred to other three feeders in case of contigency and all feeders concerned have the same capacity, we can get

Proper Loading factor of a feeder
$= 1/(1 + 1/3)$ or $3/4 = 75\%$

Furthermore, when over-loading up to 120% of the rated capacity is allowed in case of emergency.

Proper loading factor $= 0.75 \times 1.2 = 90\%$

(2) When we treat a group of feeders, the same approach can be made as in the case of distribution transformers.

4. EXPLANATION ON THE LOADING FACTOR OF SUBSTATION

(1) It is a general rule to consider that the whole load on one of transformers in a substation is to be transferred to the rest of transformers in the substation and to the other substations when the transformer is faulted.
The following assumptions are made.
- Over-loading is allowed up to 120% of rated capacity in case of emergency.
- The amount of load to be transferred to other substations is limited to 15% of the rated capacity of the transformer.
- Transformers are all three-phase and same in capacity.

Then, the proper loading factor of a transformer is,

in case of 2 banks in a substation

$$\frac{(2-1) \times 1.2 + 0.15}{2} = 67.5\%$$

in case of 3 banks in a substation

$$\frac{(3-1) \times 1.2 + 0.15}{3} = 85\%$$

(2) Based on the same assumptions as above, the proper mean loading factor of a group of transformers, which are installed in two substations with two banks and one substation with three banks, is given as follows;

Proper mean loading factor

$$= \frac{2 \times 2 \times 0.675 + 3 \times 1 \times 0.85}{2 \times 2 + 3 \times 1} = 75\%$$

(3) The distribution of the loading factors of transformers in substations and its use can be thought in the same way as in case of distribution transformers.

EXAMPLE OF CALCULATION OF REQUIRED NUMBER OF TRANSFORMERS FOR VOLTAGE IMPROVEMENT

1. APPROACH

(1) Assuming that the structure of feeders for each transformer, the conductor size and the load distribution along a line are same for all feeders, the voltage drop in low voltage lines can be represented by the following index;

(load per transformer) x (length of feeder per transformer) = K

(2) When the desirable value of K is given and the measures such as the increase of transformers for achieving the desirable value of K are determined, the necessary number of transformers can be calculated.

2. AN EXAMPLE OF CALCULATION

In the following calculation, the values of K, the load and the number of transformers in 1968 are obtained from the actual data, and the target of K in 1973 is decided based on the comparison of the values of K for different cities which are supplied at the various levels of voltage conditions, and the load in 1973 is estimated. It is assumed that in order to achieve the target of K, the measure is taken to increase the number of transformers.

Table of Calculation

Year	1968	1973
K	5,300	Target 1,500
Load (KW) " (unit)	76.2 (1.0)	132 (1, 73)
K in case no measures are taken = K_2		5.300 x 1.73 = 9.200
K_2/K		9.200/1.500 = 6.1
Number of transformer	737	737 x $\sqrt{6.1}$ = 1.820
Increase of transformers	1083	

Note: K in this table is expressed by the use of number of poles instead of length of feeders.

METHOD OF ECONOMIC EVALUATION

1. CAUTIONS REQUIRED IN ECONOMIC EVALUATION

Economic evaluation of the investment in facilities demands the quantitative determination of all elements of cost and benefit incidental to the investment. However, there are certain elements which cannot calculated by the existing techniques.

Efforts should be made to clarify as many elements as possible so that the decision may be made based primarily on the clarified elements and with consideration given to the remaining indistinct ones.

It is to be noted that the decision making can be much facilitated by devising an expedient or other which serves to calculate, though to a limited extent, those elements which refuse the application of the existing techniques.

A point never to be overlooked in the economic evaluation is that, as already discussed in the section for "Method of Planning," the investment in the electric power industry is rarely made for an isolated project. It is quite usual that any project in which investment is to be made is closely related with other concurrently planned projects as well as with projects planned at different times. It is therefore important that the economic evaluation is made with full consideration given to the interrelationship between all the relevant projects.

2. METHOD GENERALLY EMPLOYED FOR ECONOMIC EVALUATION (Rate of Return Method)

While electric power facilities in which capital has been invested produce benefit for an extensive period, such facilities inevitably incur cost during the same period of time.

In the economic evaluation of electric power facilities, therefore, comparison between benefit and cost during the service life of the facilities must be made as follows.

$$\text{Rate of return} = \frac{\text{Benefit - Cost}}{\text{Investment amount}}$$

Needless to say, the higher the above ratio, the greater the economic justifiability.

This method is most widely employed for economic evaluation, and we may call it the "Rate of Return Method."

In the calculation of the rate of return, we must consider the fact that the value of invested amount varies at different times in future. In other words, the cost and benefit during the service life should be reduced to equivalents to make the comparison possible.

(Refer to "Present Worth Factor and Capital Recovery Factor" explained later in this Appendix)

3. SIMPLE METHOD EMPLOYED FOR ECONOMIC EVALUATION (Minimum Cost Method)

In the electric power industry, it often occurs that a number of investment plans bring about the same benefit. For instance, the revenue and the service level could be the same whichever of the proposed plans may be adopted. Further, since the electric power industry is bound by the obligation to supply power, it is often the case that the question is not whether to make an investment or not, but is rather which plan is to be adopted to achieve the already established purpose.

If the purpose is thus established and the choice of plan has no influence on the derivable benefit, the economic evaluation can be made simply by comparing the cost required by respective plans.

$$\text{Rate of return} = \frac{\text{Benefit - Cost}}{\text{Investment amount}}$$

Provided that the benefit within the service life is constant, the economic preference is given to the plan which incurs less cost within the service life.

We may call this method the "Minimum Cost Method."

4. COST RATIO

In the actual application of the aforesaid methods, the quantitative clarification of cost and benefit is of utmost importance.

In the case of electric power industry, these two elements may be roughly explained by representing the former by the capital cost, operating cost and other expenses, and the latter by the revenue and the quality of electricity, or the service level.

The evaluation of the two elements should in principle be made for each project. For the cost in the electric power industry, however, it is possible to establish in advance a standard cost ratio (which is the ratio of equalized annual cost during the service life to the construction cost) for each facility pattern such as generation, transmission, substation, distribution, etc., and apply it to make the economic comparison easier.

It must be noted that the above standard cost ratio is a standard that cannot be used for specific purposes. For investments having such specific purposes as reduction in personnel cost, etc., the cost ratio must be established for each cost element. Needless to say, the cost ratio should be calculated on the basis of the past records and of the reasonable forecast in future.

Given below for reference are the facility patterns and cost elements peculiar to Indonesia upon which the cost ratio calculation is to be based.

a. Facility pattern:
- Hydro power
- Steam power
- Diesel power
- Gas turbine power
- Transmission
- Substation
- Distribution

b. Cost elements:
- Capital cost (depreciation, interest)
- Personnel expenses
- Repairing expenses
- Administrative expenses
- Miscellaneous expenses

5. PRESENT WORTH FACTOR AND CAPITAL RECOVERY FACTOR

(1) Present worth factor

It is clearly known that the benefit of capital investment is the interest accruing from it, and that the interest is the function of term.

An amount of Rp 100, if invested today, increases in value in a year's time though its superficial value remains unchanged. For instance, Rp 100 invested today at an interest rate of 5% per annum will have a value of Rp 105 because Rp 100 $(1 + i)^1$ = Rp 100 (1 + 0.05).

As will be clear from the above explanation, simple summing up of benefits and costs arising at different times in future does not produce the absolute total value. To obtain the absolute total value, cost and benefit arising in series of time should be multiplied by the factor for respective times to convert them into values at a given standard time. The factor with which to normalize cost and benefit to those at present is called the present worth factor which can be expressed by the following equation.

Present worth factor $= (1 + i)^{-n}$

Where,

i = Interest rate per annum

n = Number of years

(2) Capital recovery factor

The capital recovery factor, expressed by the following equation, is employed to obtain the amount of principal and interest recoverable equally each year over the service life of facilities in which investment is made.

$$\text{Capital recovery factor} = \frac{i(1 + i)^n}{(1 + i)^n - 1}$$

Where,

i = Interest rate per annum

n = Number of years

(3) How to obtain equalized annual cost

The above-mentioned two factors can be applied not only to determine the amount of principal and interest recoverable equally over a specified number of years, but also to equalize the cost varying by years (operating cost such as repairing expenses and personnel expenses varies each year).

In order to obtain the equalized annual cost, the varying yearly cost is to be multiplied by the present worth factor to determine its total worth at present. The total worth thus obtained multiplied by the capital recovery factor is the equalized annual cost.

The equalized annual cost can be used to determine economic preference between different facilities having different service lives, such as hydro power plant and thermal power plant.

It is to be added that the following three factors, which are based on the foregoing two factors, must be employed on certain occasions.

$$\text{Uniform annual series compound amount factor} = \frac{(1 + i)^n - 1}{i}$$

Uniform annual series present worth factor $= \dfrac{(1+i)^n - 1}{i(1+i)^n}$

Sinking fund deposit factor $= \dfrac{i}{(1+i)^n - 1}$

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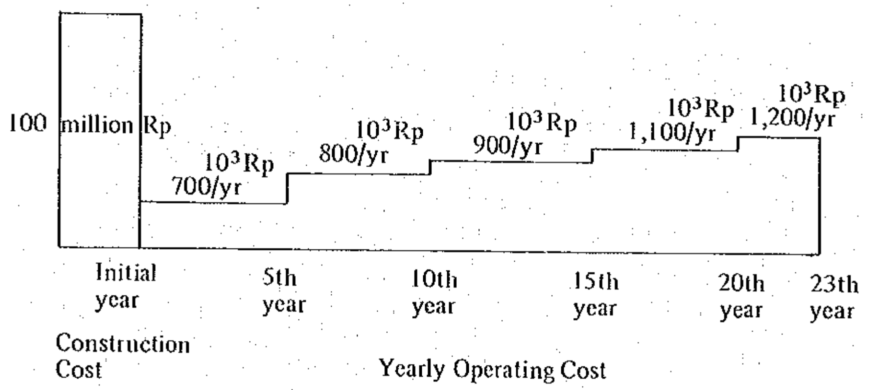
EXAMPLE OF ECONOMIC EVALUATION I

CALCULATION OF EQUALIZED ANNUAL COST DURING SERVICE LIFE

Assumption

The following cash flow is assumed for a substation. Interest rate 5% per annum, service life 25 years, rate of residual value 10%.



Method of Calculation

Calculation of equalized annual cost during service life is made separately for capital cost (interest and depreciation) and operating cost (varying yearly cost).

(1) Capital Cost (Interest and Depreciation)

When the rate of residual value is set at 10%, 90 million Rp in the total construction cost of 100 million Rp is covered by depreciation and the rest of 10 million Rp by selling the facilities when the service life has elapsed. Since a constant interest rate is applied to the remaining 10 million Rp throughout the service life, the capital recovery factor, by which to obtain the equalized annual cost, is modified as follows.

$$(1 - L)\frac{i(1 + i)^n}{(1 + i)^n - 1} + Li$$

Where, L : Rate of residual value
i : Interest rate per annum
n : Years of service life

By the application of the above formula, the equalized annual cost can be calculated as follows.

$$(100 \text{ million Rp} - 10 \text{ million Rp}) \times \frac{0.05(1 + 0.05)^{23}}{(1 + 0.05)^{23} - 1} + 10 \text{ million Rp} \times 0.05$$

= 90 million Rp x 0.07414 + 10 million Rp x 0.05 = 7,170 thousand Rp

(2) Operating Cost (Varying Yearly Cost)

Varying yearly cost is to be multiplied by the present worth factor to obtain its total present worth. Then, the equalized annual cost can be obtained by multiplying the total present worth by the capital recovery factor.

(a) Present worth of varying yearly expenses

11,348 thousand Rp (See the attached table for present worth for respective years)

(b) Calculation of equalized annual cost

$$11{,}348 \text{ thousand Rp} \times \frac{0.05(1 + 0.05)^{23}}{(1 + 0.05)^{23} - 1} = 11{,}348 \text{ thousand Rp} \times$$

0.07414 = 841 thousand Rp

(3) Equalized Annual Cost

Capital cost + operating cost

7,170 thousand Rp + 841 thousand Rp = 8,011 thousand Rp

Note: The ratio of the above equalized annual cost to the construction cost is called the cost which can be calculated as follows.

8,011 thousand Rp ÷ 100 million Rp = 0.08011 ≑ 8.01%

Attachment

Present Worth of Varying Yearly Cost

Year	Cash Flow (Thousand Rp)	Present Worth Factor $\frac{1}{(1+0.05)^n}$	Present Worth
1	700	0.9524	667
2	"	0.9070	634
3	"	0.8638	605
4	"	0.8227	576
5	"	0.7835	548
6	800	0.7462	597
7	"	0.7107	569
8	"	0.6768	541
9	"	0.6446	516
10	"	0.6139	491
11	900	0.5847	426
12	"	0.5568	501
13	"	0.5303	477
14	"	0.5051	455
15	"	0.4810	433
16	1,000	0.4581	458
17	"	0.4363	436
18	"	0.4155	416
19	"	0.3957	396
20	"	0.3769	377
21	1,100	0.3589	395
22	"	0.3418	376
23	"	0.3256	358
Total	16,800		11,348

EXAMPLE OF ECONOMIC EVALUATION II

ECONOMIC PREFERENCE BETWEEN HYDRO POWER AND THERMAL POWER

Assumption

Construction of a new power plant is demanded to meet the load increase. Which of the following two plans is economically more preferable?

Plan A: Construction of a hydro power plant ⎫ Transmission cost to load centre
Plan B: Construction of a thermal power plant ⎭ is assumed to be equivalent.

Basic data of each plan is assumed to be as given below.

Hydro Power Plant

Construction cost per KW	:	250 thousand Rp
Utilization factor $\frac{KWH}{8760^{h} \times KW}$	:	50%
Power ratio for station use	:	KW – 0.3%, KWH – 0.3%

Cost ratio : 7.13% (i = 5%, n = 40 years, rate of residual value = 10 %)

Breakdown –

1. Capital cost (interest, depreciation) 5.75%
2. Repairing expenses 0.86%
3. Miscellaneous expenses 0.20%
4. General administrative expenses 0.13%
5. Personnel expenses 0.19%

Thermal Power Plant

Construction cost per KW	:	100 thousand Rp
Thermal efficiency	:	30%
Power ratio for station use	:	KW – 6%, KWH – 6%
Unit cost of fuel oil	:	5,000 Rp/kl (9,900 Kcal/kl)
KW correction factor	:	1.1

Cost ratio : 12.34% (i = 5%, n = 15 years, rate of residual value = 10%)

Breakdown –

1. Capital cost (interest, depreciation) 9.17%
2. Repairing expenses........................ 2.00%
3. Miscellaneous expenses 0.48%
4. General administrative expenses 0.13%
5. Personnel expenses 0.56%

Note: Taxes are not considered in the cost ratio. Correction must therefore be made to meet the actual conditions.

Method of Evaluation

(1) The economic preference between the two plants assumed above should be determined by means of the equalized annual cost calculated from the cost ratio on the premise that the plant would be reconstructed upon expiration of its service life.

(2) When compared with the hydro power plant, the thermal power plant is disadvantageous in that –

(a) It requires a certain period of shut-down each year for maintenance and repair.

(b) It is subject to a higher rate of forced outs.

Hence, the KW correction factor must be applied to 1 KW of hydro power output to make the thermal power output slightly larger than 1 KW. In the present evaluation, an output of 1.1 KW is assumed against 1 KW of hydro power output.

(3) The equalized annual cost at the end of sent out is to be calculated as follows.

(a) Equalized annual cost of hydro power plant

$$\text{Construction cost per KW} \times \frac{1}{1 - \text{Power ratio for station use}} \times \text{Cost ratio}$$

(b) Equalized annual cost of thermal power plant

Construction cost per KW x KW correction factor

$$\times \frac{1}{1 - \text{Power ratio for station use}} \times \text{Cost ratio}$$

+ Annual energy output by hydro power plant

x Fuel cost per KWH

Note 1 – Since cost ratio does not involve the fuel cost, separate calculation should be made.

Note 2 – Fuel cost per KWH can be obtained by the following equation. Fuel cost at generating end (Rp/KWH) = Rp/kl ÷ Kcal/kl
x 0.86 Kcal/KWH ÷ thermal efficiency

$$\times \frac{1}{1 - \text{Power ratio for station use}}$$

Calculation

Economic preference between hydro power and thermal power is determined as follows by comparing their equalized annual costs.

(1) Equalized annual cost of hydro power at sent out 250 thousand Rp (Construction cost per KW) x 1/(1 – 0.003*) x 7.13% (Cost ratio) = 17,772 Rp ÷ 18 thousand Rp
Where, * = Power ratio for station use

(2) Equalized annual cost of thermal power at sent out

(a) Fixed cost

100 thousand Rp (Construction cost per KW) x 1.1 (KW correction factor) x 1/1 - 0.06* x 12.34% (Cost ratio) = 14,440 Rp
Where, * = Power ratio for station use

(b) Variable cost

i) Fuel cost per KWH

5,000 Rp/kl ÷ 9,900 Kcal/kl x 0.86 Kcal/KWH

$$\div\ 0.3\ \text{(Thermal efficiency)} \times \frac{1}{1 - 0.06*} = 1.54\ \text{Rp/KWH}$$

Where, * = Power ratio for station use

ii) Annaul energy output

$$8760h/KW/year \times 50\% \text{ (Utilization factor)} \times \frac{1}{1 - 0.003^*}$$

$= 4.393$ KWH/KW/year

Where, * = Power ratio for station use

iii) Variable cost

1.54 Rp/KWH x 4,393 KWH/KW/year = 6,765 Rp

(c) Fixed cost + variable cost

14,440 Rp + 6,765 Rp = 21,205 Rp ≑ 21 thousand Rp

(3) Conclusion

Economic preference is given to the hydro power plant whose equalized annual cost is smaller than that of the thermal power plant.

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EXAMPLE OF ECONOMIC EVALUATION III

ECONOMIC PREFERENCE BETWEEN LARGE CAPACITY SUBSTATION AND SMALL CAPACITY SUBSTATION

Assumption

Construction of a new substation is demanded to cope with the load increase. Which of the following two plans is economically more preferable:

Plan A: Construction of a small capacity substation satisfying the immediate demand, and its expansion in future with the load increase.

Plan B: Construction of a large capacity substation to meet the anticipated load increase in future.

It is assumed that the load estimation has revealed that the following investment is necessary for the two plans.

	Initial Year	Sixth Year	Total Investment
(Plan A)	80 million Rp	76 million Rp	155 million Rp
(Plan B)	140 million Rp	/	140 million Rp

Cost ratio: 9.64% (i = 5%, n = 23 years, rate of residual value = 10%)

Breakdown –

1. Capital cost (interest, depreciation) 7.17%
2. Repairing expenses 0.78%
3. Miscellaneous expenses 0.42%
4. General administrative expenses 0.13%
5. Personnel expenses 1.14%

Note: Taxes are not considered in the cost ratio. Correction should therefore be made to meet the actual conditions.

Method of Evaluation

(1) Since both plans are intended to satisfy the same size of load, there exists no difference in the revenue which serves as a criterion in the economic evaluation. Accordingly, the minimum cost method should be employed in which the cost of either plan is to be calculated for comparison.

(2) To determine the cost of each plan, the equalized annual cost should be calculated from the cost ratio on the premise that the substation would be reconstructed upon expiration of its service life, and the equalized annual cost thus obtained should be multiplied by the present worth factor to normalize it to the present worth. The sum total of the present worth is the cost to be compared.

(3) In the determination of economic preference between hydro power plant and thermal power plant (Example of Economic Evaluation II), cost could be represented by the equalized annual cost since it is held at a same value over a long period of time and no expansion works were involved. In the present evaluation, however, we must consider the expansion work and cannot but make the comparison of cost required for a prolonged period.

(4) The required long-term cost can be calculated by either of the following two methods.

(a) Normalization of the permanent equalized annual cost to the present worth on the assumption that the substation will be reconstructed repeatedly.

(b) Normalization of the equalized annual cost within a period set specifically for the purpose of calculation.

Due to the fluctuation in the preconditions for investment and other factors, it is not considered practicable to employ the permanent equalized annual cost in the present evaluation. Accordingly, evaluation must be made by setting a calculation period.

(4) The calculation period should first of all embody the period within which the investment to be evaluated is made. Speaking in general terms, it should cover the period within which the expansion works are carried out as well as the time required including the actual cost incurred becomes almost stabilized.

Since the investment period is based on the load estimation for 10 years, the calculation period can ordinarily be set by adding the time required for cost stabilization to this 10 years. Hence a period of 10 to 20 years can be set as the calculation period.

In the present evaluation, a period of 15 years is assumed.

* Given below is the equation which can be applied for reducing the permanent equalized annual cost to the present worth.

Equalized annual cost ÷ interest rate = Total present worth of equalized annual cost

Calculation

(i) Yearly cost (Calculation period – 15 years)

Unit: 1,000 Rp

Year	Plan A		Plan B	
	Investment in the initial year	Investment in the sixth year	Investment in the initial year	Investment in the sixth year
1	7,712	–	13,495	–
2	”	–	”	–
3	”	–	”	–
4	”	–	”	–
5	”	–	”	–
6	”	7,230	”	–
7	”	”	”	–
8	”	”	”	–
9	”	”	”	–
10	”	”	”	–
11	”	”	”	–
12	”	”	”	–
13	”	”	”	–
14	”	”	”	–
15	”	”	”	–

(ii) Total present worth of yearly cost

Plan A: 123,878 thousand Rp
Plan B: 140,084 thousand Rp
(See the attached table for detailed calculation)

(iii) Conclusion

Economic preference is given to Plan A whose total worth of yearly cost is smaller than that of Plan B.

Attachment

Calculation of Present Worth of Yearly Cost

Unit: 1,000 Rp

Year	Plan A							Plan B		
	Investment in the Initial Year			Investment in the Sixth Year						
	Cost	PWF	Present worth	Cost	PWF	Present worth	Total P.W.	Cost	PWF	Present worth
1	7,712	0.9524	7,345	–	–	–	7.345	13,496	0.9524	12,854
2	"	0.9070	6,995	–	–	–	6,995	"	0.9070	12,241
3	"	0.8638	6,662	–	–	–	6,662	"	0.8638	11,658
4	"	0.8227	6,345	–	–	–	6,345	"	0.8227	11,103
5	"	0.7835	6,042	–	–	–	6,042	"	0.7835	10,574
6	"	0.7462	5,755	7,230	0.7462	5,395	11,150	"	0.7462	10,071
7	"	0.7107	5,481	"	0.7107	5,138	10,619	"	0.7107	9,592
8	"	0.6768	5,219	"	0.6768	4,893	10,112	"	0.6768	9,134
9	"	0.6446	4,971	"	0.6446	4,660	9,631	"	0.6446	8,700
10	"	0.6139	4,734	"	0.6139	4,438	9,172	"	0.6139	8,285
11	"	0.5847	4,509	"	0.5847	4,227	8,736	"	0.5847	7,891
12	"	0.5568	4,294	"	0.5568	4,026	8,320	"	0.5568	7,515
13	"	0.5303	4,090	"	0.5303	3,834	7,924	"	0.5503	7,157
14	"	0.5051	3,895	"	0.5051	3,652	7,547	"	0.5051	6,817
15	"	0.4810	3,709	"	0.4810	3,478	7,187	"	0.4810	6,492
Total	115,680	–	80,046	72,300	–	43,741	123,787	202,440	–	140,084

Note: When the yearly cost maintains a smae value as in the above example, the total present worth can be calculated by the following equation.

Total cost for n years reduced to the present worth

$$= \frac{(1 + i)^n - 1}{i\,(1 + i)^n} \times \text{Yearly cost}$$

The multiplicand in the above equation is called the uniform annaul series present worth factor.

If an expansion work is to be considered, the total present worth can be calculated by the application of the following equation.

Total cost for n years reduced to present worth

$$= \text{Yearly cost} \times \frac{(1+i)^n - 1}{i(1+i)^n} \times \frac{1}{(1+i)^m}$$

Where, m = Years of interval between the initial investment and the investment for expansion work.

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EXAMPLE OF UNITS TO BE USED FOR ESTIMATION OF CONSTRUCTION COST

Hydro-Power Plant;

Coment, Gate and Penstock etc.	Rp/t
Machinery	Rp/t, Rp/Kw
Excavation	Rp/M³
Building	Rp/M³

Thermal Power Plant;

Machinery	Rp/Kw
Civil works and Building	Same as for hydro-power project.

Transmission Line;

For each voltage and each size of conductors	Rp/Kw

Substation;

For each voltage and each unit capacity of transformers	Rp/KAVA
New installation and addition	Rp/KVA
Average construction cost	Rp/KVA, Rp/substation

Distribution;

Distribution transformer	Rp/KVA, Rp/transformer
High tension line	Rp/Km, Rp/feeder
Low voltage line	same as above
New connection	Rp/consumer