# REPORT
# ON
# HYDROPOWER SURVEY PROJECT
# IN
# REPUBLIC OF INDONESIA

## VOLUME I
## GENERAL DESCRIPTION



OVERSEAS TECHNICAL COOPERATION AGENCY
JAPAN

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# PREFACE

It is quite clear that the success of the present Five-Year Development Plan of Indonesia mainly depends upon the acquisition of hydro-power resources.

The Government of Japan, in response to the request of the Republic of Indonesia, decided to conduct a comprehensive study on the hydro-power resources survey project of Indonesia and entrusted this task to the Overseas Technical Cooperation Agency (OTCA).

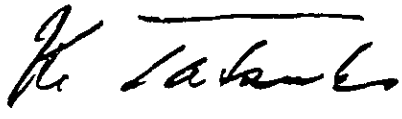
OTCA organized a study team of 4 experts headed by Mr. Ichiro Miyachi, Deputy Manager of Construction Department of Tokyo Electric Power Co., Inc. and dispatched them to Indonesia in May, 1970.

They stayed there for six months and successfully completed the field study including discussions with the authorities concerned and collection of data under the whole-hearted cooperation of the Government of the Republic of Indonesia.

After their return to Japan, they made further studies on data and information and the results were hereby compiled into the report of 3 volumes for presentation.

It is my sincere hope that this report will be fully utilized for the development of the exploitation of hydro-power resources in Indonesia.

March, 1971



Keiichi Tatsuke
Director-General
Overseas Technical Cooperation Agency
Tokyo, Japan

**Letter of Transmittal**

March, 1971

Mr. Keiichi Tatsuke
Director-General
Overseas Technical Cooperation Agency
Tokyo

Dear Sir,

Our team was dispatched by your Agency for the hydro-power resources survey project in Indonesia, complying with the request of the Government of the Republic of Indonesia, and we fulfilled our duties of six months covering from May 22nd to November 21st, 1970.

It is my great pleasure to submit you the report on the activity of our team herewith.

In Indonesia, we investigated, at first, the present situation of the hydro-power survey and development project and then studied the method of survey, the problems to be solved and the future plan of survey with the counterparts of Indonesia, and we described the results of our studies in this report.

All the members of the team sincerely wish that this report would contribute not only to the future survey of the hydro-power resources in Indonesia, but also to the promotion of the friendship between Indonesia and Japan.

In submitting this report, I wish to express my deepest respects to the Indonesian staff concerned who positively rendered their cooperation to the activity of our team, as well as my sincere gratitude to the Japanese persons concerned who gave a great deal of support to us.

I. Miyachi

Ichiro Miyachi
The Head,
Expert Team for Hydro-Power Resources
Survey Project in Indonesia

## Foreword

This report is composed of Volume I 'General Description', Volume II 'Detailed Description' and Volume III 'Appendices'.

(1) Volume I forms the main part of this report, describing the introductory note, outline of electric power industry in Indonesia and general tendency of the hydro-power development, along with the summary of Volume II which deals with the present situation, the problems to be solved and the future plan of the hydro-power survey in Indonesia.

Furthermore, the matters, which will be required for the future hydro-power survey, are also listed in this report as the recommendations.

(2) Volume II is a compilation of papers over which we have discussed with Indonesian counterparts on the general methods of surveying and planning related to the hydro-power development, the present situation, the problems to be solved and also the future plan of the hydro-power survey.

This Volume was prepared to be used also as a mannual of surveying and planning of hydro-power for Indonesian technical personnel.

(3) Volume III contains the reference data supplementing Volume II.

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## Volume II Detailed Description

**Volume III Appendices**

# 1. Introduction

# 1. Introduction

## 1-1 Background of the formation of the expert team for the hydro-power resources survey in Indonesia

The present Government of Indonesia, which has ruled since 1965, has been striving to stabilize its economic condition. The Five Year Development Plan was commenced in 1969 for the purpose of economic rehabilitation and development.

Before enforcement of the said Five Year Plan, the Government of Indonesia launched a series of basic studies for its economic rehabilitation by industrial sectors. Along with this movement, the Government of Indonesia requested the Government of Japan to make a study of the electric power industry in Indonesia. Complying with the said request, the Government of Japan sent a preliminary study team to Indonesia in July 1968, and further, based on the report of the team, it dispatched, in December 1968, a study team of fourteen experts headed by Mr. Juzaburo Terada, Consultant of the Tokyo Electric Power Co., Inc., joined by Mr. Taian Ishii, former chief of the Public Utilities Research Section, Public Utilities Bureau, Ministry of International Trade and Industry, as the advisor, and the team made a basic study on electric power rehabilitation in Indonesia. (This team will be referred to as the Terada Mission hereafter.)

At present, in the electric power industry in Indonesia, steps are being taken for the construction of power plants, expansion and consolidation of transmission and distribution lines and improvement of the efficiency of the organization and management required in the electric power industry, based on the recommendations of the Terada Mission.

Under these circumstances, on November 10th 1969, the Government of Indonesia requested the Government of Japan to send an expert team for the energy resources survey project in Indonesia as a part of the technical cooperation scheme under the Colombo Plan.

The Government of Japan, complying with the said request, entrusted dispatching the expert team to the Overseas Technical Cooperation Agency (hereafter referred to as OTCA). OTCA, after having consulted on this matter with the authorities concerned, understood that the said request conformed to one of the recommendations in the report of the Terada Mission, which mentioned that the electric power industry of Indonesia should obtain technical assistance from a developed country in order to draw up a hydro-power research program. At the same time, it took into consideration the necessity of a series of detailed surveys over a long period of time for the development of the hydro-power resources. OTCA then decided to send a team of hydro-power experts to Indonesia and the Government of Indonesia agreed.

OTCA asked the Tokyo Electric Power Co., Inc. to render its cooperation, and formed a team of the following four experts.

Ichiro Miyachi (Construction Department, the Tokyo Electric Power Co., Inc.)
Susumu Ikeda ( do. )
Tetsuo Kato ( do. )
Norio Yamaguchi ( do. )

## 1-2 Purposes and duties of expert team

According to A-1 Form submitted by the Government of Indonesia, "Survey of energy recources project" is a part of the Indonesian Five-Year Development Plan, and its purposes are as follows.

(1) Survey and exploration of energy resources for electric power generation.

(2) Evaluation and inventory of data of energy resources.

And, the duties of the expert team requested in the said A-1 Form are as follows.

(1) To assist Indonesian technical personnel in;

(a) planning, programming and scheduling of survey of energy resources in Indonesia.

(b) execution of field survey of energy resources in Indonesia.

(c) report preparation.

(2) To prepare an outline of work involved in a comprehensive energy survey for Indonesia.

(3) To prepare an estimation of costs of (1) and (2) above.

The expert team carefully studied the above-mentioned purposes and duties requested by the Government of Indonesia, and after the consultation with the Indonesian authorities prepared the Terms of Reference in which its duties are described as follows.

(1) To assist Indonesian technical personnel in collecting, evaluating and investigating the comprehensive data of hydro-energy resources which are available.

These data include the following items;

(a) Topographical data

(b) Geological data

(c) Climate data

(d) Precipitation data

(e) Run-off, discharge of rivers and flow duration

(f) The location of weather bureaus, their facilities, organization for observation, and the numbers of personnel.

(g) The location of run-off gauging stations, their facilities, organization for gauging, and the numbers of personnel.

(h) The reports on hydro-power resources which have been prepared by others.

(2) To give advices to Indonesian technical personnel in;

(a) How to organize the observation and gauging

(b) How to estimate the hydro-energy resources

(c) How to estimate the economy of the hydro-energy development.

(3) To make a guidance to the Indonesian technical personnel about the planning, programming and scheduling of the hydro-energy development with regard to the example site, in order to prepare them for the execution of future similar studies of their own.

### 1-3 Activities of expert team

The expert team arrived at Djakarta on May 22nd 1970, and started its activities for the assigned duties which extended over the period of six months, being in close contact with the Embassy of Japan and OTCA overseas office in Indonesia.

The Indonesian electric power authorities appointed the following five engineers to the post of counterpart who were assigned to cooperate directly with the Japanese expert team. All of them are from the Directorate General of Power and Electricity, Department of Public Works and Electric Power.

| | |
|---|---|
| Sufrani | Chief of the counterparts,<br>Director for Planning & Investigation. |
| Soewarno | Deputy Manager, Power Research Institute. |
| Soepartomo | Chief of Unit Survey, Power Research Institute. |
| Hutasoit | Chief of Survey Project, Power Research Institute. |
| Muslim | Engineer, Directorate of Planning & Investigation. |

Among the above-mentioned counterparts, Mr. Soewarno retired from the Indonesian team of counterparts in the middle of his assigned works, and later, two persons, Mr. Sumardi and Mr. Soewartojo, both working in the Power Research Institute, were assigned for the full-time assistants.

The expert team was actively engaged in the following work fields in an effort to fulfill its before-mentioned duties.

(1) Collection and arrangement of basic data.

The expert team collected and arranged the data related to the hydro-power survey, as much as possible, such as topographical data, geological data, precipitation data, run-off data, etc.

For this purpose, the team asked the cooperation to the Power Research Institute, the Institute of Meteorology and Geophysics, the Institute of Hydraulic Engineering and others.

(2) Grasp of the present situation of hydro-power resources in Indonesia by hearing

The team was explained about the present situation in Indonesia by the following authorities related to the hydro-power survey.

(i) Directorate of Planning & Investigation, Directorate General of Power & Electricity (D.G.P.E.), Department of Public Works & Electric Power (D.P.W.E.P.)

(ii) Directorate of Development and Construction, D.G.P.E., D.P.W.E.P.

(iii) Power Research Institute, D.G.P.E., D.P.W.E.P.

(iv) Directorate of Planning, Directorate General of Water Resources Development (D.G.W.R.D.), D.P.W.E.P.

(v) The Institute of Hydraulic Engineering, D.G.W.R.D., D.P.W.E.P.

(vi) Directorate of Irrigation, D.G.W.R.D., D.P.W.E.P.

(vii) The Institute of Meteorology & Geophysics, Directorate General of Air Communication, Department of Communication.

(viii) Directorate of Construction, PLN (The National Enterprise of Electric Power in Indonesia)

(ix) Directorate of Operation & Supply, PLN.

(x) Exploitasi (branch office) I, PLN (Medan)

(xi) " VIII, " (Denpasar)

(xii) " X, " (Semarang)

(xiii) " XI, " (Bandung)

(xiv) " XII, " (Djakarta)

(xv) Survey Office of Asahan Hydro-power Project

(xvi) Construction Office of Garung Hydro-power Project

(xvii) Construction Office of Karangkates & Seloredjo Hydro-power Project

(xviii) Others

(3) Field survey of the hydro-power site

The team carried out a field survey at several hydro-power sites including those already constructed and those under construction or under survey, and tried to grasp the present situation of each site. The main sites at which the team made a field survey are as follows.

(i) Djatiluhur Hydro-power Station (West Djawa, Tji Tarum River)

(ii) Ubrug Hydro-power Station (West Djawa, Tji Tjatih River)

(iii) Plengan, Lamadjan, Tjikalong Hydro-power Stations and Tjipanundjang, Tjileuntja Reservoirs (West Djawa, Tji Sangkuj River)

(iv) Djelok, Timo Hydro-power Stations (Central Djawa, Tuntang River)

(v) Mendalan, Siman Hydro-power Stations (East Djawa, Konto River)

(vi) Garung Hydro-power Construction Project (Central Djawa, Seraju River)

(vii) Karangkates Hydro-power Construction Project (East Djawa, Brantas River)

(viii) Seloredjo Hydro-power Construction Project (East Djawa, Konto River)

(ix) Peusangan Hydro-power Survey Site (North Sumatera, Atjeh, Peusangan River)

(x) Asahan Hydro-power Survey Site (North Sumatera, Lake Toba, Asahan River)

(xi) Middle Part of the Tji Tarum River Survey Site (West Djawa, Tjitarum River)

(xii) Wonogiri Dam Site (Central Djawa, Solo River; under planning)

(xiii) Badegan Dam Site (East Djawa, Tributary of Solo River; under planning)

(xiv) Djipang Dam Site (Central Djawa, Solo River; under planning)

(xv) Wlingi Dam Site (East Djawa, Brantas River; under planning)

(xvi) Lake Batur, Lake Bratan, Ajung River (Bali Island)

(xv) Others

(4) Preparation of manual

The team prepared a manual describing fundamental matters to be taken into consideration in the hydro-power survey, present situation and future problems of hydro-power in Indonesia, and presented it to the regular meeting with the Indonesian counterparts. At the meeting, the team gave explanations of it to the counterparts and held the questions and answers discussion.

This manual shows the matters of technical guidance which the team gave to the Indonesian technical personnel, and it is contained in the volume II of this report. This manual was prepared with due regard to furnish the Indonesian technical personnel with information which would be useful at the time of hydro-power survey in the future.

(5) Survey of example site

In addition to the before-mentioned technical guidance of hydro-power survey in general, the team gave a practical instruction on the method of studying run-off data, of selecting the sites of a dam and power plant, of determining the capacity of a reservoir and the output of a power plant, etc., with respect to an example site of hydro-power survey in the middle part of Tji Tarum River, West Djawa, and carried out a field survey on the site.

(6) Planning of hydro-power resources survey

Taking the present situation of Indonesia into consideration, the expert team recommended the Indonesian authorities to provide the basic data for hydro-power survey, to expand and improve its observation system, to make a survey on hydro-power potential in Indonesia, etc. as the matters which have to be carried out in the future. Moreover, the team estimated the amount of hydro-power survey works which is necessary to meet the increasing demand of electric power in future, and estimated the expenses which are required for the surveys. And further, the team outlined the way of managing the organization of electric power industry in order to carry out hydro-power survey in Indonesia.

The above-mentioned are the outlined activities of the Japanese expert team in Indonesia. The team left Indonesia on November 21st 1970, after completion of its services of six months.

After having returned to Japan, the team finished the preparation of this report, keeping a close contact with OTCA and other related authorities, and submitted it to OTCA.

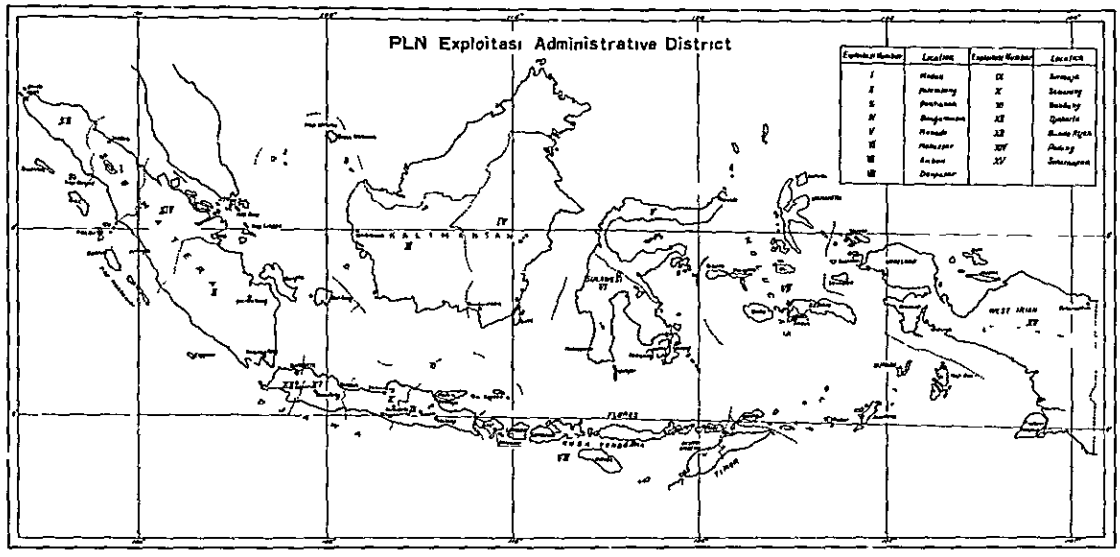
# 2. General remarks

## 2. General Remarks

### 2-1 Outline of electric power industry in Indonesia

Indonesia is an archipelago comprising some 3,000 islands of various sizes, straddling the equator. Sumatera, Djawa, Kalimantan, Sulawesi and West Irian are the main islands among them. It is said that the territory covers a total area of more than 1,900 thousand square kilometers and the population reaches to about 120 million.

In Indonesia, the electric power industry is almost exclusively governed by the National Enterprise of Electric Power in Indonesia (hereafter referred to as PLN). PLN divided the territory into fifteen districts and, in the main city of each district, set up its branch office (Exploitasi) undertaking the generation, transmission and distribution of electric power in the respective assigned service area.




PLN owned the generating facilities with the total installed capacity of about 540 MW, as of 1970, of which 37 % was diesel power, 34 % hydro-power, 21 % thermal power, and the remaining 8 % gas turbine. Apart from the facilities owned by PLN, there is Djatiluhur Power Station (125 MW) of Djatiluhur Authority, located in West Djawa, which is interconnected to the transmission system of PLN.

Among 224 power stations owned by PLN, more than 85 % are the diesel power stations. This prevalence of diesel power stations is due to the fact that, outside Djawa, there

is not the so-called transmission system interconnecting several regions and the electric power is supplied to each limited region by the diesel power plant with the capacity required to meet the demand there.

Although Djawa has the area of about 130 thousand square kilometers or only 7 % of the total area of Indonesia, it is the most developed island among others. Its inhabitants amount more than 70 million or some 65 % of the total population of Indonesia, forming one of the most densely populated area in the world.

From the viewpoint of electric power, the generating facilities in Djawa account almost 80 % of the total installed capacity in Indonesia. In Djawa, the interconnection of power stations has been set forward to some extent and there are five electric power systems in all; one in the western district, two in the central district, and two in the eastern district.

In 1969, the electric power consumption in Indonesia amounted to about 1,450 million KWH of which some 80 % (1,180 million KWH) was consumed in Djawa. The demand was made up of 56 % for domestic use, 9 % for commercial use, 16 % for public use, and 19 % for industrial use. The major part is for the lighting use. Therefore, the load curve showed a peak in the evening when lights were turned on. A reason why the demand of lighting is predominant in the system of PLN is the fact that many enterprises have their own power plants independently, at present. The total capacity of the privately owned power plants is estimated to be some 200 MW, though the definite amount is not yet confirmed.

In Indonesia, the Five-Year Development Plan has been pushed forward since 1969 and, for the electric power sector, following four items are the main objects of the plan.

(i) the rehabilitation and expansion of transmission and distribution networks

(ii) the rehabilitation and construction of power plants

(iii) the preparation and construction of micro-hydro and diesel power plants.

(iv) the introduction of institutional improvements and the application of great efficiency.

The object (i) is to improve the present situation that the electric power loss is remarkable due to overloading resulted from insufficiency of the transmission and distribution facilities and the loss amounts to about 400 million KWH or 22% of the total generated energy, as of 1969, inclusive of the loss due to other factors. This object aims furthermore to spread the service area of the electric power.

The object (ii) is to improve the present situation that the generating facilities amounting up to about 60 MW, or 11 % of the total installed capacity owned by PLN, cannot be operated in the present condition. This object aims furthermore to develop the electric power resources newly.

The object (iii) is to prepare a new power stations in order to supply newly the electric power to the local regions where the electric power is not yet supplied up to now. Because, there are many such regions, as the territory of Indonesia is quite vast.

The object (iv) is to reorganize the institution of the electric power sector so as to make PLN fulfill surely the responsibility of power supply and improve the efficiency of management.

In Indonesia, gearing to the recent stabilization of the political situation, the people's livelihood has been improved and the activity of the industries in various fields has become brisk. Under these circumstances, the remarkable increase of the electric power demand is naturally expected. Therefore, the smooth progress of the said Five-Year Plan is hoped for in every field.

## 2-2 Hydro-power development in Indonesia

### 2-2-1 General circumstances

(1) Topography

Indonesia consists of the Sunda Islands which comprise Sumatera, Djawa, Nusa Tenggara, and Halmahera forming a semi-circle, Kalimantan and Sulawesi located inside the said semi-circle, and West Irian located in the east, outside that.

Taking a general view of the topography of Indonesia, Sumatera has a range of mountains with the height of 2,000 m to 3,000 m alongside with the coast of Indian Ocean and the vast plain and marshy field spread towards the north-eastern coast. Most of major rivers in Sumatera flow through this plain and field. The Batang Hari and the Musi are the major rivers among others, and they have the length of several hundreds kilometers.

In Djawa, many volcanos with the height of some 3,000 m stand at places, away from each other, and their skirts spread towards northern and southern plains. There are many tablelands and basins between mountains. The major rivers, such as the Tji Tarum, the Solo and the Brantas, pour themselves into the Djawa Sea.

In Kalimantan, there is a mountain range with the height of some 1,000 m to 2,000 m at the northern part, along the border to Malaysia. There are other smaller mountain ranges, one in the south-east part and another from the central part to the south-west part. The major rivers are the Mahakan, the Barito and the Kapuas, flowing eastwards, southwards and westwards respectively. The plain and the marshy field spread over vast area.

Sulawesi is a K-shaped island and the mountains with the height of some 2,000 m to 3,000 m stand at places. The plain part is relatively limited and consequently, the very long river does not exist.

In West Irian, there is a great mountain range with the height of 4,000 m to 5,000 m at the central part and there is also a smaller mountain range in the northern district. The vast plain spread over southern district. The major rivers are the Mamberamo, flowing northwards, the Digul and the Baliem, both flowing southwards.

In Indonesia, there are more than five hundred of water systems with various scales and it is their characteristics that there is a remarkable difference between the run-off in rainy season and that in dry season.

(2) Climate

The climate in Indonesia is generally that of tropics with high temperature, high humidity and much rain. The annual precipitation amounts to more than 2,000 mm in the plains, in general, and it is over 3,000 mm in the mountainous area. In some places, it reaches to more than 4,000 mm.

As Indonesia lies between the Asiatic Continent and the Australian Continent, it is subject to the influence of the monsoons and most districts in Indonesia have two distinctive seasons, namely, the wet season and the dry season. The duration periods of both seasons vary with districts.

In Djawa, generally speaking, the dry season is from May to October and the wet season is from November to April. In the wet season, the rain falls concentratedly at almost the same fixed time everyday, as the so-called squall.

(3) Tendency of hydro-power development

Indonesia has plenty of hydro-power resources, being endowed with much rainfall and the mountainous area of high altitude, and these resources have been or are being developed with the increase of electric power demand.

On the other hand, the increased production and self-sufficiency of food, especially of rice, is the problem of the first priority in Indonesia at present, and the Five Year Development Plan with the main purpose to solve the said problem has been actively put forward. Accordingly, the river basin development with the purpose of irrigation and flood control have been strongly expected and, in order to make fully use of water-resources, some multipurpose development projects, which aim also at power generation as well as the above-mentioned purposes, have been proceeded.

Along with these tendencies, the hydro-power development projects of large scale are now under planning for the purpose of refining the mineral products, making use of the plenty and inexpensive hydro-energy. Furthermore, there are several projects of micro-hydro power plants to supply locally the electric power for the purpose of improvement of people's livelihood.

As above-mentioned, the hydro-power development in Indonesia is expected from various viewpoints at present.

### 2-2-2 Present situation and future plan of hydro-power development

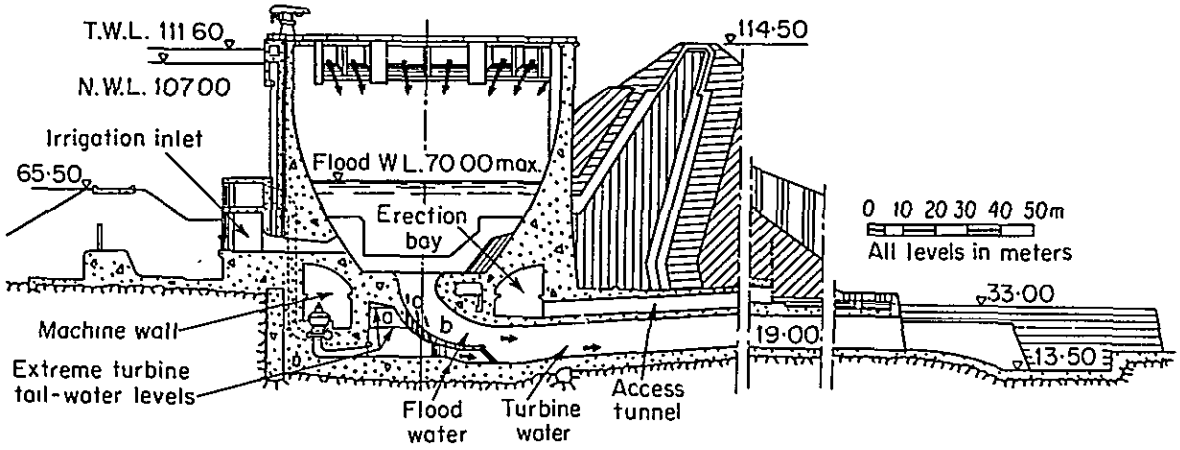
In Indonesia, 27 hydro-power stations amounting to some 300 MW of capacity, have been developed so far and most of them are located in Djawa. The existing main hydro-power stations are listed in the following table.

Table 2.2.1 Existing main hydro-power stations

| Name | District | Number of units | Capacity |
|---|---|---|---|
| Ubrug | West Djawa | 3 | 17,100 kW |
| Kratjak | do. | 3 | 16,575 |
| Parakan Kondang | do. | 4 | 10,000 |
| Lamadjang | do. | 3 | 19,200 |
| Tjikalong | do. | 3 | 19,200 |
| Djatiluhur | do. | 5 | 125,000 |
| Djelok | Central Djawa | 4 | 20,480 |
| Timo | do. | 3 | 12,000 |
| Mendalan | East Djawa | 4 | 23,000 |
| Siman | do. | 3 | 10,800 |
| Other 17 stations | | 31 | 36,519 |
| Total | | 66 | 309,874 |

The most important one among them, is Djatiluhur Power Station which is a part of the multipurpose development of the Tji Tarum River, of which main aims are irrigation, power generation and flood control. At present, it has five units with the capacity of 25 MW, 125 MW in total, and supplies electric power to Djakarta and Bandung district.

The Djatiluhur Dam is a fill-type dam of large scale with the height of 103.5 m and its storage capacity amounts up to three billion cubic meters. The design of this dam and power station is quite unique as illustrated below. The power plant, together with the spillway and the outlet facilities, installed in the cylindrical structure, with the height of 110 m and the diameter of 90 m, which is situated at the upstream part of the dam. The discharge from the power plant and the outlet is conducted to the downstream of the dam through the waterway which is also used as the spillway.




Among the projects, which are now under construction, the Karangkates and the Kali Kont in East Djawa and the Riam Kanan in South Kalimantan are the main projects and they are called '3–K'. The following table shows the main features of these three projects.

Table 2.2.2 Outline of 3K projects

| | Karangkates | Kali Konto | Riam Kanan |
|---|---|---|---|
| Total storage | 343,000,000 $m^3$ | 62,000,000 $m^3$ | 1,200,000,000 $m^3$ |
| Effective storage | 253,000,000 $m^3$ | 50,000,000 $m^3$ | 600,000,000 $m^3$ |
| Type of dam | Fill-type | Fill-type | Fill-type |
| Height of dam | 100 m | 46 m | 56 m |
| Volume of dam | 6,500,000 $m^3$ | 1,600,000 $m^3$ | 600,000 $m^3$ |
| Installed capacity | 105,000 kW | 4,500 kW | 30,000 kW |
| for the first stage | 35,000 kW x 2 | – | 10,000 kW x 2 |
| Start of operation* | in 1972 35,000 kW | in 1970 4,500 kW | in 1971 10,000 kW |
| | 1973 35,000 | | 1972 10,000 |

* according to the Five Year Plan.

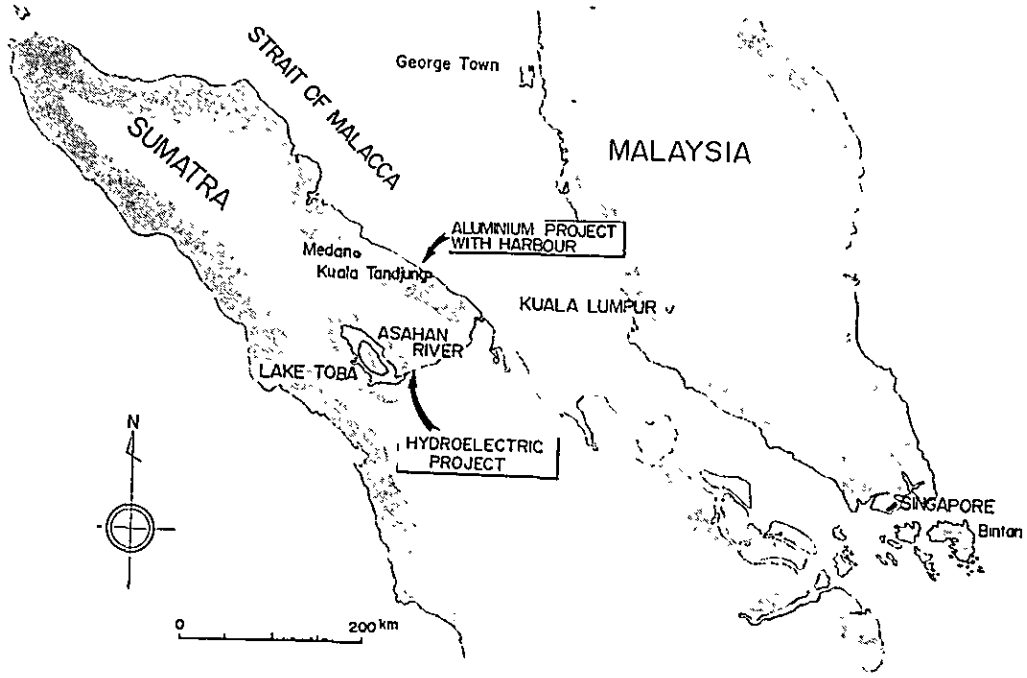
According to the First Five-Year Plan, which is under way since 1969, and the Second Five-Year Plan, which will be commenced in 1974, the hydro-power development is expected to be executed at the sites listed in the following table.

Table 2.2.3 Hydro-power development plan according to the First and the Second Five-Year Plan

(unit : MW)

| Site | District | Capacity | | First | | | | | Second | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1968 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 |
| Micro-hydro power | All over the country | kW 6,600 | | 0.4 | 0.4 | 0.6 | 0.6 | 0.6 | 1 | 1 | 2 | | |
| Ngebel | East Djawa | 2,250 | | 2.25 | | | | | | | | | |
| Riam Kanan | South Kalimantan | 30,000 | | | | 10 | 10 | | | 10 | | | |
| Karangkates | East Djawa | 105,000 | | | | | 35 | 35 | 35 | | | | |
| Seloredjo | do. | 4,500 | | | 4.5 | | | | | | | | |
| Garung | Central Djawa | 10,000 | | | | | | | 10 | | | | |
| Bt. Agam | West Sumatera | 10,000 | | | | | | | 10 | | | | |
| Asahan | North Sumatera | 460,000 | | | | | | | | | 460 | | |
| Tonsea Lama | North Sulawesi | 4,400 | | | 4.4 | | | | | | | | |
| Larona | South Sulawesi | 100,000 | | | | | | | | 50 | | 50 | |
| Kiara | West Djawa | 250,000 | | | | | | | | | | | 250 |
| Peusangan | Atjeh | 50,000 | | | | | | | | | | | 50 |

The Asahan Project is the largest one and is now under planning and surveying. This project is to construct a power plant with the installed capacity of 460 MW, as its first stage, making use of the available high head and the abundant run-off of the Asahan River (its annual mean discharge is 106 $m^3/s$) originating from the Lake Toba, in North Sumatera, which is a quite favorable water-source with the water surface area of 1,263 $km^2$, the catchment area of some 4,500 $km^2$ and the water surface elevation of 905 m above sea level. Its annual output energy is expected to be 3,500 million KWH and is to be used at the aluminum plant and also to be supplied to Medan district.




As mentioned before, Indonesia is endowed with plenty of hydro-power resources and the development of them has great possibilities.

Up to now, the hydro-power development in Indonesia has been undertaken independently in each district according to the requirement. But, it is necessary to draw up the integrated development plan of nation-wide, after grasping the amount and the distribution of hydro-power resources, carrying out the basic survey actively, in order to make use of this endowed resources effectively for the national benefit.

## 2-3 Hydro-power survey

### 2-3-1 General

The hydro-power is one of the most important, God-sent resources, and its development and utilization contributes greatly to the progress of national economy and the improvement of people's livelihood. Therefore, the survey and development of hydro-power resources have been executed as the projects of national importance in every country.

The hydro-power plant requires a large amount of investment for construction and, after the completion, its durable years are quite long. Therefore, the development plan of the hydro-power resources should be drawn up carefully, making thorough investigation into its economic feasibility in advance. For the determination of the type, scale, layout, design and operational plan of a power plant, it is necessary to take into due consideration the various factors from the social conditions such as the demand of electric power, related facilities and projects, to the natural conditions such as the topography, geology, precipitation and river run-off. In order to grasp these factors precisely and put forward the development project smoothly, the detailed survey and investigation over a long period is required.

The survey of hydro-power may be divided into the following three categories.

(i) Survey of basic data
(ii) Survey of hydro-power potential
(iii) Survey of hydro-power project

In Indonesia, these surveys were executed to some extent before the second world war, during the Dutch time, mainly in Djawa. But after the war, the systematic survey has been scarcely carried out and only the surveys for the individual development projects in respective districts have been executed.

In recent years, however, the importance of the hydro-power resources has been well recognized, gearing with the establishment of the Five-Year Development Plan, and the survey of hydro-power is going to be set forward systematically and independently.

With respect to the hydro-power survey in Indonesia, the present situation, problems to be solved, and future plan are dealt with in the following sections.

### 2-3-2 Basic data

The basic data for the hydro-power survey are the topographical data, geological data, precipitation data, run-off data and others. Some descriptions about these data are given below.

(1) Topographical data

The topographical data are the fundamental data required not only for the hydro-power survey but also for the national land planning.

The present situation of map preparation in Indonesia is descrived in Vol. II, Section 2-1, and only the main points are outlined here.

The topographical maps with the scale larger than 1/50,000, which are indispensable for the hydro-power survey, have been scarcely prepared for the districts outside Djawa. Furthermore, most of the topographical maps, which are now available, were prepared several decades ago and are inconsistent in many points with the present aspect. Therefore, the preparation of the topographical maps all over the country is a urgent problem from the national standpoint of view.

The aerial survey may be the most effective method of making topographical maps nowadays. In order to draw up the fundamental plan of hydro-power development, it is necessary to make the topographical maps with the scale of 1/50,000 or so, covering all the main river courses in Indonesia, in the present circumstances. For this purpose, apart from the districts where such maps are now available, the aerial photographs would be taken over the area of some 950 thousand square kilometers and some 400 thousand square kilometers of them would be mapped out.

As the topographical maps are under the administration of Directorate of Topography, Indonesian Army, it may be necessary to ask the cooperation to that Directorate as to the map preparation.

Another problem is that the topographical maps with the scale larger than 1/100,000 are kept confidential for reasons of military secrecy and this situation may be the restriction on the map utilization. Accordingly, it is desirable to prepare the topographical maps of large scale which can be used freely for the works concerning the national land development, such as the survey of natural resources.

(2) Geological data

As the geological condition around the development site has a remarkable influence on the construction cost of the project, it is necessary to grasp the condition precisely, in planning the hydro-power development, carrying out the geological survey in advance.

The geological features in Indonesia have been made clear to some extent by the survey up to now. The present situation of geological map preparation is described in Vol. II, Section 2-2.

For the purpose of hydro-power development, the detailed geological survey should be executed hereafter to obtain the geological data which are required for planning and designing the individual project, making use of the available references.

In Indonesia, the number of engineering geologists in the electric power sector is quite limited. Therefore, it is desirable for the sector to keep at least several engineering geologists, in order to let them execute the geological survey works of necessity and administrate the geological survey works which are entrusted to the consultants.

(3) Precipitation data

The precipitation is the origin of the hydro-power resources and accordingly, it is quite important to know precisely its amount and distribution.

In Indonesia, the precipitation has been observed since old times, fairly extensively. There are 1,858 observation stations as of 1968 and they are under the administration of the Institute of Meteorology and Geophysics, Department of Communication. The present situation of precipitation observation is described in Vol. II, Section 2-3.

Although the number of observation stations in Indonesia is relatively large, it is not sufficient in the districts outside Djawa in order to obtain the data required for the hydro-power planning.

With respect to the precipitation observation hereafter, it would be required to install at least two or three observation stations for each run-off gauging station in a water system, at the places where the representative characteristics of precipitation in

the region can be observed, so as not to bring about hindrance to the survey of hydro-power potential or of the individual development project.

For this purpose, it is necessary to install 78 observation stations in total additionally, for the time being, in the representative river basins in the districts outside Djawa.

Since the precipitation data are often used to supplement the run-off data, they should be so arranged that the correlation between the run-off and the precipitation can be made clear.

(4) Run-off data

The run-off data are the most important and fundamental for planning of hydro-power development.

The present situation of run-off gauging is described in Vol. II, Section 2-4. As of 1967, there are 92 run-off gauging stations in total and most of them are in Djawa. All of them are under the administration of the Institute of Hydraulic Engineering, Directorate General of Water Resources Development, Department of Public Works and Electric Power.

However, from the viewpoint of hydro-power survey, the present situations of the data provision, of the distribution of gauging stations, and of the execution of stream flow measurement are not seemed to be sufficient.

Accordingly, it is necessary to provide the gauging stations for the representative rivers all over the country without delay, and to expand and reinforce the organization of run-off gauging, in order to obtain the run-off data required for the survey of hydro-power potential and development projects.

For this purpose, 88 run-off gauging stations in total, which are provided with the automatic water-stage recorder or the staff-gauge, should be installed additionally all over the country.

Furthermore, it is also necessary to improve the accuracy of the run-off data, by increasing the frequency of stream flow measurement and by executing the high water observation.

(5) Others

In addition to the afore-mentioned data, the evaporation data and the sedimentation data are also fundamental for the hydro-power survey. These are required mainly for planning of the reservoir.

Regarding the evaporation data, there remain the records of measurement as to major cities in Indonesia, which were prepared in the Dutch time. With respect to the sedimentation data, the investigation of the suspended sediments in some rivers has been carried out to some extent by the Institute of Hydraulic Engineering.

In collecting and providing these data, it is necessary to cooperate with related authorities and it is desirable to execute the survey of the sedimentation results in the existing reservoirs and other surveys, in order to obtain the data required for future reservoir planning.

### 2-3-3 Survey of hydro-power potential

Since the hydro-power potential indicates the amount of the hydro-power resources which are endowed to a country, its precise estimation is quite important for setting up the energy policy of a country.

Generally speaking, the hydro-power potential may be classified into two categories, namely, the theoretical potential and the technically developable potential. The former is the total amount of the potential energy of the river discharge and is necessary for estimating the amount of endowed hydro-power potential and its regional distribution, statistically.

The latter indicates the output of the hydro-power stations which can be developed from the technical point of view and some part of it, which can be developed economically at a certain time, is called as the economically developable potential.

The survey of hydro-power potential in Indonesia was carried out before the second world war, in Dutch time, mainly in Djawa as the survey of technically developable potential. After the war, the systematic survey has been scarcely executed.

As the data of hydro-power potential survey, the report, which was compiled by the Power Research Institute in 1968, is the sole data at present. According to this report, the hydro-power resources in Indonesia are estimated to be 28 million KW. But the accuracy of this estimation seems to be not so high, because this estimation was carried out by using the ratio of non-surveyed area to the surveyed area or adopting simple assumptions, for the estimation of the potential in the non-surveyed districts. In due consideration of the topography, precipitation and other factors in Indonesia, the above-mentioned value of estimation seems to be rather small.

Table 2.3.1 Hydro-power potential in Indonesia

| District | Hydro-power Potential (MW) |
|---|---|
| Sumatera | 6,000 |
| Djawa | 725 |
| Kalimantan | 6,000 |
| Sulawesi | 5,250 |
| West Irian | 9,500 |
| Nusa Tenggara & Maluku | 150 |
| Total | 27,625 |

There are more than five hundred of water systems in Indonesia, and it is necessary to estimate the hydro-power potential precisely for each water system. For this purpose, the preparation of the afore-mentioned basic data is the precondition.

But it is quite necessary to estimate the theoretical hydro-power potential without delay with respect to the major water systems, which are some 150 in number, by making use of available topographical data, run-off data and precipitation data as much as possible, in order to use the result of the estimation as the fundamental data for the comprehensive plan of hydro-power development, which is expected to be drawn up in near future, from the countrywide viewpoint.

The works required for this estimation would take about two years, with some five full-time staffs. This works should be extended over all the water systems thereafter, to obtain the fundamental data for the energy plan.

With respect to the technically developable hydro-power potential, it is necessary to promote the surveys of individual development projects which are required at present, and to expand the systematic survey works successively all over the country, preparing the afore-mentioned basic data.

#### 2-3-4 Survey of hydro-power project

In drawing up the comprehensive plan of electric power development, the future demand of electric power should be estimated precisely in advance. For this purpose, the demand should be properly forecasted, keeping a watch on the social and economic tendency such as the user's plan of increasing electric power consumption and the trend of new demand or domestic electrification.

With respect to the demand forecast of the electric power in Indonesia, we can refer to the estimation by the Terada Mission and the result of this estimation is briefly described in Vol. II, Section 5-1.

The facilities of electric power generation, which supply the above-mentioned demand, are desirable to be constituted by the most economical combination of the hydro-power, thermal power, diesel and others. For this purpose, as for the hydro-power, it is necessary to carry out the survey of development sites positively and extensively and prepare the economically developable sites, of which output is enough to meet the electric power demand complying with any request of development.

Preparing the several economically developable sites with sufficient output is necessary also for finding out the most economical site among them, in drawing up the hydro-power development plan.

The survey of hydro-power projects in Indonesia has been carried out, after the second world war, mainly by the foreign aid and the reparation regarding individual development projects with the purpose of power generation or with many purposes including irrigation, flood control and others besides power generation. The survey and planning of some projects have been executed independently by the Indonesian authorities themselves. The survey works, which have been carried out after the war, are described in Vol. II, Section 1-2.

As already mentioned in the Section 2-2, the First and the Second Five-Year Development Plans have been established but, up to now, the substantial survey works have not yet been carried out even at the sites which will be developed by the Plan, except the Asahan Project.

Accordingly, it is an urgent problem to execute the survey of hydro-power project positively and extensively, also for the smooth progress of the Five-Year Plan.

As for the survey works hereafter, it is regarded as appropriate in Indonesia, which is endowed with the plenty of hydro-power resources, to promote the survey works so as to prepare the economically developable sites already surveyed, of which output corresponds to the demand increment.

Assuming that the annual increase ratio of demand is 12 %, the required output of the already surveyed sites will be as indicated on the table below.

Table 2.3.2 Capacities of hydro-power to be surveyed

(unit: KW)

| Year | Djawa | Outside Djawa | Total |
|---|---|---|---|
| 1971 | 42,000 | 9,000 | 51,000 |
| 1972 | 45,000 | 10,000 | 55,000 |
| 1973 | 51,000 | 11,000 | 62,000 |
| 1974 | 58,000 | 12,000 | 70,000 |
| 1975 | 66,000 | 14,000 | 80,000 |
| 1976 | 72,000 | 16,000 | 88,000 |
| 1977 | 80,000 | 18,000 | 98,000 |
| 1978 | 91,000 | 20,000 | 111,000 |
| 1979 | 101,000 | 22,000 | 123,000 |
| 1980 | 116,000 | 24,000 | 140,000 |

### 2-3-5 Cost of future hydro-power survey

The problems of future hydro-power survey have been described so far and the matters, which require the expenditure besides ordinary expenses, are as follows.

(i) Preparation of new topographical maps (mainly by the aerial survey)

(ii) Expansion of the organization of precipitation observation (establishment of new observation stations and their management)

(iii) Expansion of the organization of run-off gauging (purchase of new current-meters, establishment of new gauging stations with the automatic water-stage recorder or the staff-gauge, and their management.)

(iv) Survey of individual development projects

The expenses of each item are as listed in the table below.

Table 2.3.3 Expenses for hydro-power survey

(unti: 1,000 U.S. Dollar)

| Item | Total | 1971 | 1972 | 1973 | 1974 | 1975 | 1976 | 1977 | 1978 | 1979 | 1980 | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Precipitation observation | – | 3.2 | 6.3 | 9.4 | 12.5 | 15.6 | 15.6 | 15.6 | 15.6 | 15.6 | 15.6 | ------ |
| Installation of new precipitation observation stations | 93.6 | 18.7 | 18.7 | 18.7 | 18.7 | 18.8 | – | – | – | – | – | |
| Purchase of current meters | 56 | 56 | – | – | – | – | – | – | – | – | – | |
| Stream flow measurement | – | 26 | 46 | 66 | 86 | 106 | 126 | 146 | 166 | 186 | 186 | ------ |
| Installation of new run-off gauging station (Automatic) | 340 | 70 | 70 | 70 | 70 | 60 | – | – | – | – | – | |
| Ditto (Staff-gauge) | 9.8 | – | – | – | – | 2 | 2 | 2 | 2 | 1.8 | – | |
| Project survey | – | 510 | 550 | 620 | 700 | 800 | 880 | 980 | 1,110 | 1,230 | 1,400 | ------ |
| Sub total | – | 683.9 | 691.0 | 784.1 | 887.2 | 1,002.4 | 1,023.6 | 1,143.6 | 1,293.6 | 1,433.4 | 1,601.6 | ------ |
| Aerial survey | 27,600 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | 1,380 | ------ |
| Total | – | 2,063.9 | 2,071 | 2,164.1 | 2,267.2 | 2,382.4 | 2,403.6 | 2,523.6 | 2,673.6 | 2,813.4 | 2,981.6 | ------ |

*Note: Excluding personal salary, expenses for administration, working expenses of the offices, and working expenses of the observation and gauging at the existing stations.*

### 2-3-6 Management of organization

The electric power sector in Indonesia is in the course of the reorganization as of November of 1970. It is said that this reorganization aims to make the National Enterprise of Electric Power (P.L.N.) the independent and autonomous enterprise, and let it manage all the activities related to the electric power industry, from generation to transmission and distribution.

In these circumstances, the description is given in this report, not to the problem of the organization or the institution itself but to the management of organization and affairs of the hydro-power survey and the related fields.

With respect to the central office, the following duties should be assigned to its appropriate sections.

(i) Fundamental research (demand forecast; standardization of the facilities and equipments; standardization of the design; research of the new technology; statistics)

(ii) Facilities planning (general and fundamental planning of the new establishment or extension of the electric power supply system including generation, transmission, transformation and distribution; funds supply and demand programme)

(iii) Planning and survey (collection and administration of the basic data; planning and survey of the proposed sites of the power development; planning and survey of the transmission, transformation and distribution facilities; administration of the survey works which are executed by local branch offices)

(iv) Design (design work and its administration of the electric, civil and architectural facilities and structures related to the new establishment or extension of generation, transmission, transformation and distribution facilities)

(v) Research and investigation (technical research, investigation and experiment related to the electric power)

(vi) Training (cultivation of technical skill; technical education; training of the technicians)

On the other hand, the local agencies like the branch office (Exploitasi) of P.L.N should assist the central office in the afore-mentioned affairs, and carry out the local survey of the basic data and also administrate the simple survey works which are undertaken in the region concerned, in order to improve the efficiency of business. Furthermore, it is desirable to make the local agencies undertake the preliminary survey and planning of the hydro-power development step by step, educating and training their staff personnel.

At the major project sites under surveying, the survey offices should be set up, when the occasions demand, for the execution of field works of survey and also for the administration of the survey works entrusted to the consultant.

At present, the number of engineers in the electric power sector is limited, therefore, it is desirable to undertake fundamental planning and designing, as a rule, at the central office concentratedly for making use of engineers effectively.

The works related to planning, surveying and designing would be undertaken mainly by consultants for the time being, but, in order to execute these works independently and efficiently, it may be expedient to keep the standing advisers in the electric power sector and make them cooperate with its technical personnel.

# 3. Summary of recommendations

## 3. Summary of recommendations

In order to put forward the hydro-power survey in Indonesia smoothly, following matters would be necessary.

(1) Basic data

(a) Topographical data

(i) To provide the topographical maps with the scale larger than 1/50,000 covering the whole country, which are required for the hydro-power survey, and to make it possible to use them freely so as not to bring about hindrance to planning of hydro-power development:

(ii) To prepare new topographical maps, with the purpose of (i), for the districts where such maps are not available now, by the aerial survey or other methods; and, to revise and improve the accuracy of the map which are available now, as occasions demand:

(b) Geological data

To organize a group comprising several engineering geologists in the electric power sector in order to execute the geological survey at the individual development sites and also to administrate the geological survey works entrusted to the consultants:

(c) Precipitation data

(i) To expand and reinforce the organization of precipitation observation for the districts outside Djawa: (for this purpose, it is necessary to install additionally 78 observation stations in total and observe the precipitation)

(ii) To collect and arrange the existing data so that they can be used conveniently; and to investigate the correlation with the run-off data, in arranging the precipitation data, for the convenience of the survey of hydro-power potential:

(d) Run-off data

(i) To expand and reinforce the organization of run-off gauging all over the country: (for this purpose, it is necessary to install additionally 88 gauging stations in total and gauge the river run-off)

(ii) To improve the accuracy of the run-off data by increasing the frequency of the stream flow measurement and by executing high-water observation as well:

(iii) To collect and arrange the existing run-off data so that they can be used conveniently; and to prepare the data indicating the duration of river run-off, in arranging the data, for the convenience of planning the hydro-power development projects:

(2) Survey of hydro-power potential

(i) To estimate the theoretical hydro-power potential of some 150 major water-systems, without delay; and to expand this work successively to the remaining water-systems all over the country:

(ii) To put forward the survey of individual development projects, for the time being, as for the survey of the technically or economically developable potential; and to execute the systematic survey works successively all over the country, preparing basic data:

(3) Survey of hydro-power project

To grasp the tendency of the electric power demand precisely and to undertake the survey of hydro-power projects systematically in each district, in order to prepare the economically developable sites which are already surveyed so as not to bring about hindrance to drawing up the electric power development plan to meet the demand: