Republic of India
Meghalaya Energy Corporation Limited (MeECL)
Meghalaya Power Generation Corporation Limited (MePGCL)

Preparatory Survey
on
Umiam Umtru Stage III
Power Station Renovation Project
in the Republic of India

Final Report
<Advanced Version>

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Japan International Cooperation Agency (JICA)

Tokyo Electric Power Services Co., Ltd. (TEPSCO)
Tokyo Electric Power Company Holdings, Inc. (TEPCO HD)
TEPCO Power Grid, Inc. (TEPCO PG)

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Abbreviations

Abbreviation	Word
AC	Alternating Current
ADB	Asian Development Bank
BOQ	Bill of Quantity
CEA	Central Electricity Authority
CERC	Central Electricity Regulatory Commission
CFD	Computational Fluid Dynamics
CVC	Central Vigilance Commission
DC	Direct Current
DPR	Detailed Project Report
E&M	Electrical and Mechanical
EIRR	Economic Internal Rate of Return
FIRR	Financial Internal Rate of Return
FR	Final Report
FY	Fiscal Year
GPS	Global Positioning System
HRD	Human Recourse Department
HTLS	High Tension Low Sag
ICR	Inception Report
IDC	Interest During Construction
IDMT	Inverse Definite Minimum Time Relay
IED	Intelligent Electronic Devices
INR	Indian Rupee
IRR	Internal Rate of Return
ITR	Interim Report
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
JV	Joint Venture
LCB	Local Competitive Bid
M/M	Man-Month
MDoNER	Ministry of Development of North Eastern Region
MeECL	Meghalaya Energy Corporation Limited
MePDCL	Meghalaya Power Distribution Company Limited
MePGCL	Meghalaya Power Generation Company Limited
MePTCL	Meghalaya Power Transmission Company Limited
MeSEB	Meghalaya State Electricity Board
MNREDA	Meghalaya New and Renewable Energy Development Agency
MOP	Ministry of Power
MSDA	Meghalaya State Designated Agency
MSERC	Meghalaya State Electricity Regulatory Commission
MU	Million Unit (MU and GWh has the same meaning)

Abbreviation	Word
MW	Mega Watt
MWh	Mega Watt Hour
NEEPCO	North Eastern Electric Power Corporation Limited
NEIIPP	North East Industrial & Investment Promotion
NHPC	National Hydroelectric Power Corporation
NTPC	National Thermal Power Corporation
O&M	Operation and Maintenance
ODA	Official Development Assistance
OLTC	On Load Tap Changer
ONGC	Oil and Natural Gas Corporation
OTPC	ONGC Tripura Power Company Ltd
PCMS	The Protection, Control and Monitoring System
PIU	Project Implementation Unit
PLC	Programmable Logic Controller
PQ	Pre-Qualification
QBS	Quality Based Selection
QCBS	Quality and Cost Based Selection
QC	Quality Control
R&M	Renovation and Modernization
ROA	Return on Assets
RTU	Remote Terminal Unit
SCADA	Supervisory Control And Data Acquisition
SERC	State Electricity Regulatory Commission
T/L	Transmission Line
TOR	Terms of Reference
TQM	Total Quality Management
WAN	Wide Area Network

Chapter1 Outline

1.1 Background

Energy consumption is increasing in accordance with rapid economic growth in recent years in India. India was the fourth largest energy-consuming country after China, America and Russia in 2014. National electricity supply was 1,090,851 GWh in 2015 while electricity demand was 1,114,408 GWh, with a shortfall of 2.1%. Total generation capacity was 148,463 MW in 2015 while demand was 153,366 MW, with a shortfall of 3.2%. Although it had improved, considering that the shortfalls in 2014 were 4.5% and 3.6% for electricity supply and capacity, respectively, electricity is still insufficient. According to the Draft National Electricity Plan that the Central Electricity Authority announced in December 2016, 317,000 MW of peak demand and 2,132,000 GWh of energy demand in 2026 are forecasted.

There are sufficient natural resources such as uranium, coal, forest and natural gas in the seven northeastern states, including Meghalaya state, but development has been delayed compared with other regions. The Government of India has placed significance on development in the northeastern states, including Meghalaya state, politically from the standpoint of regional connection. In addition, the Government of Japan has expressed support for strengthening regional connection, including northeastern development, and JICA has supported projects such as the North East Road Network Connectivity Improvement Project (Phase 1).

Meghalaya state is known for having many hilly areas, and it has the highest precipitation on record in India (annual precipitation of 12,000 mm). It has great hydropower potential because of many monsoons. However, the current status of electricity supply in this state is severe compared with other northeastern states and the nationwide average. Power supply in this state was 1,725 GWh to serve demand of 1,833 GWh in 2015, with a shortfall of approximately 6%. This shortfall is higher than the average for all northeastern states and the nationwide average, which were 5.2% and 2.1%, respectively. For this reason, the Government of Japan extended an ODA loan to the “Umiam Power Station Renovation Project” in 1997 and “Umiam Stage II Power Station Renovation Project” in 2004, which contributed to the expansion of electricity supply in Meghalaya state. However, hydropower development is an urgent issue because the electricity supply capacity is still approximately 350 MW while the hydropower potential in this state is 3,000 MW or more. The Twelfth Five-year Plan of Meghalaya state, covering 2012 to 2017, states the necessity of power development due to the severe power shortage, and the rehabilitation of the Umiam Umtru Stage III HEPP, which started operation in 1979 and has deteriorated since then.

Under these circumstances, the Government of India requested a project to renovate the Umiam Umtru Stage III HEPP. According to the request from the Government of India, this study is implemented to confirm the background information described in the Detailed Project Report made by MeECL in 2014 and review the renovation project, including the basic design, cost, project structure,

and the operation and maintenance structure. This study is to conduct the survey necessary for the evaluation of Japanese ODA loan implementation.

1.2 Objective of Survey

1.2.1 Objective

The objective of this study is to review the Umiam Umtru Stage III Power Station Renovation Project, including basic design, project cost, estimation, implementation structure, and O&M structure, and to conduct the survey necessary for evaluation of ODA loan implementation.

1.2.2 Implementation Agencies in India

MeECL: Meghalaya Energy Corporation Limited
MePGCL: Meghalaya Power Generation Company Limited
MePTCL: Meghalaya Power Transmission Company Limited
MePDCL: Meghalaya Power Distribution Company Limited
Moreover, the related agencies are as follows:
Ministry of Power (MOP)
Central Electricity Authority (CEA)

1.3 Study Contents

(1) **Preparation (Inception Report and Discussion)**
  (a) Study and analysis of related materials including DPR (Detailed Project Report) made by MeECL
  (b) Study of survey items and survey plan
  (c) Issue of inception report

(2) **Additional Survey by a Local Firm at Site**
  (a) Selection and contract of additional survey items
  (b) Implementation and acceptance of the additional survey

(3) **Collection and Analysis of Information**
  (a) Understanding of overall project
  (b) Understanding of the renovation plan of the current DPR
  (c) Criteria setting for selection of renovation equipment
  (d) Site survey
  (e) Confirmation of validity by system analysis
  (f) Tentative selection of renovation equipment
  (g) Confirmation of other organization such as funds and banks

(4) **Design Examination, Renovation Planning and Concurrence**
  (a) Confirmation of validity of equipment for the power generation

(b) Revision and collection of renovation plan for the power station and the transmission and substation facilities

(c) Study of consulting service

(d) Study of implementation and O&M structure

(e) Planning of project implementation schedule

(f) Study of implementation cost and financing plan

(g) Selection and confirmation of equipment to be renovated

(5) **Study of Procurement and Implementation Method**

(a) Procurement status of similar project in India

(b) Proposal for procurement method, contract condition, etc.

(c) Survey of example related to contract management

(6) **Survey of Important Notice on Project Implementation**

(a) Survey of items that have direct impact on project implementation

(7) **Project Evaluation and Proposal for the Implementation**

(a) Risk analysis and preparation of risk management sheet

(b) Economic and financial analysis

(c) Selection of quantitative and qualitative operating target

(d) Necessity of technical support

(e) Confirmation and analysis of impact on northeastern state and neighboring countries by project implementation

(f) Proposal for future support

Chapter2 Basic Policy

2.1 Outline of Survey Plan

2.1.1 Effective Survey of Structuring Sub-group

The following shows the investigation for this survey.

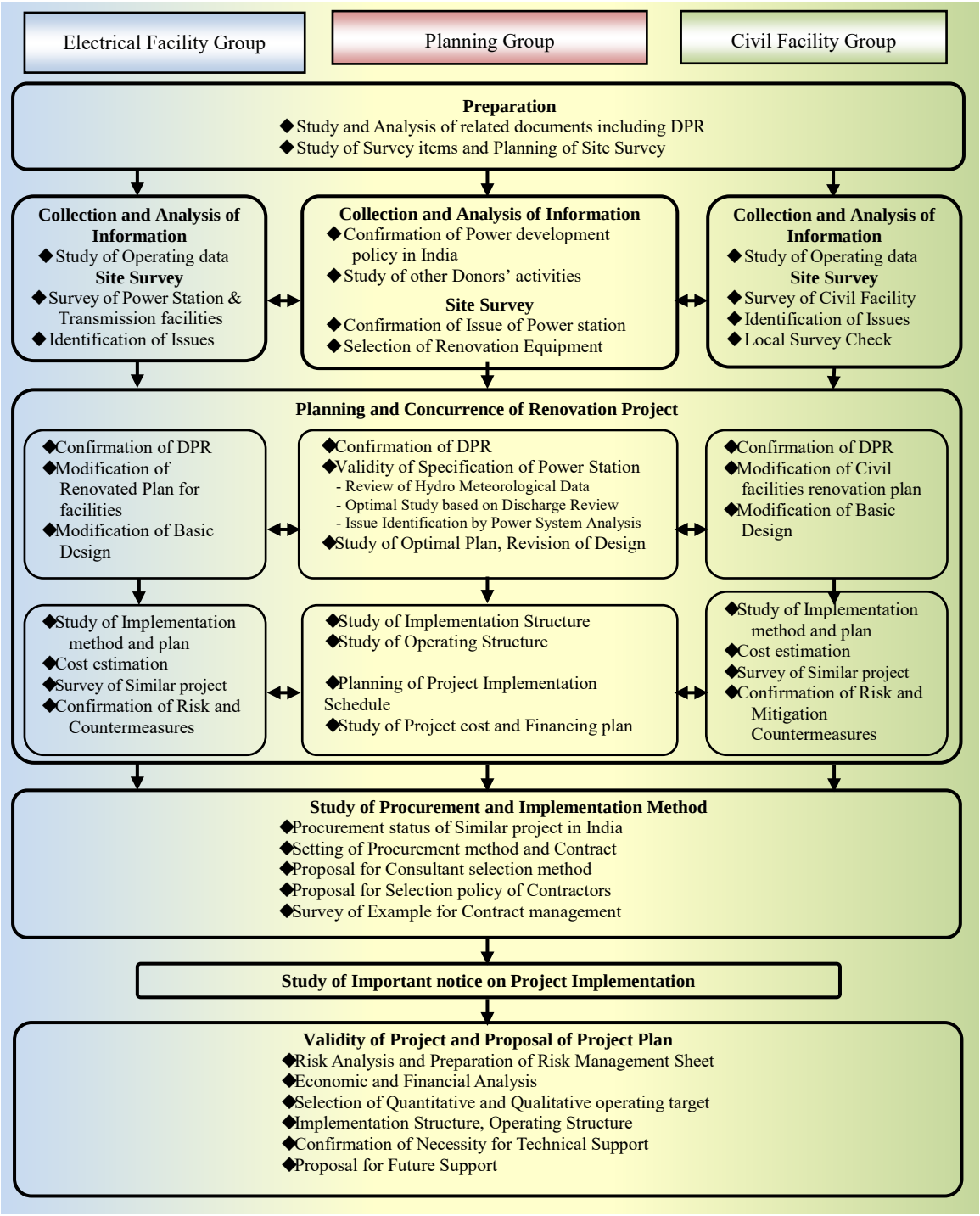


Figure 2-1 Outline flow of survey (concept of survey)

The JICA Survey team consists of "Planning Group," "Electrical Facility Group" and "Civil Facility Group." Each group conducts an individual survey, but each survey result is not evaluated on its own. The groups in the JICA Survey team share useful survey results with each other and prepare a final survey report.

For implementation of this study, the important technical items are as follows:

(1) Study of Optimal Generating Capacity
(2) Confirmation of Current status of Power Station and Renovation Plan on DPR
(3) Selection of Renovation Facilities and Modification of Outline Design
(4) Study of Operation and Maintenance Structure
(5) Capacity Building and Technical Transfer
(6) Preparation of Evaluation Items for a Smooth Transition to Japanese ODA loan
(7) Impact on the North Eastern States and Neighboring Countries

2.1.2 Study of Optimal Generating Capacity

(1) **Hydrological and Meteorological Study**

Hydrological and meteorological data are reviewed in order to confirm fluctuation of annual inflow, which seems to be the reason that the previous projects (Umiam and Stage II) did not reach the target generation value after start of operation.

Annual inflow at the project site, its fluctuation and trend are estimated by analyzing river inflow and meteorological data collected by a local firm, and inflow and discharge data from the Umiam Umtru Stage III HEPP.

- Collection and Review of River Inflow and Meteorological data including Rainfall and Evaporation
- Collection and Review of Inflow and Discharge of Umiam Umtru Stage III HEPP
- Review and Estimation of Inflow at the Project Site

(2) **Confirmation of Operation of Regulating Reservoir**

(a) Current Status of Regulating Reservoir Operation

The current status of the regulating reservoir operation is confirmed based on actual data of operating and maintenance (O&M), the O&M manual, and interviews of operating staff.

On the upper side of the Umiam Umtru Stage III Power Station, there are two reservoirs, Kyrdemkulai and Nongmahir. Umtru River Inflow goes to the Kyrdemkulai reservoir, and then to the Umiam Umtru Stage III Power Station thorough a link tunnel, Nongmahir reservoir and penstock. It is noted that overflow from the reservoir was reported due to non-operation of the regulating gate of the link tunnel.

- Collection and Review of Design Documents during Construction Period
- Confirmation of O&M Record and Manuals
- Interviews of relevant Staff

(b) Confirmation of Water Balance of Reservoirs

MeECL pointed out in its study that the flow volume of the link tunnel during some limited periods is short compared with design flow.

Water imbalance calculation between the two reservoirs is considered as the reason that shortage of the flow volume is regarded. It is necessary to improve the water balance calculation because the reservoir capacity cannot be utilized effectively in the case of the imbalance. Information of the current water balance operation by MeECL is collected and reviewed. Necessary capacity building during the project implementation period is planned.

- Collection and Review of Water Balance Operation Information
- Planning of Capacity Building during Project Implementation Period

(c) Confirmation of Effective Capacities of Reservoirs

The current status of the reservoirs, water balance operation, and effective capacities of the reservoirs are confirmed and reviewed. The results are considered to study the generating capacity of the renovation plan.

Effective capacities of the reservoirs and decrease of the overflow from the reservoirs, which can be obtained by renovation of the link tunnel intake gate, are confirmed. Those are considered for project evaluation.

(3) **Study of Generating Capacity**

Generating capacity is studied based on the estimated inflow and reservoir capacities. Sensitive analysis is carried out in consideration of the inflow reduced.

In the case that the design flow of the power plant is different between the existing power plant and the renovation plan, flow capacity of existing facilities are confirmed whether it satisfies the renovation plan. If the flow capacity does not satisfy the renovation plan, the renovation plan is modified accordingly.

2.1.3 Confirmation of Current Status and Renovation Plan in DPR

(1) **Topographical and Geological Survey**

Generating capacity is studied based on the estimated inflow and reservoir capacities. Sensitive analysis is carried out in consideration of the inflow reduced.

In the case that the design flow of the power plant is different between the existing power plant and the renovation plan, flow capacity of existing facilities are confirmed whether it satisfies the renovation plan. If the flow capacity does not satisfy the renovation plan, the renovation plan is modified accordingly.

(2) **Confirmation of Current Condition and Renovation Plan in DPR**

(a) Confirmation of Current Status of Electrical Equipment and Renovation Plan in DPR

The current status of electrical and mechanical equipment is confirmed by the actual result of O&M, relevant manuals, and interviews with relevant staff such as operators.

For the electrical and mechanical equipment, the most important item to be checked is one unit that was stopped due to runner trouble. A turbine runner is one of the most important in the electrical and mechanical equipment, and there are severe cracks in the runner, according to the DPR and the latest information from the site. The damaged runner has been repaired repeatedly since the commissioning. The current status of the runners and influence on the operation are confirmed through the inspection result and interviews with relevant persons during the survey.

In addition, it is noted that there is water leakage from many turbine parts, such as guide vanes and oil coolers for turbine bearings, and oil leakage from lower bearings, and that some meters should be replaced due to their malfunctioning.

- Confirmation and Review of As-built drawings
- Confirmation and Review of Actual Records and Manuals of O&M
- Interviews with Relevant Persons and Review

(b) Confirmation of Current Status of Civil Facility and Renovation Plan in DPR

The current status of the civil facility is confirmed by the actual result of O&M, relevant manuals, and interviews with relevant staff such as operators. Visual inspection is carried out for particular failure facilities.

It is noted that the intake gate of the link tunnel is not able to operate, and it causes overflow discharge from reservoirs without generation.

In the previous study in 2006, a small leakage was confirmed at the stream close to the tunnel between the Nongmahir reservoir and surge tank.

The status of the leakage is confirmed at the site. The status of the cave, which was confirmed at the small overburden zone of the pressure tunnel in the previous study, is also confirmed, and whether the cave is progressing.

As it is considered that implementing an internal inspection of the link tunnel is not possible, additional tunnel survey necessary for the detailed design Stage is studied and planned. In the case that an internal inspection of the link tunnel is possible to implement during this preparatory survey according to discussion with MeECL, then the inspection is implemented in consultation with MeECL and JICA.

Two kinds of design thickness value of the penstock are indicated, according to documents collected in the previous study, and the collect value is not clear. The shell thickness was smaller than the thinner thickness design value, as the result of the shell thickness measurement in the previous study in 2006. As more than ten years have passed since the previous measurement, the thickness measurement of the penstock is carried out by a local firm in order to confirm the current status. It is calculated whether there is overstress in the penstock shell based on the thickness measurement.

In the case that the design flow of the power plant is different between the existing power plant and the renovation plan, the flow capacity of existing facilities is confirmed whether it satisfies the renovation plan. If the flow capacity does not satisfy the renovation plan, the renovation plan is modified accordingly.

- Collection and Review of As-built drawings
- Confirmation and Review of Actual Records and Manuals of O&M
- Interviews with Relevant Persons and Review
- Confirmation of Current Status by Visual Inspection
- Measurement of Penstock Thickness (by a local firm)
- Topographical Survey at the Small Overburden Zone of the Pressure Tunnel (by a local firm)

(c) Confirmation of Current Status of Transmission & Substation Equipment and Renovation Plan in DPR

The current status of transmission and substation equipment is confirmed by the actual result of O&M, relevant manuals, and interviews with relevant staff such as operators. According to the confirmation result, it is noted that some equipment may have failure, and visual inspection is carried out.

It is noted that the renovation plan includes replacement of the existing circuit breakers, current transformers and switchboards for switchyard due to manually operated circuit breakers and deteriorated current transformers and switch boards.

Capacity of the existing equipment is confirmed in consideration of power analysis result, and then the validity of the existing equipment is confirmed.

- Confirmation and Review of As-built drawings
- Confirmation and Review of Actual Records and Manuals of O&M
- Interviews with Relevant Persons and Review

Confirmation of Validity of the Existing Equipment by Comparison with Power System Analysis

2.1.4 Selection of Equipment to be Renovated and Modification of Outline Design

(1) **Selection of Equipment to be Renovated and Modification of Outline Design**

(a) Confirmation of Issues for the Existing Facilities and Modification of Selection of Equipment to be renovated

According to the above results, issues for the existing facilities are extracted and the deterioration is confirmed.

When the validity for the existing facilities cannot be confirmed, the JICA Survey team will discuss with JICA and examine revision of the renovation project. Criteria to select equipment to be renovated are set, and the criteria are revised, if necessary, after explanation to the related organization, including MeECL. Preventive maintenance and stable operation after renovation are noted when selection of equipment to be renovated is revised. In addition, the renovation plan for time-related deterioration is prioritized according to factors such as the effect of failure and deterioration.

- Extraction of Issues for the Existing Facilities and Confirmation of the Deterioration
- Modification of Criteria to select Equipment to be Renovated based on the Revised Criteria
- Prioritization for Renovation Plan

(b) Modification of Outline Design for Equipment to be renovated

In the modification of outline design, it is noted that this project becomes feasible in the reference of the similar project. The outline design is modified according to the explanation to the related organization such as MeECL.

- Confirmation of Actual Result of Similar Projects
- Modification of Outline Design for Equipment to be Renovated

The current DPR shows the renovation plan to reutilize existing spiral case of the turbine. As the existing component is currently scheduled to be utilized, the JICA Survey team discusses with MeECL to hold an explanatory meeting at the site for turbine manufacturers by MeECL. In case the explanatory meeting is not hold by MeECL, the Survey team conducts an alternative survey, such as an internal survey of the spiral case taking photos, in consultation with MeECL and JICA.

2.1.5 Operation & Maintenance (O&M)

Firstly, the JICA Survey team identifies the related implementation organizations. Next, the JICA Survey team starts reviewing the maintenance and administrative system and organizations.

- Identify the roles and functions of related implementation organizations for O&M and administrative works.
- Organizational structures
- Financial conditions of related organizations
- Technical levels of related organizations
- Actual records of related organizations
- Actual O&M costs and revenues

The JICA Survey team takes care of the following in the O&M and administrative systems during a renovation period and a post-renovation period:

(1) **Organizational Structure to implement Operation & Maintenance during a Renovation Period**

During a renovation period, the JICA Survey team lists necessary administration works and reviews a suitable system and organization, taking the current organizational structure of the Umiam III HEPP into account.

(2) **Organizational Structure to implement Operation & Maintenance during a Post-renovation Period**

During a post-renovation period, the JICA Survey team sets up a suitable system and organization, taking an organizational structure and technical skills into account.

- Planning of a patrol and O&M works
- Troubleshooting
- Record operational data to be reported
- Revenue and cost control
- Inspection method and its frequency

2.1.6 Educational Program and Technical Transfer Program

(1) **Planning of an educational program**

The continuous upgrading of operational and R&M skills in the post-rehabilitation period is important to maintain the renovated facilities in a proper and effective way, so the JICA Survey team plans the following educational programs. Meanwhile, a QC circle activity that was introduced in the Rehabilitation of Umiam Stage II Project was evaluated in the Ex-Post Evaluation to have helped improve operational and R&M skills to some extent. Therefore, the JICA Survey team plans to introduce this QC circle activity to the Umiam Umtru Stage III Project as well.

Educational program for field operators

- Arrangement of operation manuals
- Arrangement of drawing charts and equipment
- Skill- up plan and an introduction of QC circle activity

(2) **Necessity of soft-components**

In order to implement an educational program, the JICA Survey team reviews a necessity of education for an ODA project or Technical Assistance and sets up a plan while considering a target, a result, its input and activities.

2.1.7 Collection of Documents leading to a Smooth Transfer to achieve a ODA Loan

(1) **Construction costs and a budget plan**

(a) Estimate of a rough construction cost

The JICA Survey team calculates total construction cost while taking a price escalation, a real market price and a fluctuation of a foreign currency rate into account.

Total construction cost consists of items such as price escalation, physical contingency, interest during construction (IDC), consulting fee, land acquisition fee, taxes and duties, and training fee, as well as construction cost. In calculating the consulting fee of an ODA project, we count necessary man-months (M/M) and applicable fields and items.

With regard to an estimate of total cost, the JICA Survey team estimates a yearly cost during a whole project period, with the Cost Support System (Excel) of JICA. Finally, the JICA Survey team summarizes a cost table, referring to the cost manual and receives approval from JICA.

(b) Project Implementation Schedule

The JICA Survey team puts together a monthly schedule with bar charts, considering necessary procedures to relevant organizations as well as construction work. Finally, the JICA Survey team sets up a “Time-bound Action Plan” to cover a full project period.

(c) Budget Plan

The JICA Survey team makes a yearly schedule plan with a total cost and an implementation schedule. With regard to applicable funds, following a variety of funds such as a Japanese ODA Loan extended by the Government of Japan to the Government of India, a sub-loan extended by the Government of India

to the Government of States of India, an annual budget extended to the MeECL group would be available.

When the JICA Survey team sets up a yearly budget plan, while considering procedures for borrowing, its terms and conditions, the plan consists of two parts: a foreign portion and a local portion.

(d) Safety Plan and Risk Management Program

With regard to risk management, the JICA Survey team identifies potential risks based on a risk management sheet of JICA and considers countermeasures at the beginning of the project formation.

And the JICA Survey team requests the counterparts of India to recognize the importance of safety at the construction stage, listing safety measures necessary to conduct construction work under an ODA program. Finally, the JICA Survey team selects an appropriate construction method and a construction schedule, if necessary.

(e) Procurement Plan

The JICA Survey team sets up a procurement plan, based on the "Procurement and Consultant Guideline of Japanese ODA Loan"

- Bidding method、TOR of a contract
  Basic policy of contract agreement, TOR, standard forms of JICA
- Selection of consultant
  Selection of international consultants, QBS
- Policy to select a contractor
- PQ (Pre-Qualification) conditions, application of LCB (Local Competitive Bid), Lot package, an approval process in the tender

(f) Identification of an implementation organization and a financial analysis

The JICA Survey team identifies which corporation of the MeECL group becomes an implementation organization for the renovation and analyzes its financial statements. Moreover, the JICA Survey team makes a pro-forma financial statement, given the renovation project, to review the changing financial conditions year by year.

(g) Economic and Financial Analysis

Evaluation of the project will be based on the principle of "with project" and "without project". Following this principle, the JICA Survey team calculates costs and benefits so as to lead both Economic Internal Rate of Return (EIRR) and Financial Internal Rate of Return (FIRR). Moreover, the JICA Survey team also calculates Equity IRR.

1) Project cost and a yearly budget plan

The JICA Survey team evaluates the project with a total cost and a yearly cost plan. In estimating a total project cost, the JICA Survey team considers an O&M cost that will be accrued after the renovation as well as a construction cost.

2) Benefit

DPR calculates EIRR, based on the alternative method. Following this method, DPR firstly presumes a diesel power plant that has an equivalent capacity of Umiam III and estimates its construction cost and O&M cost. Next, DPR estimates a benefit of the project as the difference between the construction cost

and O&M cost deriving from a diesel power plant and the construction cost and O&M cost of the existing Umiam III power plants. Taking into consideration the benefit described in the DPR, and fact that the Northeast Region, which covers the Umiam Umtru Stage III Power Station, receives power from the Eastern Region, the JICA Survey team calculates EIRR in adequate method in consultation with MeECL and JICA.

In addition, the JICA Survey team estimates with the "Supporting Tool of Green gas Emission" the amount of reduced gas emission for the project and counts it as a part of the benefit.

(h) Review on indices

This renovation project will facilitate the lessening of a power shortfall and contribute to industrial development and improvement of life in Meghalaya state as well. Therefore, indices to measure the effect of renovation are to be used in Ex-Post Evaluation and shall be chosen from a viewpoint of proper evaluation. In setting targets, the JICA Survey team chooses them two years after the renovation, while considering ease of availability of data and of monitoring in daily work.

(i) Request to the Central Government of India

The JICA Survey team reviews necessary procedures and days, given that when MeECL officially requests the ODA loan from the Government of Japan. The JICA Survey team interviews MeECL and relevant organizations and reflects its results on a project schedule.

2.1.8 Impact on the North Eastern Region and Neighboring Countries

(1) **Power development plan in the Northeastern Region**

(a) Impact of renovation of Umiam Umtru Stage III on the Northeastern Region

With regard to the Umiam Umtru Stage III project, it is listed in the 12th Power Development Plan (2012-2017) as an R&M project. And its R&M is to be completed within the period of the 13th Power Development Plan (2018-2023).

In 2016, the total installed capacity in Meghalaya state was 515.1 MW, including 356.58 MW of hydropower capacity. After the project finishes fixing the generator, which had been suspended, it is able to secure a total of 60 MW by restoring a 30 MW installed capacity. As the restored capacity of 60 MW is almost equal to 12% of the total existing installed capacity and 20% of the total existing hydropower capacity, it might be said that this renovation project contributes much to the current power condition.

(b) Current power condition in the Northeastern Region

Generally, the Northeastern Region is said to have high potential for hydropower, but the actual development has not been going well so far. With regard to the inter-regional power trades in India (Northern Region, Eastern Region, Western Region, Southern Region and Northeastern Region), the Northeastern Region receives power from the Eastern Region, which covers Kolkata city. Its received amount was 431.2 MU in 1988-99, but it increased to 2,345 MU in 2014-15. The fact that the Northeastern Region had to import more power from the Eastern Region means that the Northeastern Region does not meet its power demand, and the power development there has been slow. The JICA

Survey team confirms the inter-regional power trades between the Northeastern Region and the Eastern Region as well as other regions with MeECL and relevant agencies.

Therefore, an increase of power supply through this renovation project in Meghalaya state may help reduce power import from the Eastern Region. As a result, it is expected to lead to both a reduction of transmission loss and consumption of fossil fuels for thermal power plants as well.

With this in mind, the JICA Survey team collects data and analyzes a relationship between the Northeastern Region and other regions and the impact on neighboring countries.

2.2 Basic Operational Policy

(1) **A short term effective and efficient implementation of survey**

With regard to the project, the time to collect necessary information and documents is short. As the time allowed for the project is 5 months shorter than that of other projects, it seems hard to make an appropriate decision. Based on the idea that a fast understanding of the current situation is useful, the JICA Survey team plans to conclude an outsourcing contract with a company at the beginning of the field survey.

(2) **Coordination and corporation with the implementation organizations and relevant organizations**

The main counterparts for the study would be: MePGCL, MePTCL and MePDCL of the MeECL group as well as MeECL, the holding company. In addition, other relevant organizations include the Government of Meghalaya State, the Ministry of Power and CEA. The JICA Survey team keeps in close contact with these organizations, identifying a role for each organization.

(3) **Close communication and rapport with relevant organizations of Japan**

The JICA Survey team makes every effort to keep in close communication with JICA to let this study contribute to promoting a good relationship between India and Japan. And the JICA Survey team makes every effort to obtain the most suitable results for India from both the technical and economical standpoints.

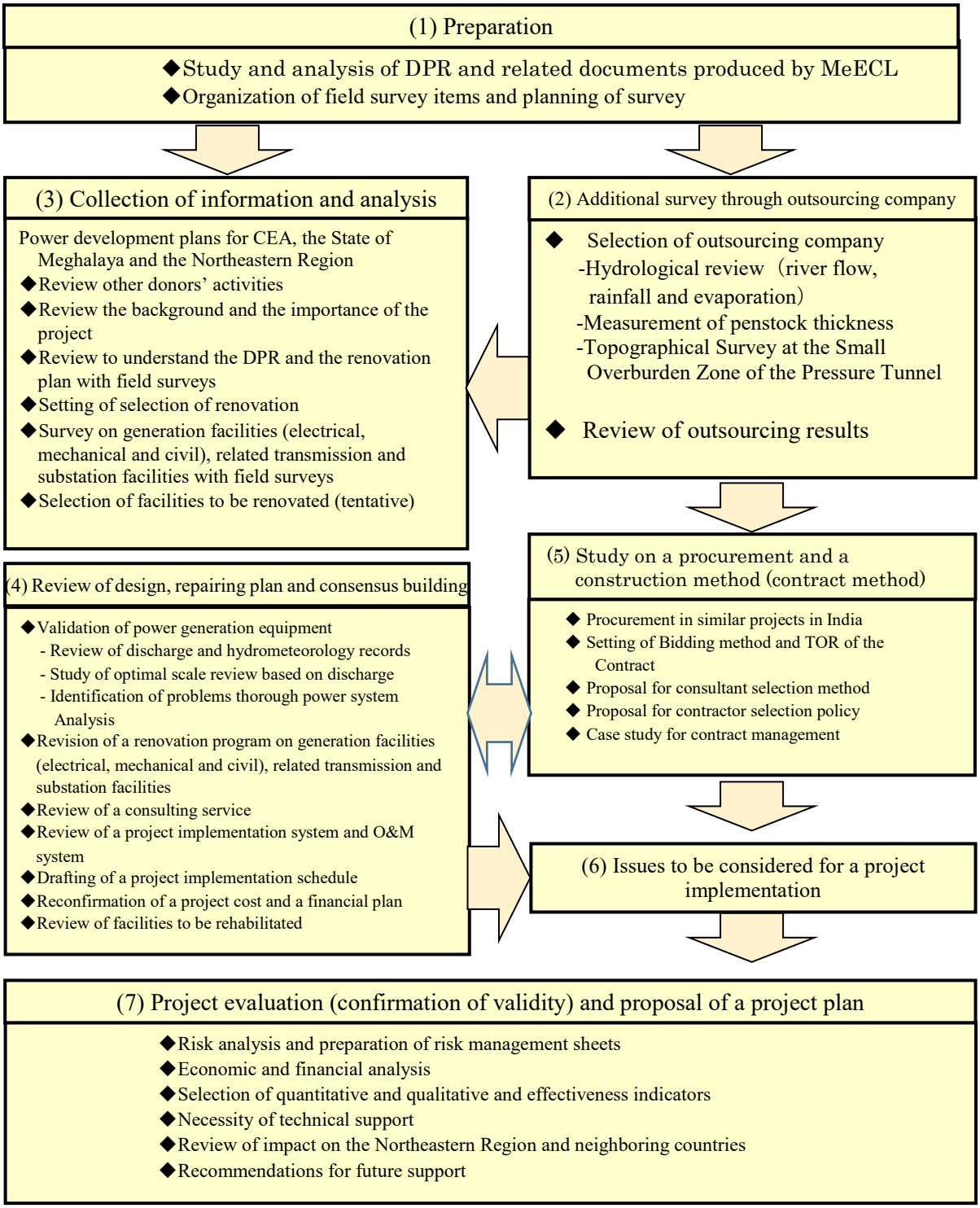
(4) **Field survey with due attention to safety management and health management**

(a) Safety management

With regard to safety information, the JICA Survey team collects it from JICA Headquarters and the India Office of JICA by maintaining a good relationship. Moreover, all members of the JICA Survey team register themselves on “Tabiregi,” the overseas official site issued by the Ministry of Foreign Affairs. At the same time, the JICA Survey team requests close coordination and support for safety from relevant organizations and ministries of India.

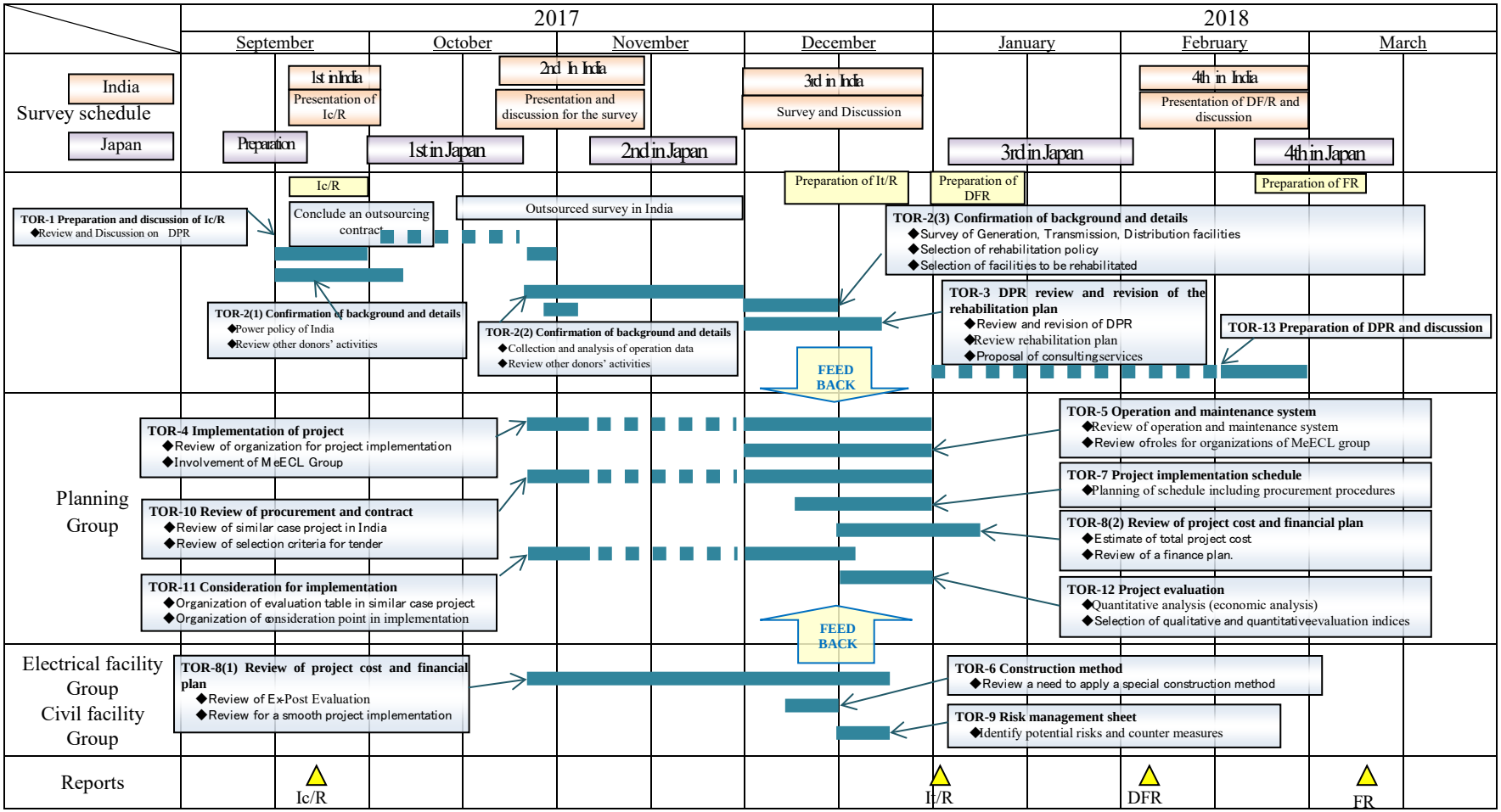
2.3 Methodology of Implementation

The JICA Survey team carries out this study with four (4) field surveys and five (5) domestic works, including preparatory works. The basic workflow is shown below.


(1) Preparation
◆Study and analysis of DPR and related documents produced by MeECL
◆Organization of field survey items and planning of survey
(3) Collection of information and analysis
Power development plans for CEA, the State of Meghalaya and the Northeastern Region
◆Review other donors' activities
◆Review the background and the importance of the project
◆Review to understand the DPR and the renovation plan with field surveys
◆Setting of selection of renovation
◆Survey on generation facilities (electrical, mechanical and civil), related transmission and substation facilities with field surveys
◆Selection of facilities to be renovated (tentative)
(2) Additional survey through outsourcing company
◆ Selection of outsourcing company
-Hydrological review (river flow, rainfall and evaporation)
-Measurement of penstock thickness
-Topographical Survey at the Small Overburden Zone of the Pressure Tunnel
◆ Review of outsourcing results
(5) Study on a procurement and a construction method (contract method)
◆ Procurement in similar projects in India
◆ Setting of Bidding method and TOR of the Contract
◆ Proposal for consultant selection method
◆ Proposal for contractor selection policy
◆ Case study for contract management
(4) Review of design, repairing plan and consensus building
◆Validation of power generation equipment
- Review of discharge and hydrometeorology records
- Study of optimal scale review based on discharge
- Identification of problems thorough power system Analysis
◆Revision of a renovation program on generation facilities (electrical, mechanical and civil), related transmission and substation facilities
◆Review of a consulting service
◆Review of a project implementation system and O&M system
◆Drafting of a project implementation schedule
◆Reconfirmation of a project cost and a financial plan
◆Review of facilities to be rehabilitated
(6) Issues to be considered for a project implementation
(7) Project evaluation (confirmation of validity) and proposal of a project plan
◆Risk analysis and preparation of risk management sheets
◆Economic and financial analysis
◆Selection of quantitative and qualitative and effectiveness indicators
◆Necessity of technical support
◆Review of impact on the Northeastern Region and neighboring countries
◆Recommendations for future support

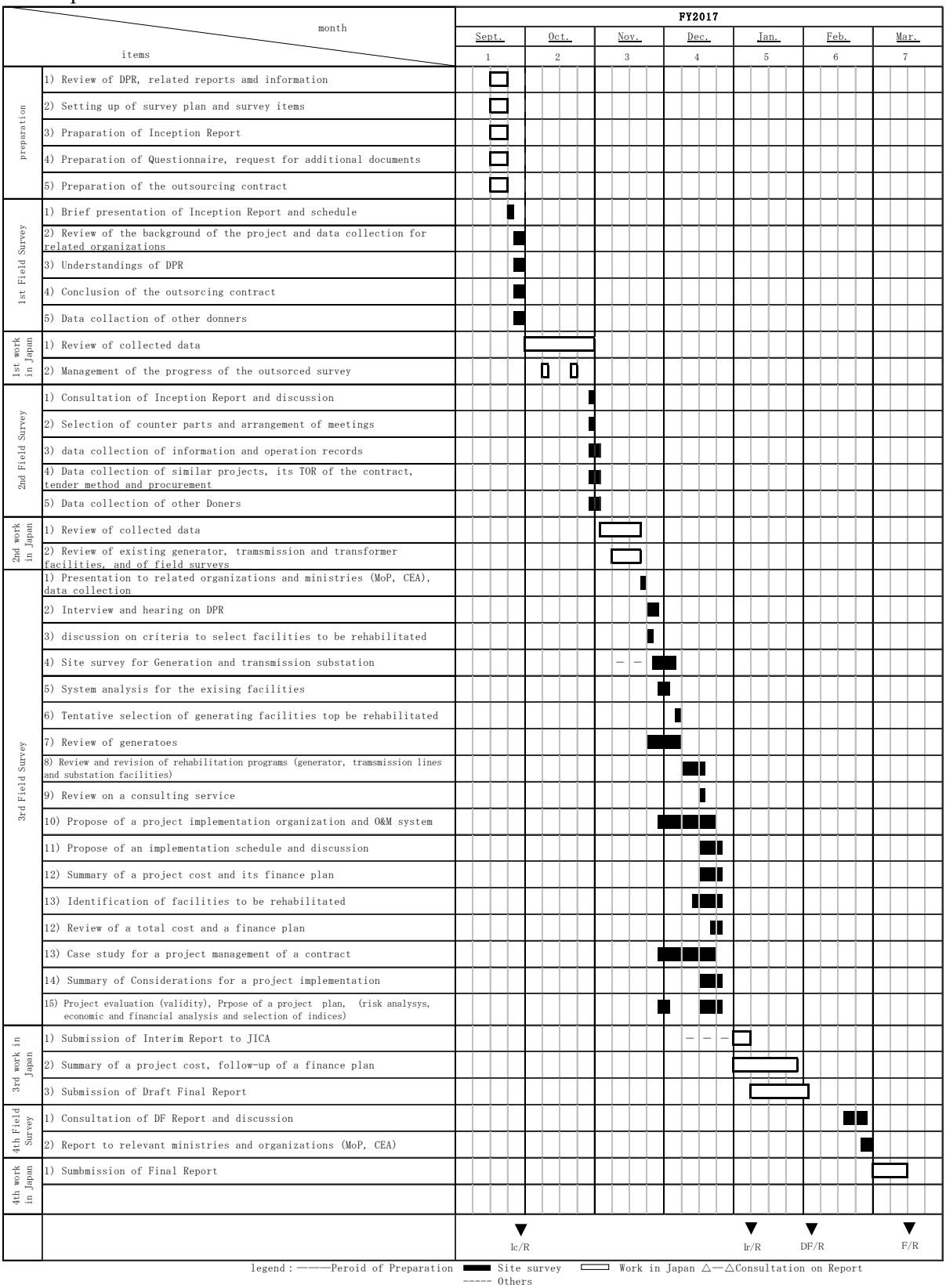
2.4 Flow Chart of Survey

The outline of the project is summarized in the following flow chart:



2.5 Work Plan

The work plan is as follows:



Chapter3 Power Sector of India

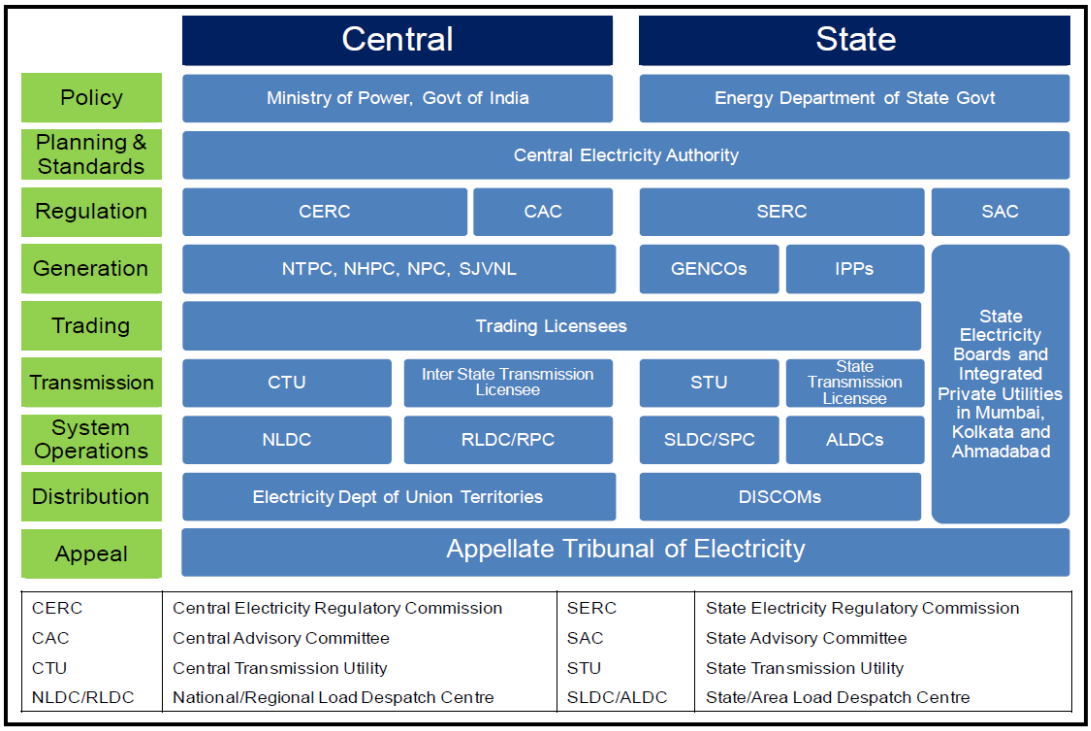
3.1 Organization of Power Sector in India

3.1.1 Overall Structure of Indian Power Sector

The Indian Power Sector consists of two parts: the Central Government side and the State side. On the Central Government side, the Ministry of Power and Ministry of Renewable Energy governs this sector. The Central Electricity Authority (CEA) supports the Ministry of Power from a technical viewpoint and the Central Electricity Regulatory Commission (CERC) supports from a regulatory viewpoint.

On the State side, the Energy Department of State Government governs the power sector of the State, with regulatory support by the State Electricity Regulatory Commission (SERC).

Generation can be operated without license. It is owned and operated by a mixture of Central, State and Private entities. Transmission is largely owned by State and Central utilities with a few private participants. Distribution is largely state owned.



(Source: Petition for the Approval of Business Plan and Annual Revenue Requirement for FY2015-16 to FY2017-18 (MePGCL))

Figure 3-1 Overall structure of Indian Power Sector

3.1.2 The North Eastern Region and Meghalaya State

With regard to power development in the North Eastern Region, North Eastern Electric Power Corporation Ltd. (NEEPCO) was incorporated in 1976 and owned by the Government of India under

the Ministry of Power. Role of NEEPCO is to plan, investigate, design, construct, generate, operate & maintain power stations in the North Eastern Region. According to the official website of NEEPCO, it operates 4 hydro, 3 thermal and 1 solar power stations with a combined installed capacity of 1347MW as shown in Table 3-1. And also NEEPCO has 3 power projects under development which include 110MW Pare HEP and 600MW Kameng HEPP.

Table 3-1 NEEPCO Power Plants under Operation

No.	Name of Power plant	Type	Installed capacity (MW)	Location (State)
1	Rangandi	Hydro	405	Arunachal Pradesh
2	Doyang	Hydro	75	Nagaland
3	Kopili	Hydro	275	Assam
4	Tuirial	Hydro	60	Mizoram
5	Assam	Gas Thermal	291	Assam
6	Tripura	Gas Thermal	101	Tripura
7	Agartala	Combined Cycle	135	Tripura
8	Solar PV Project	Solar	5	Tripura
		Total (MW)	1,347	

(Source: NEEPCO Web site)

Next, the Ministry of Development of North Eastern Region (MDoNER) was established in 2001. MDoNER covers a wide area of infrastructures: road, telecommunication, railroad and power etc. It mainly acts as a facilitator between the Central Ministries/ Departments and the State Governments of the North Eastern Region. As of December 2017, 98,650 million INR (US$1.5 billion or €1.3 billion) power transmission grid project approved in 2014 is said to be being implemented of which 2,540 km lines already laid, and 16 hydro power projects of 5,676 MW being implemented and additional 694 MW projects already implemented.

Regarding power utility in the Meghalaya state, the Meghalaya State Electricity Board (MeSEB) was constituted under Section (5) of the electricity (Supply) Act 1948 by the Government of Meghalaya (notification no. PE 304/74 dated 21/12/1974). The board came into existence on 21 January in 1975 after bifurcation of Assam State into Assam State and Meghalaya State, and bifurcation of Assam SEB into Assam SEB and Meghalaya SEB.

In order to bring about accountability, transparency, competitiveness, reduction of losses and improved performance for better customer satisfaction, the government unbundled MeSEB into four corporations under the Meghalaya Power Sector Reforms Transfer Scheme 2010.

The newly formed corporations are:

- Meghalaya Energy Corporation Limited (MeECL); the holding company
- Meghalaya Power Distribution Corporation Limited (MePDCL); the distribution utility arm
- Meghalaya Power Generation Corporation Limited (MePGCL); the generation utility arm
- Meghalaya Power Transmission Corporation Limited (MePTCL); the transmission utility arm

There are the other relevant organizations established by the Government of Meghalaya as follows.

- Meghalaya State Electricity Regulatory Commission (MSERC); a statutory body responsible for licensing transmission, distribution and trade of electricity (power transaction from MePGCL to MePTCL, and power transaction to MePDCL via MePTCL) in the State
- Meghalaya State Designated Agency (MSDA); the Senior Electrical Inspector for the implementation of Energy Conservation activities and efficiency
- Meghalaya New and Renewable Energy Development Agency (MNREDA); a State Nodal Agency for the Ministry of New and Renewable Energy Sources, the Government of India

3.1.3 Power Sector Policy in India

(1) **Initiative of the Central Government**

The Government of India is committed to improving the quality of life of its citizens through higher electricity consumption. The aim is to provide each household consistent access to electricity. The 'Power for All' program is a major step in this direction. Under this policy, the Government of India and the Government of Meghalaya issued a joint initiative "24x7 POWER FOR ALL MEGHALAYA" in March 2015, which aims to further enhance the satisfaction levels of the consumers and improve the quality of life of people through a 24x7 power supply. The Government of Meghalaya is attaching the highest priority to the power sector and the power supply position is constantly being reviewed. The State is committed to provide full support to all utilities for ensuring a quality power supply. Therefore, it is expected that this initiative will lead to the rapid economic development of the state in primary, secondary & tertiary sectors resulting in inclusive development.

Regarding renovation of the existing power station, the CEA held a national workshop on "Renovation, Modernization, Uprating & Life Extension of Hydro Power Plants" in December 2016, and stated in the workshop that Renovation, Modernization, Uprating & Life Extension of old hydro power plants has been given high priority by the Government of India as it is considered a faster and cheaper option for increasing supply capacity in comparison to installing new units and for improvement in its operational reliability & efficiency.

(2) **Power Policy of Meghalaya State**

The governor of Meghalaya released "The Power Policy 2007 of the Government of Meghalaya", which is the latest policy in the power sector. The following is stated in the Power Policy.

Regarding generation, the policy stated that "In order to meet the increasing power demand and to harness the untapped power potential of the state, both hydro and thermal, the Government of Meghalaya has decided to involve the State Sector, Joint Sector, Central Sector and Private Sector for execution of power projects". Among this, the Central Sector is defined as an undertaking of the Government of India. The organizations related to power policy of Meghalaya state are as follows.

- North Eastern Electric Power Corporation Limited (NEEPCO); an organization established under the Ministry of Power as explained in section 3.1.2.
- National Hydroelectric Power Corporation (NHPC); an Indian Hydropower generation company was established to plan, promote and organize integrated and efficient hydropower development
- National Thermal Power Corporation (NTPC); The largest power utility in India with the aim of becoming the world's largest and best power major, also contributes to the economic development of the nation and upliftment of the society
- Damodar Valley Corporation (DVC); A government organization was established with the concept to control the wild and erratic Damodar River and operates hydro and thermal power stations in the Damodar River area of West Bengal and Jharkand states
- Oil and Natural Gas Corporation (ONGC); The largest producer of crude oil and natural gas in India, aiming to become the global leader in integrated energy business through growth, knowledge excellence and exemplary governance practices

Development of the power project was encouraged in this power policy, especially for the projects utilizing the potential in the state including hydropower and coal thermal power at the time.

3.2 Approval Procedure for a Power Project

The approval procedure for requesting an ODA loan is summarized and shown in Figure 3-2.

Current status of the approval procedure for the Umiam Umtru Stage III renovation project is as follows.

- Approval of DPR by the CEA: letter issued on 28 November 2014
- Meghalaya state requested funds from Ministry of Finance: letter issued on 10 October 2016
- Ministry of Finance of India approves trying of fund: letter on 1 August 2017
- Ministry of Finance of India has listed the project in the long list
- The Government of India issued an official request for a Japanese ODA Loan to the Government of Japan: letter in 29 August 2017.

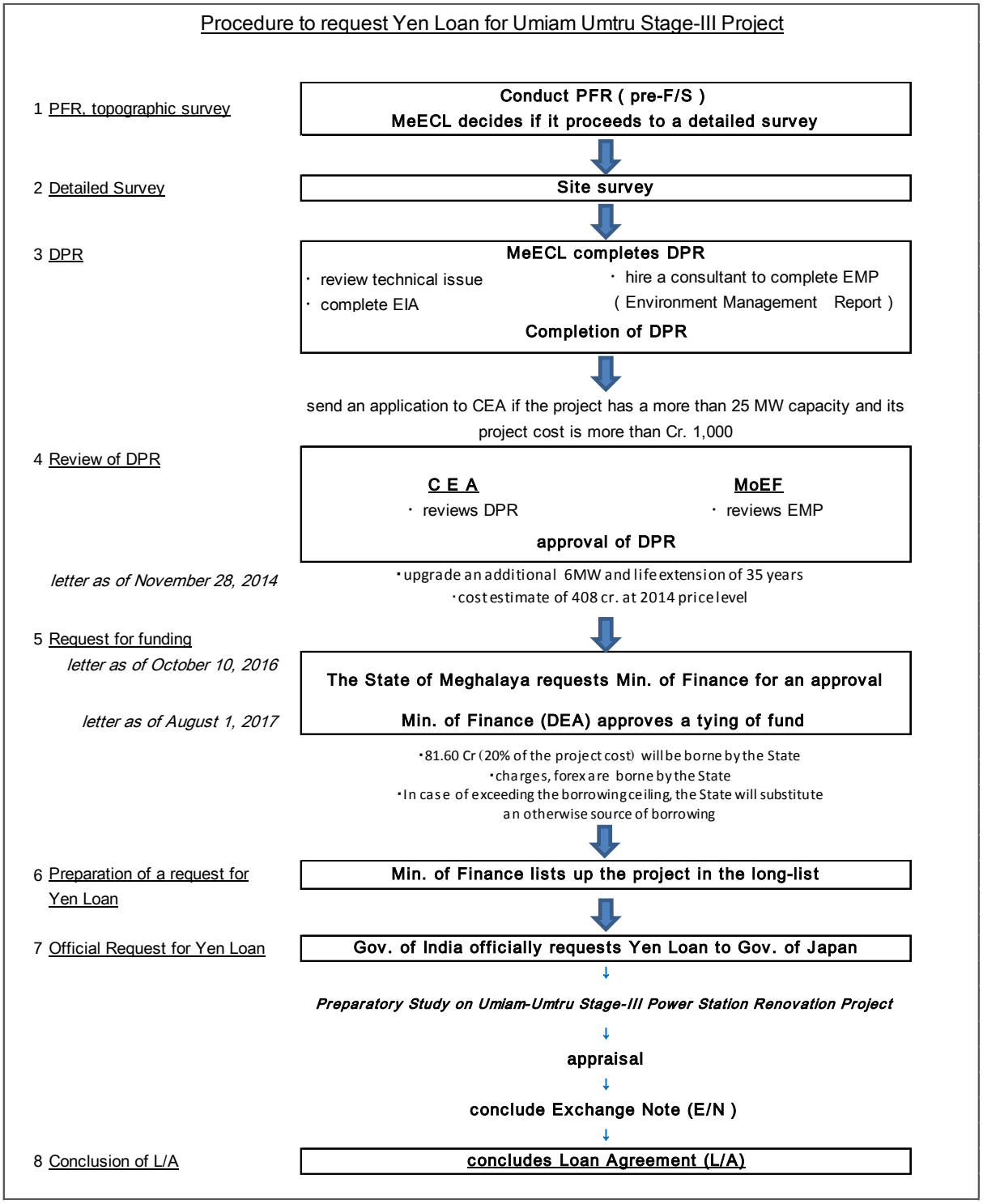


Figure 3-2 Approval procedure for a power project

3.3 Current Situation of the Support of Donors in Power Sector

3.3.1 World Bank

The World Bank has supported the strengthening and augmentation of the transmission and distribution networks in the northeastern region including the Assam and Meghalaya state. The World Bank approved a USD 470 million loan for the North Eastern Region Power System Improvement Project on 24 June, 2016. This project will lead to power supply improvement to a region whose economy is constrained by power shortage, and contribute to more efficient power transfer. In addition, the capacity building for the state departments and power utilities has been carried out in order to manage the network efficiently. After completion, the transmission and distribution lines created under this project will be transferred to the respective power utilities. This project is moving towards completion in March 2023.

3.3.2 Asian Development Bank

The Asian Development Bank (ADB) has contributed to power sector development in the Assam state. In the Assam state, power demand has grown much faster than power supply, and transmission and distribution losses are high. The power shortages that the Assam state faced have undermined the industrial competitiveness. Under these circumstances, the ADB and the Government of India are working together to strengthen the Assam Power Sector. The ADB has supported the Assam Power Sector Investment Program in order to upgrade power generation and distribution systems, including the construction of a 120 MW hydropower plant. The program includes financial management training and other support for staff of the state power company, Assam Power Generation Corporation and Assam Power Distribution Company, which will be implemented from 2013 to 2020.

Though the specified project has not been clarified yet, the ADB is planning to assist preparation survey of small hydro development for rural electrification in the Meghalaya state.

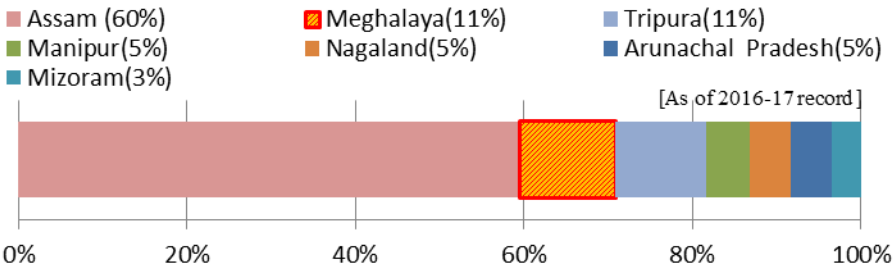
Chapter4 Supply Demand Balance in Meghalaya State

4.1 Current Situation of Supply Demand Balance in Meghalaya State

4.1.1 Electricity Demand (energy)

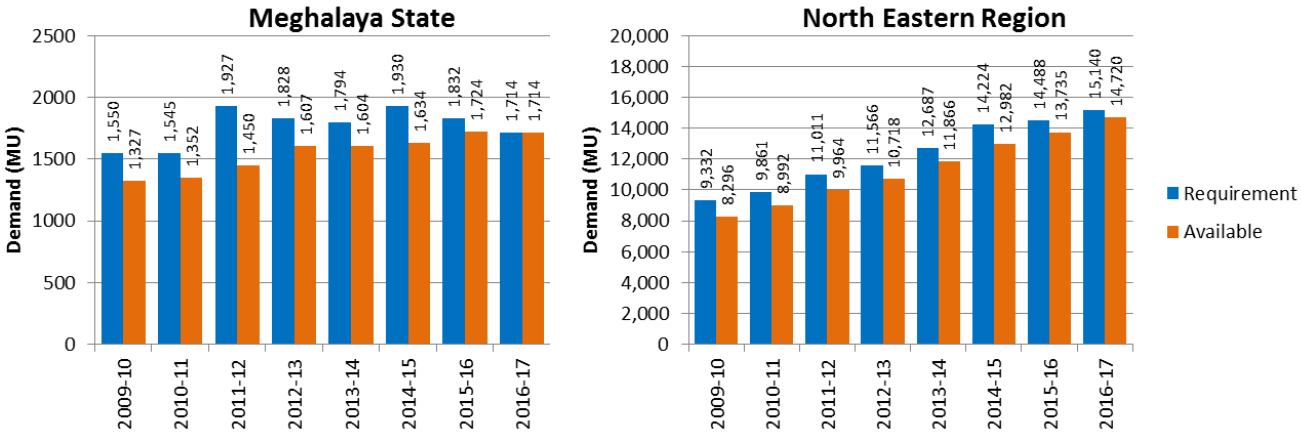
Figure 4-1 shows share of electricity consumption by states in the North Eastern Region. Share of the Assam state reaches 60%, and the Meghalaya state is the second largest in the electricity consumption of the North Eastern Region(1).

Historical records of electricity requirement and available supply in the Meghalaya state and in the North Eastern Region are shown in Figure 4-2. Electricity requirement in the North Eastern Region has been on an increasing trend, and the available supply has also been increasing year by year but it does not yet meet the requirement. As for the forecast on the balance in the Meghalaya state, the electricity requirement has been on a decreasing trend since fiscal year 2011-12, while the electricity requirement and availability were balanced in the fiscal year 2016-17.



(Source: JICA Survey team based on CEA LGBR data)

Figure 4-1 Share of Meghalaya State in electricity consumption of North Eastern Region



(Source: JICA Survey team based on CEA LGBR data)

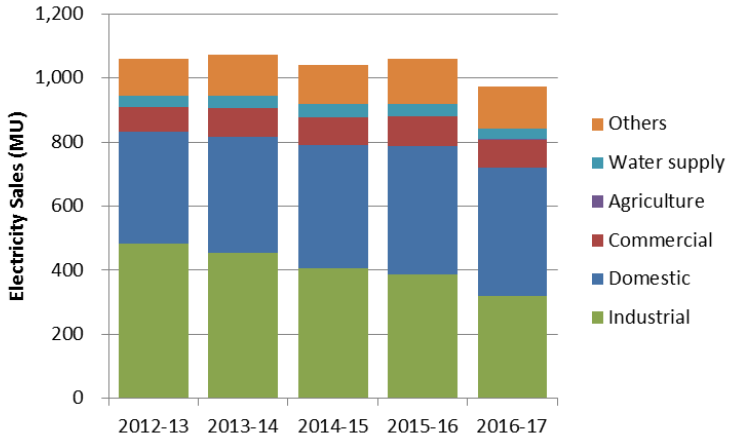
Figure 4-2 Energy requirement and availability

(1) North Eastern Region consists of eight states, including Sikkim state. Meanwhile the Sikkim state is categorized in the Eastern Region in the electricity record of CEA. Therefore, the Sikkim state is not included in the North Eastern Region in this report.

Figure 4-3 shows the composition of electricity sales in the Meghalaya state by category. According to this record, the electricity sales of the domestic category are constantly increasing but that of industry sales has been decreasing at a greater rate. Therefore, total sales are on a decreasing trend.

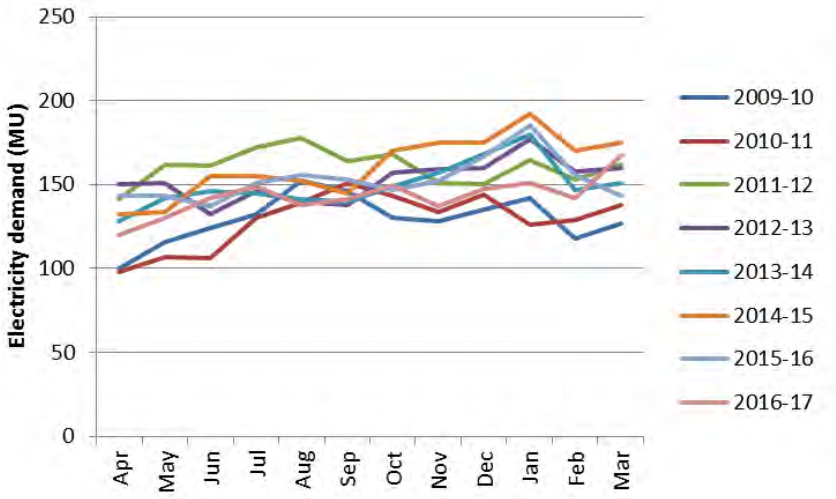
It seems that most of the reason for the decrease of the industrial consumption is the withdrawal of large factories. Especially, the fact that iron & steel factories withdrew from the Meghalaya state is especially problematic; more than half of the contracted capacity to the factories was dropped in the high voltage power supply from 2012 to date. It is analyzed and explained by MePDCL that the main reason for the reduction of the gap is expected to be the movement of industrial firms to the other state because of the revision of the "North East Industrial & Investment Promotion Policy (NEIIPP)" in 2016 which set limitations on the capital investment of subsidy. The NEEIIPP is the policy announced by the Department of Industrial Policy & Promotion, the Ministry of Commerce and Industry and target state is the northeastern state including the Sikkim state.

The monthly change of electricity demand over the past eight years is shown in Figure 4-4. Electricity demand in December and January seems higher than in other months, because a lot of electricity is consumed for heating during winter season.



(Source: JICA Survey team based on MePDCL data)

Figure 4-3 Composition of electricity sales by category

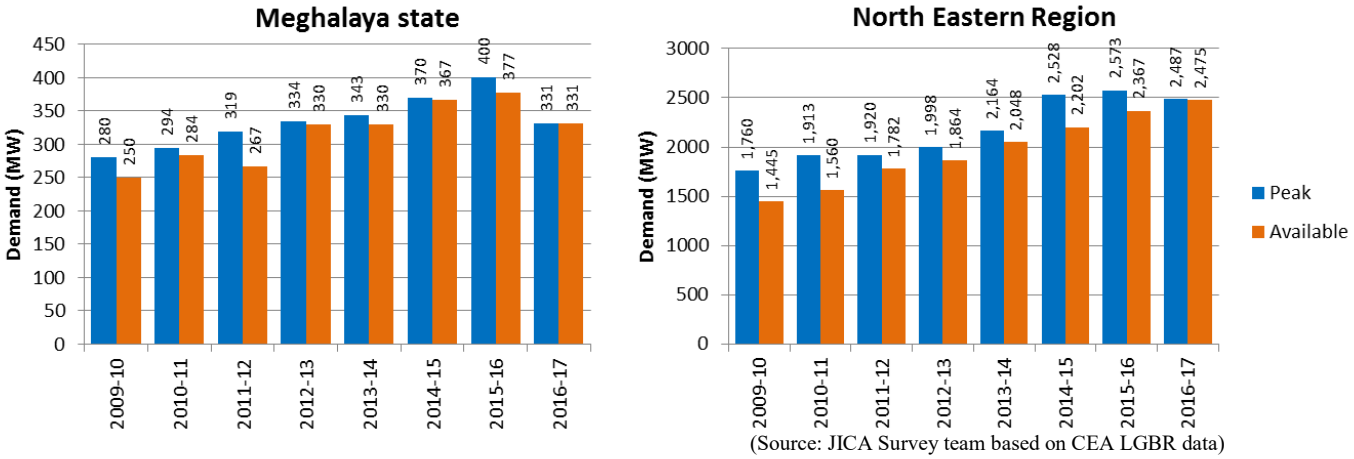


(Source: JICA Survey team based on CEA LGBR data)

Figure 4-4 Monthly change of electricity demand (Energy)

4.1.2 Peak Demand

Peak demand and available supply in the North Eastern Region and Meghalaya state were increased by the fiscal year 2015-16, and then decreased in 2016-17. The main reason for this decrease, which is explained by MePDCL, is the withdrawal of industrial factories as explained in the previous section.



(Source: JICA Survey team based on CEA LGBR data)

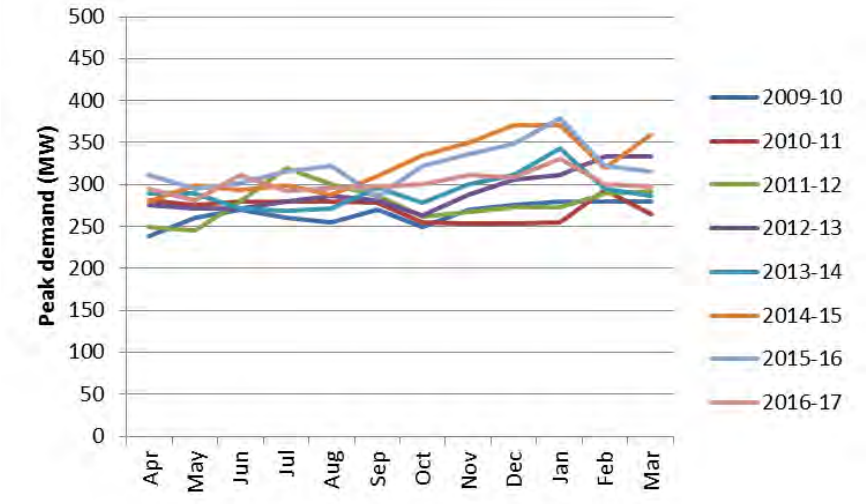
Figure 4-5 Peak demand and available supply

According to the power policy 2007 of the government of Meghalaya, unrestricted peak demand for the year 2007-08 was 610 MW; among this about 70% is shared by industry. The unrestricted demand is defined in MePDCL as total capacity of a contract. Accordingly, it is higher than the actual peak demand.

As a result, the peak demand and available supply were almost balanced though the peak supply was still not sufficient since a reserve margin for a stable power supply which is usually more than 10% of

demand was not secured. In addition, rural electrification progressed and remained with the capacity to be increased by only an expected few MW. Therefore, the impact to the demand forecast seems insignificant.

Figure 4-6 shows the monthly change of the peak demand during the past eight years. Peak demand of the year appears in January, which is the dry season and less discharge for hydropower generation is available.



(Source: JICA Survey team based on CEA LGBR data)

Figure 4-6 Monthly change of peak demand

4.2 Power Supply in Meghalaya State

4.2.1 Measures to Meet Electricity Demand

To meet the demand of the Meghalaya state, generation of MePGCL is not enough. To fulfill the deficit, the following schemes have been introduced and utilized in planning and dispatching.

Power banking and power market are operated in the whole of India, and the power trading scheme limited in the northeastern state has not been established. In addition, the power trading between the northeastern state and the neighboring countries have not been implemented.

(1) **MePGCL's power stations**

Generation of power stations owned by MePGCL

(2) **Power share (allocation of power supply)**

Obtaining share and receiving electricity from allocated Central Government's power stations

(3) **Power banking**

Bilateral contract with other states; providing surplus electricity in the wet season and receiving the same amount of electricity in the dry season. The Meghalaya state has already exchanged the Power through the Power banking system with the state of Orissa, Kashmir, etc. Power transaction cost is not incurred in the Power banking system. (Consignment fee is beared by receiving State)

(4) **Power market**

Buying / selling electricity at a power market. The power trading is implemented every 15 minutes and the prices are determined through selling and buying side bidding process. The actual record of power trade price is shown in .

4.2.2 Generation by MePGCL in Meghalaya State

MePGCL owns eight (8) hydropower stations and generates electricity. Total installed capacity increased to 354.7 MW, since New Umtru HEPP, which has an installed capacity of 40 MW, was commissioned in July 2017.

Currently three (3) hydropower projects are in the construction stage and the installed capacity is expected to increase by 27 MW by the year 2021.

According to the information from the Meghalaya Government, there are about 3,000 MW of hydropower potential in the Meghalaya state, but only 12% has been developed so far. MePGCL has continuously worked to study plans for candidate hydropower projects as listed in Table 4-3. Preparation of DPR for the expected projects has progressed.

Table 4-1 Power stations in Meghalaya state

No.	Name of power plant	Installed capacity (MW)	Available capacity (MW)	Owner	Commissioning year
1	Umiam Stage I	36.0 (4x9MW)	36	MePGCL	1965, R&M 2002 completed
2	Umiam Stage II	20.0 (2x10MW)	20	MePGCL	1970, R&M 2012 completed
3	Umiam Umtru Stage III	60.0 (2x30MW)	28	MePGCL	1979
4	Umiam Umtru Stage IV	60.0 (2x30MW)	60	MePGCL	1992
5	Umtru	11.2 (4x2.8MW)	0	MePGCL	1957-1968
6	Sonopani	1.5 (1x1.5MW)	1.3	MePGCL	2010
7	Myndu Leshka	126.0 (3x42MW)	126	MePGCL	2012-2013
8	New Umtru	40.0 (2x20MW)	40	MePGCL	1st unit: July 2017
Total		**354.7**	**311.3**		(as of Nov.2017)

(Source: MePGCL)

Table 4-2 Power stations under construction stage

No.	Name of power plant	Installed capacity (MW)	Stage (as of Nov. 2017)	Owner	Commissioning year
1	Lakroh Mini Hydro	1.5	under construction stage 97% completed	MePGCL	Sep.2018
2	Ganol Small Hydro	22.5	under construction stage 43% completed	MePGCL	Mar.2019
3	Riangdo Small Hydro	3.0	Construction Stage initiated	MePGCL	Mar.2021
Total		**27.0**			

(Source: MePGCL)

Table 4-3 Candidate power projects in Meghalaya state

No.	Name of Power plant	Type	Installed capacity (MW)	Stage	Owner
1	Tyrsaw Small Hydro	Hydro	1.8	DPR completed. Submitted to higher authority for approval. Statutory clearance from District Council/WRD under progress	MePGCL
2	Risaw Small Hydro	Hydro	0.1		MePGCL
3	Umran Small hydro	Hydro	0.2		MePGCL
4	Selim Storage	Hydro	170	DPR to be completed by December 2018	MePGCL
5	Myntdu Leshka Stage II	Hydro	280	DPR to be completed by March 2019	MePGCL
6	Mawblei	Hydro	140	DPR to be completed by December 2019	MePGCL
7	Nongkolait	Hydro	120	DPR to be completed by 2020	MePGCL
8	Umngi	Hydro	54	DPR to be completed by 2020	MePGCL
9	Umngot Stage I	Hydro		Draft DPR sent to CEA in June 2013	MePGCL
10	Ganol Stage II	Hydro	15	Survey & Investigation completed	MePGCL
11	Um Rina Stage I S	Hydro	5	Survey & Investigation 87.7% completed	MePGCL
12	Ummynrat M	Hydro	2	Survey & Investigation 70.7% completed	MePGCL
13	Sidugiri S	Hydro	7	Survey & Investigation 10% completed	MePGCL
14	Um Sangot M	Hydro	3	Survey & Investigation to start	MePGCL
15	Rongdi S	Hydro	10	Survey & Investigation to start	MePGCL
1	Umduma	Hydro	N/A	N/A	Private
2	Kynshi Stage I	Hydro	N/A	N/A	Private
3	Umjaut	Hydro	N/A	N/A	Private
4	Mawphu	Hydro	N/A	N/A	Private
5	Rangmaw	Hydro	N/A	N/A	Private
6	Kynshi Stage II	Hydro	N/A	N/A	Private
7	Thermal in Garo Hills	Thermal	N/A	N/A	Private
1	Um Sohra S	Hydro	5	Not yet decided	N/A
2	Upper Khri Diversion	Hydro	25	Not yet decided	N/A
3	Umlaphang	Hydro	28	Not yet decided	N/A
4	Umkhen Stage I	Hydro	120	Not yet decided	N/A
5	Nongnam	Hydro	50	Not yet decided	N/A
6	Mawput	Hydro	21	Not yet decided	N/A
7	Suchen	Hydro	65	Not yet decided	N/A
8	Umngot Stage II	Hydro	70	Not yet decided	N/A
9	Upper Kheri Stage II	Hydro	48	Not yet decided	N/A
10	Amagam Synrage(Rongdi)	Hydro	35	Not yet decided	N/A
11	UmSiang M	Hydro	2	Not yet decided	N/A
12	Riang M	Hydro	3	Not yet decided	N/A
13	Um Rilang Stage I S	Hydro	11	Not yet decided	N/A
14	Um Niangsiang M	Hydro	2	Not yet decided	N/A
15	Riangdo (Sidiguri)	Hydro	20	Not yet decided	N/A
Total			1,311		

(Source: MePGCL)

4.2.3 Share Allocation of Meghalaya State

Currently MePDCL has the rights for receiving electricity generation from the four firms as shown in Table 4-4, which is allocated to the Meghalaya state among the States. 320 MW of electricity is available to be received at the peak time according to this share allocation scheme. Firm allocation means the minimum certified amount for the Meghalaya state, and the firm allocation can be received definitely even during off-peak period.

Table 4-4 Share allocation of Meghalaya state

as of 2017, (MW)

Name of firm	Total capacity	Allocation to Meghalaya	
		Firm	Total for peak hrs
North Eastern Electric Power Corporation Ltd. (NEEPCO)	1,176	95.4	154.1
National Hydroelectric Power Corporation (NHPC)	105	8.1	13.1
ONGC Tripura Power Company Ltd. (OTPC)	726	79.0	79.0
National Thermal Power Corporation Ltd. (NTPC)	5,190	17.7	73.9
Total	7,197	**200.2**	**320.1**

(Source: MePDCL)

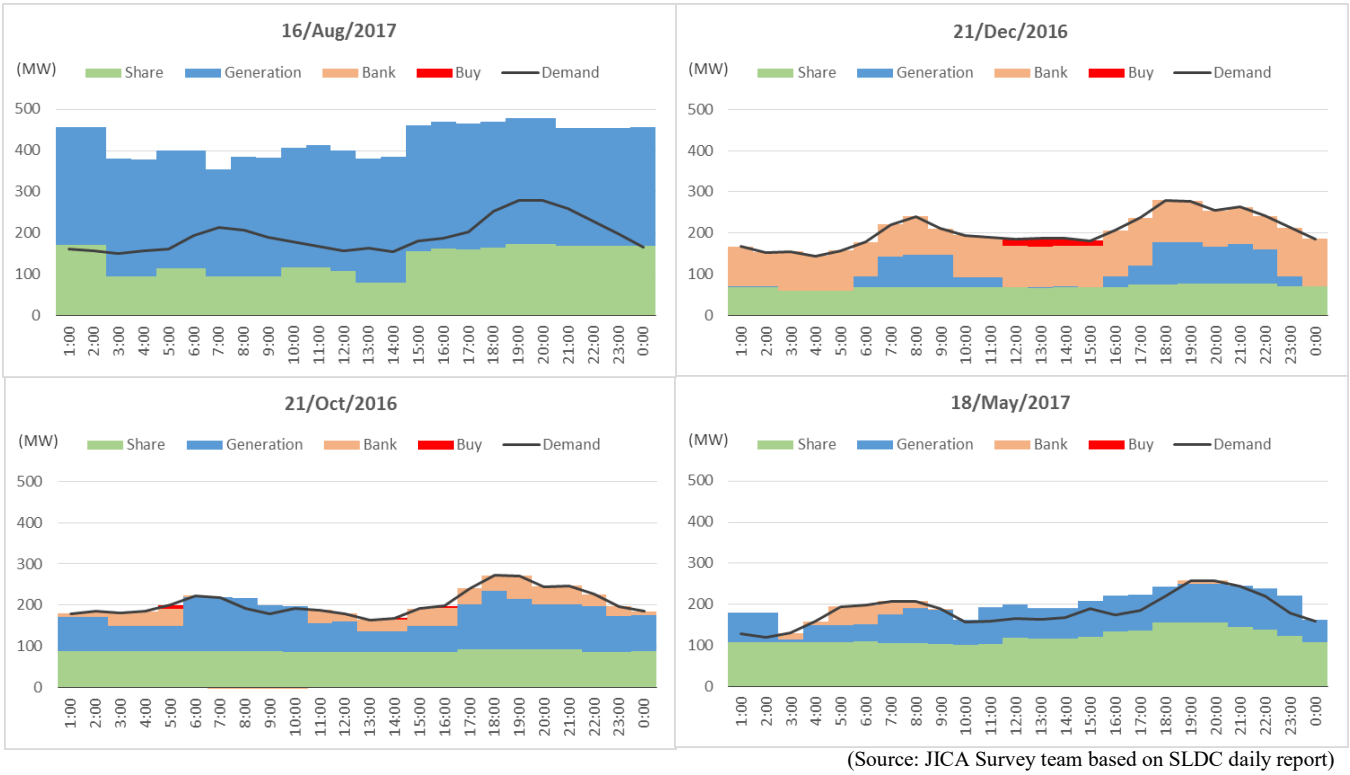
4.2.4 Current Situation of Power Supply

Available generation of HEPP varies depending on the season. During the wet season, available discharge for generation is large but it decreases during the dry season. The relation between demand and generation, including the source of generation, on a typical day in wet/dry/intermediate seasons is shown in Figure 4-7.

There are two peaks, in the morning and evening, which appear in every season. Power supply from power share is almost constant since generally allocated electricity needs to be received.

In August, which is in the wet season, power generation is larger than demand. The surplus electricity is sent to the power banking or sold at the power market. In December, during the dry season, hydropower stations supply power at the peak time, and a shortage of electricity is provided from power banking and buying at the power market, if necessary. As for the intermediate seasons, surplus/deficit is adjusted utilizing power banking.

Therefore, the power supply system is prepared and utilized to meet the electricity demand.



(Source: JICA Survey team based on SLDC daily report)

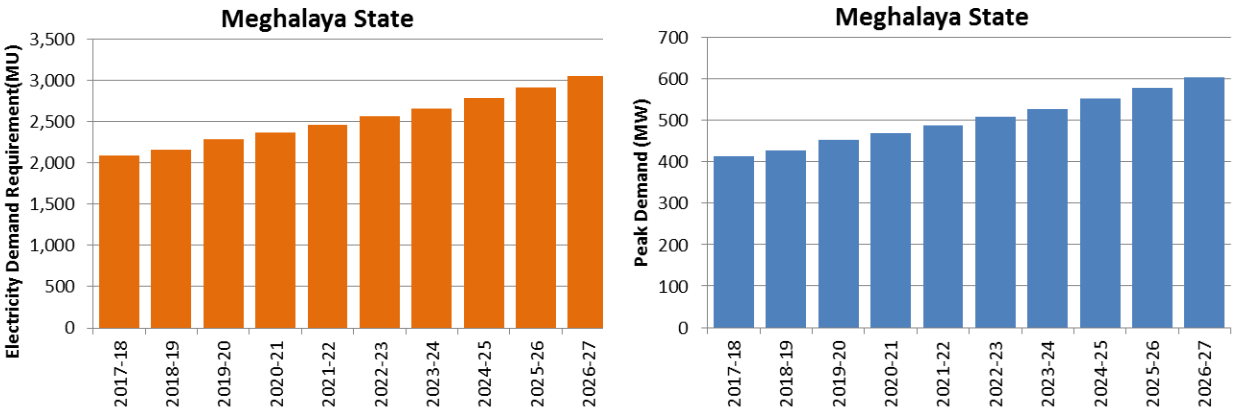
Figure 4-7 Typical record of power dispatching for rainy/dry/intermediate seasons

4.3 Power Supply Plan in the Future

4.3.1 Demand Forecast

(1) **Energy Requirement and Peak Demand**

According to the CEA "Report on Nineteenth Electric Power survey of India", a stable increase of electricity demand in Meghalaya state is expected as shown in Figure 4-8.



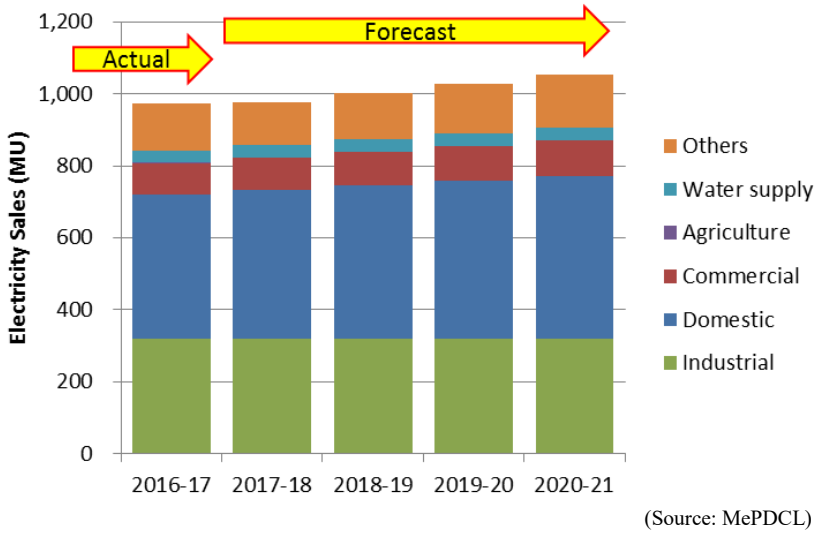
(Source: CEA, Report on Nineteenth Electric Power Survey of India)

Figure 4-8 Forecasted demand in MU and MW

The annual increase rate is applied in a range of 3.5% to 6.1%/year in this forecast, and peak demand is expected to increase by about 200 MW over ten years.

(2) **Energy Requirement by Category**

The projection of electricity demand in sales by category, studied by MePDCL, is shown in Figure 4-9. In this forecast, the increase of domestic demand is larger than other categories.



(Source: MePDCL)

Figure 4-9 Electricity demand forecast (sales)

4.3.2 Supply Plan

MePDCL also prepares the future plan for electric power supply as shown in Figure 4-10. According to this plan, sufficient electricity from power share and power banking is planned to be obtained in the near future.

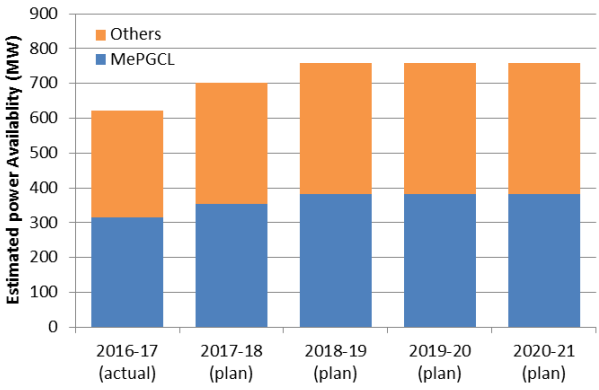


Figure 4-10 Planned Peak Power Availability of MePDCL

(Source: MePDCL)

4.3.3 Unit Cost of Electricity Supply

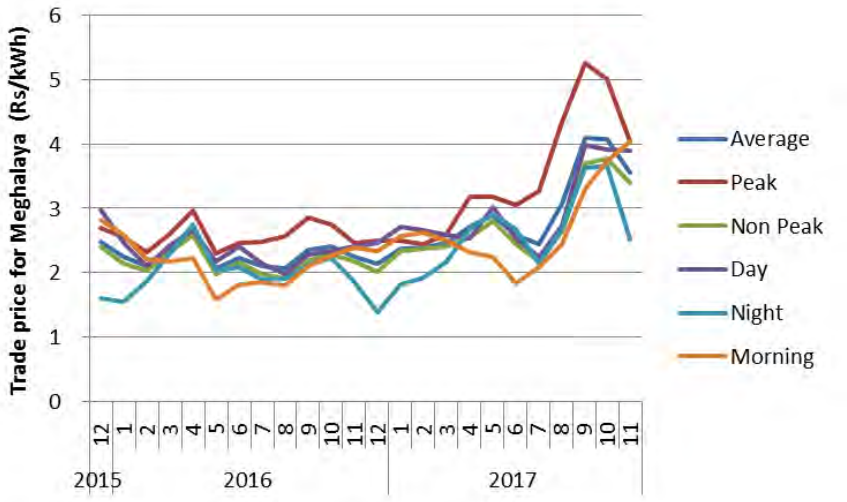
Table 4-5 show the average power purchase costs in FY 2017-18, which was approved by Meghalaya State Electricity Regulatory Commission (MSERC)[(2)]. Each purchase cost mainly reflects the different types of generation and the average costs of hydropower plants tends to be lower than those of thermal power plants. The Meghalaya State has remaining hydropower potential, so it seems reasonable to develop hydropower in the Meghalaya state for increasing power supply with lower generation cost.

Figure 4-11 shows the actual record of power trade price for the area including the Meghalaya state during the past two years. The trade prices are different depending on the time zone. The peak time price is the highest and recorded above 5 INR/kWh in September 2017. Even in the case of buying electricity outside of peak time, it seems that the trade prices are higher than MePGCL's unit cost.

Table 4-5 Comparison of unit cost

	Average unit cost (INR/kWh)	Note
MePGCL	2.28	Generated by HEPPs
Shared power stations (NTPC, OTPC, NEEPCO)	3.08 (average of all PPs)	35% higher than MePGCL's cost
	3.60 (average of TPPs)	58% higher than MePGCL's cost

(Source: MePGCL)



(Source: JICA Survey team based on IEX website data)

Figure 4-11 Actual record of power trade price (IEX)

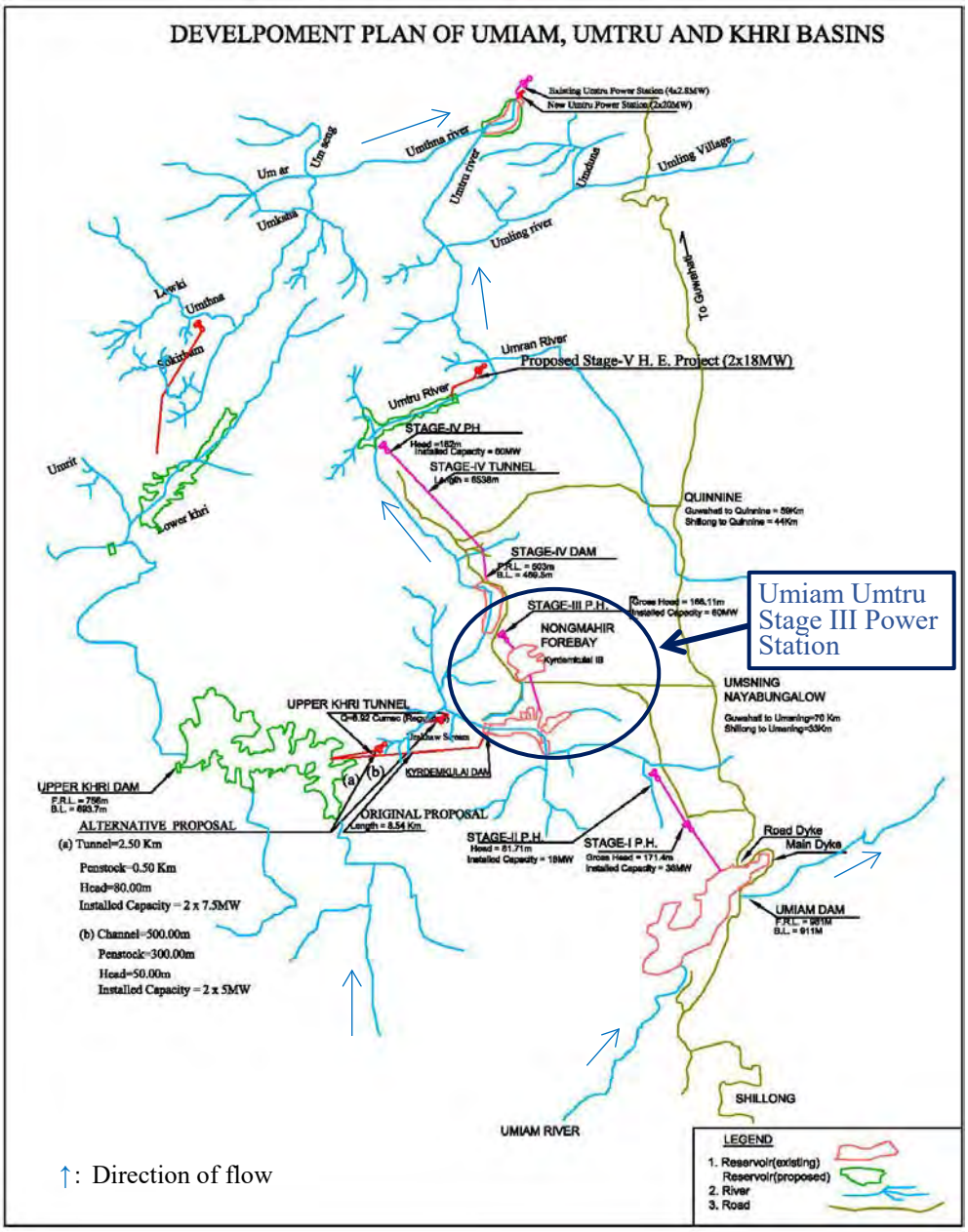
(2) The average unit cost is considered as an index, which includes the depreciation, O & M Cost and so on, though the cost break down are not published by MSERC.

Chapter5 Current Condition of Umiam Umtru Stage III HEPP

5.1 General Outline

5.1.1 Location

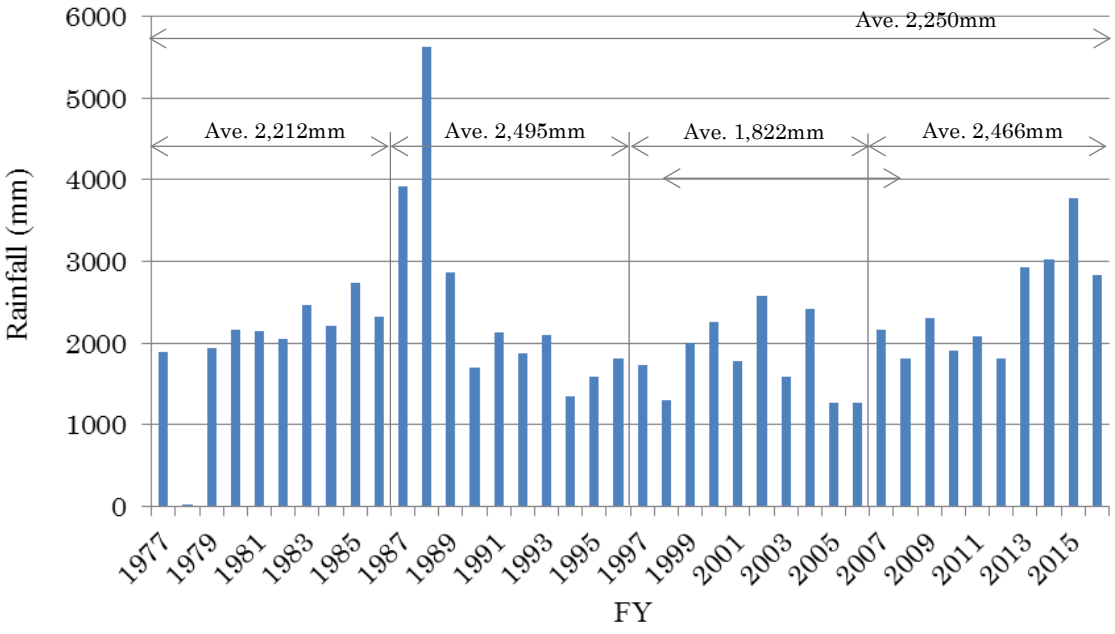
Umiam Umtru Stage III HEPP is located on the Umtru river basin in Meghalaya state, the North Eastern Region of India, which is located downstream of Umiam Stage I and Stage II HEPPs.



(Source: MePGCL)

Figure 5-1 Location of Umiam Umtru Stage III HEPP

The long-term series data in the Umiam Umtru basin is limited to the data at Barapani (Umiam) recorded by Indian Metrological Department (IMD). Figure 5-2 shows the transition of the annual rainfall. The data does not show decreeing trend of the rainfall. The area has 2 season, monsoon season and non-monsoon season. Most of rainfalls are brought in the monsoon season as shown in Figure 5-3.



Remark: Data in 1978 is not available

(Source: JICA Survey team based on data provided by MePGCL)

Figure 5-2 Annual rainfall at Barapani (Umiam) from 1977 to 2016

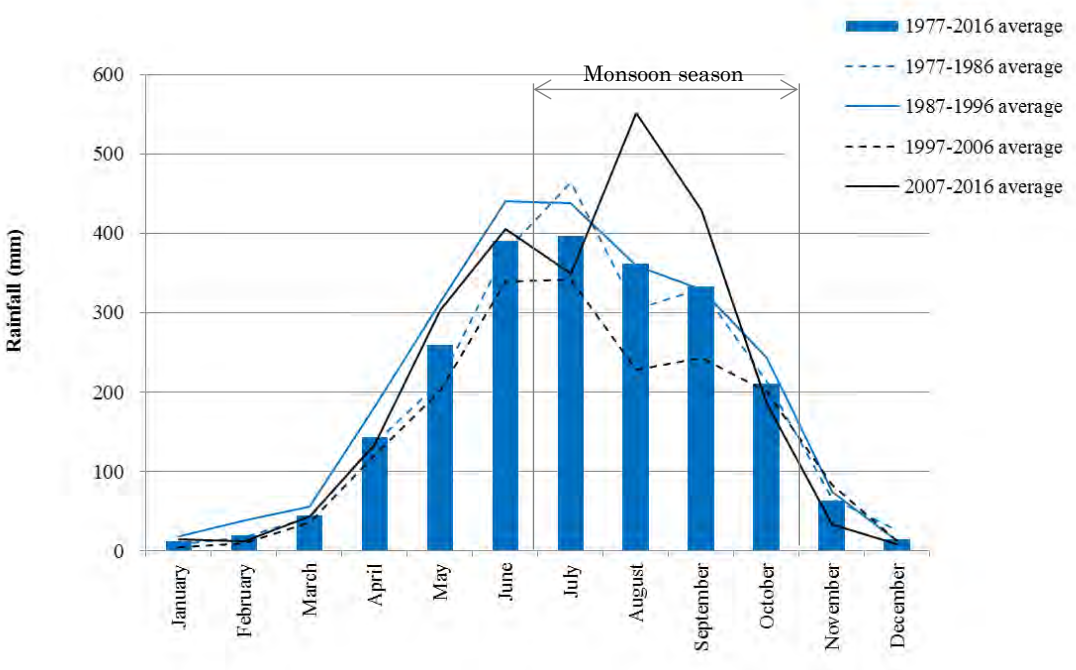


Figure 5-3 Monthly rainfall at Barapani (Umiam)

5.1.2 Design

Typical features of Umiam Umtru Stage III HEPP are shown in Table 5-1.

Table 5-1 Typical figures of Umiam Umtru Stage III HEPP

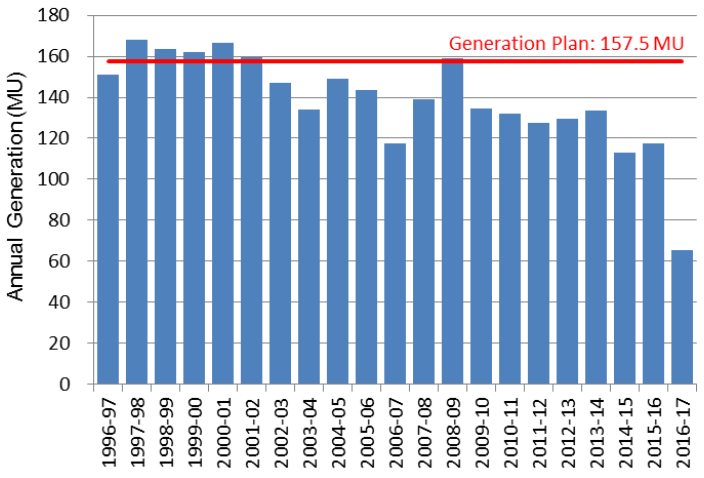
	Items	Features
General	Type Annual Generation (Plan) Commissioning year	Hydropower 125.4 MU 1979
Civil facilities	Reservoir - Kyrdemkulai Reservoir - Nongmahir Forebay	 Effective capacity : 2.8 million m^3 Effective capacity : 3.1 million m^3
	Dam - Kyrdemkulai dam - Nongmahir Dam (Main Dyke)	 Concrete Gravity, Height:30m Earthfill, Height:47m
	Waterway - Link tunnel - Pressure tunnel - Surge tank - Penstock - Tailrace	 Length: 2,840m, Diameter: 3m Length: 594m, Diameter: 4m Chamber, Height: 52m, Diameter:6.1m Nos: 2, Length: 433m, Diameter: 2.6m Open channel
Generating facilities	Rated output Type of turbine Height of net head Rotating speed	60 MW (30MW x 2 units) Vertical Frances type 162 m 429 min^{-1}

5.2 Performance of the HEPP

5.2.1 Generation

The annual generation record of Umiam Umtru Stage III HEPP is shown in Figure 5-4. According to this record, annual generation has been lower than planned generation and it has been on a decreasing trend for more than fifteen years.

It is believed that the main reason for this is the frequent electro-mechanical trouble as described in the following section.



(Source: JICA Survey team based on MePGCL data)

Figure 5-4 Annual generation record of Umiam Umtru Stage III HEPP

5.2.2 Forced Outage Records

The major failures of the Umiam Umtru Stage III HEPP are shown in Table 5-2. The number of failures related to runners is the largest. The total outage duration for two units is about 61,000 hours in 11 years. The percentage of forced outage hours is about 33%, and that percentage is very high, since the percentages of forced outage hours of Umiam Stage I, Umiam Stage II and Umiam Umtru Stage IV HEPP are 0.6%, 0.3%, and 3.4% respectively.

Considering only the total outage hours, it means that one of the two units is stopped due to failures in 70% of the operation hours. For the power plants that correspond to peak demand like Umiam Umtru Stage III, this means a decrease in value.

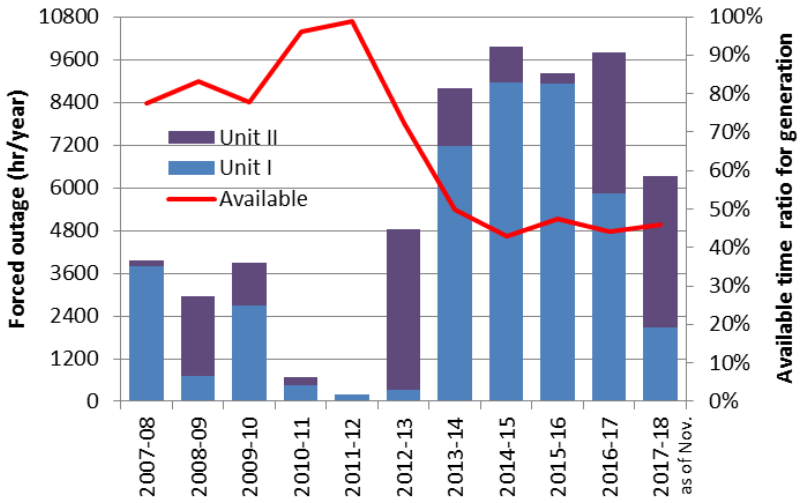
Figure 5-5 shows annual stoppage time by forced outage and ratio of available generation time in a year. Recently this power station has been forced to not be available to generate for more than half of a year. The main reason is a problem with the stator of the No.1 unit which requires long term stoppage for repair.

Table 5-2 Major Failures of Umiam Umtru Stage III HEPP in recent years

Event	Unit	Forced Outage		Outage Duration [hrs]
		Start	End	
Repair of Runner	1	22 Mar 2007	6 Jun 2007	1864:00
Failure of Runner	1	28 Aug 2007	23 Sep 2007	673:00
Heavy Vibration (Runner Replacement)	2	20 Oct 2007	30 Nov 2007	835:30
Failure of Runner	1	1 Dec 2007	27 May 2008	3570:10
Failure of Runner	2	23 May 2008	13 Nov 2008	1992:20
Repair of Runner	2	24 Mar 2009	30 Apr 2009	888:00
Failure of Runner	2	12 Jul 2009	14 Jul 2009	288:00
Failure of Runner	1	20 Nov 2009	19 Apr 2010	3596:00
Failure of Runner	2	19 Feb 2010	27 Feb 2010	210:00
Replacement of Pressure Relief Valve	2	20 Sep 2012	21 Jun 2013	6596:00
Failure of Stator	1	2 Jun 2013	17 Aug 2016	28128:00
Failure of Runner	2	31 May 2016	25 Sep 2016	2789:00
Main Inlet Valve Problem	1	22 Aug 2016	28 Sep 2016	888:00
Penstock Air Valve Problem	1	15 Oct 2016	3 Mar 2017	3333:20
Failure of Runner	2	11 Feb 2017	25 Sep 2017	5431:15
Failure of Runner	1	9 Sep 2017	Under Repair	
Total Hours				61082:35

* The yellow cells are failures related to the runners.

(Source: JICA MePGCL)



(Source: JICA Survey team based on MePGCL data)

Figure 5-5 Forced outage time and available time ratio for generation

5.3 Expected Annual Generation after Renovation

5.3.1 Performance of Neighboring Hydropower Stations

Umiam Umtru Stage III HEPP is located downstream of Umiam Stage I HEPP and Umiam Stage II HEPP. Both of these HEPPs have been rehabilitated by a Japanese ODA Loan and were completed in January 2003 and December 2011 respectively.

Table 5-3 Features of Umiam Stage I and Stage II HEPP

Item	Stage I	Stage II	(Stage III)
Renovation completed	Jan. 2003	Dec. 2011	-
Installed capacity	36 MW	20 MW	60 MW
No. of units	4	2	2
Unit capacity	9 MW	10 MW	30 MW
Net head	145 m	77.67 m	150 m
Design discharge (per unit)	7.7 m^3/s	15.47 m^3/s	23.4 m^3/s
Planned annual power generation	143 GWh	70 GWh	174.5GWh

(Source: JICA Survey team based on MePGCL data)

Annual generation records of these HEPPs are shown in Figure 5-6 and Figure 5-7. During the renovation, the target value for annual generation after renovation was set as shown in the Figures, and

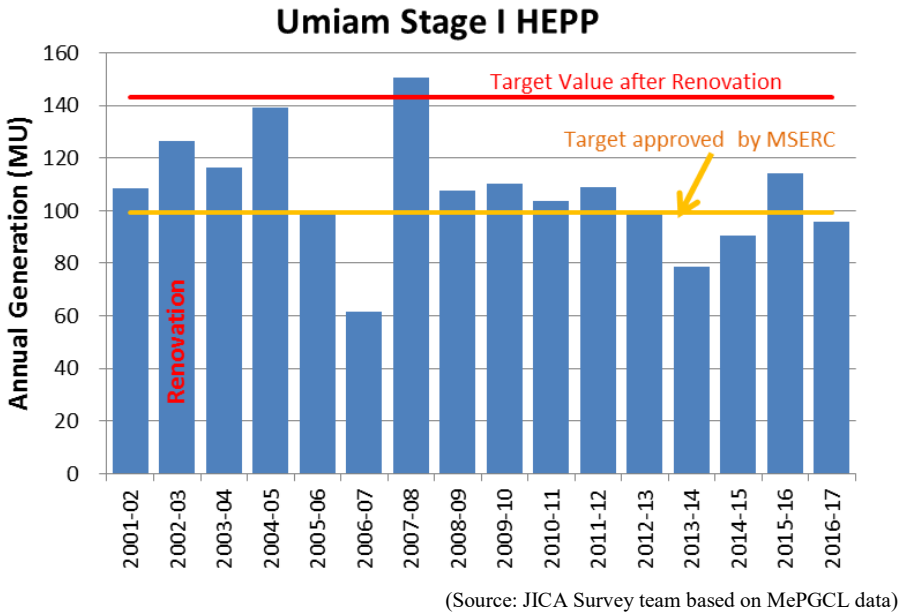
the target value of annual generation in both HEPPs were not achieved in the post-evaluation studies of JICA.

The target values of both HEPP are actually higher than generation records, which are almost the same value or above the 5% excess probability value of the current generation records as shown in Table 5-4. There are annual generation target for each HEPP approved by MSERC. This value is rather lower compare to the actual record but almost average. Therefore, the target values set at the renovation stage for both Stage I and Stage II are too high, and it seems reasonable for use the value approved by MSERC as an index value for annual generation.

Table 5-4 Evaluation of the target value of annual generation

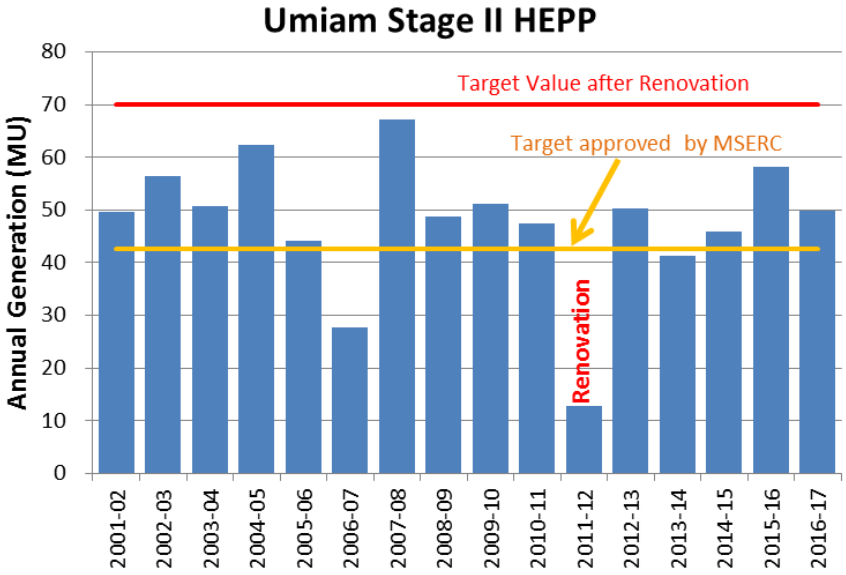
HEPP	Target value at renovation stage	Average FY2001-2006	Standard Deviation, σ	5% excess probability value (Average+1.65*σ)	Target value approved by MSERC
Stage I	143 MU	107 MU	21.4 MU	142 MU	99.45 MU
Stage II	70 MU	48 MU	12.9 MU	69 MU	42.65 MU

(Source: JICA Survey team based on MePGCL data, Tariff Order MESRC)



(Source: JICA Survey team based on MePGCL data)

Figure 5-6 Annual generation record of Umiam Stage I HEPP



(Source: JICA Survey team based on MePGCL data)

Figure 5-7 Annual generation record of Umiam Stage II HEPP

5.3.2 Index Value of Annual Generation for Stage III HEPP

As described in the above section, referring to the value of MSERC for the index of annual generation seems preferable. The approved annual generation for Umiam Umtru Stage III has been reduced as shown in Table 5-5. Therefore, 157.5 MU, which is the value before reduction which is also mentioned in the DPR, is reasonable for the index value of annual generation after renovation.

Table 5-5 Annual generation of Umiam Umtru Stage III HEPP

HEPP	Target value approved by MSERC	Note
Stage III	125.38 MU	FY2017-18, reduced because of troubles
	157.5 MU	Value before reduction, mentioned in DPR

(Source: JICA Survey team based on MePGCL, Tariff Order MESRC)

Chapter6 Necessity and Applicability of the Renovation Project

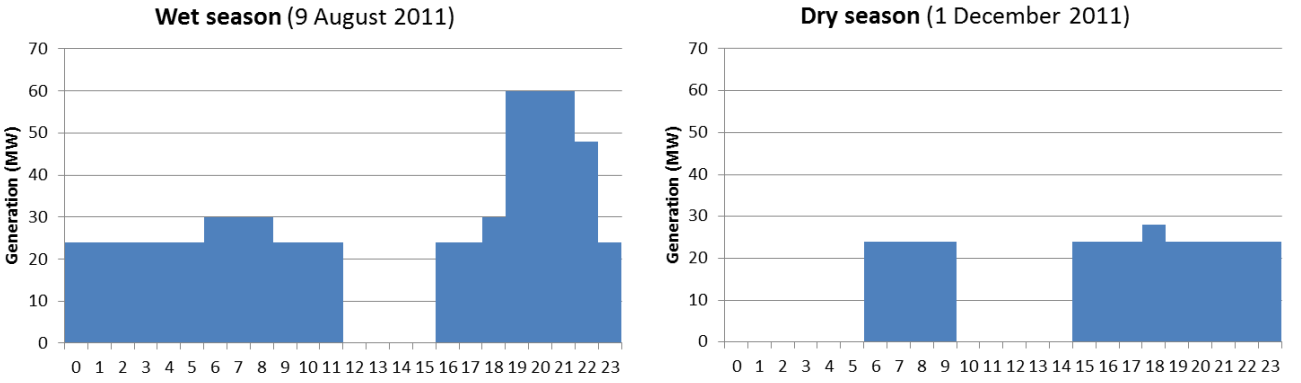
6.1 Confirmation of Necessity and Applicability

6.1.1 Necessity of Umiam Umtru Stage III HEPP

(1) **Current Role and Contribution of Umiam Umtru Stage III HEPP**

The installed capacity of Umiam Umtru Stage III HEPP is 60 MW, consisting of two units of 30 MW each. The share of this HEPP is 17% in installed capacity of MePGCL.

This HEPP has been utilized as a peak power supply. Typical daily generation records in wet and dry seasons are shown in Figure 6-1. Daily peak demand appears twice, in the morning and night. In both the wet/dry seasons, this HEPP generates peak times to meet the electricity demand. In the case of the wet season, the maximum generation was recorded during night peak hours and both of the units operated. In the case of the dry season, daily generation hours were shorter in the wet season since available discharge for generation was less. This is despite the fact that electricity was generated during peak hours. Therefore, this HEPP bears an important role as a peak power supply.



(Source: MePGCL)

Figure 6-1 Typical daily generation in wet/dry seasons when both units are available

(2) **Necessity of Renovation**

It is recommended that early renovation and recovery of stable generation be necessary due to the following reason.

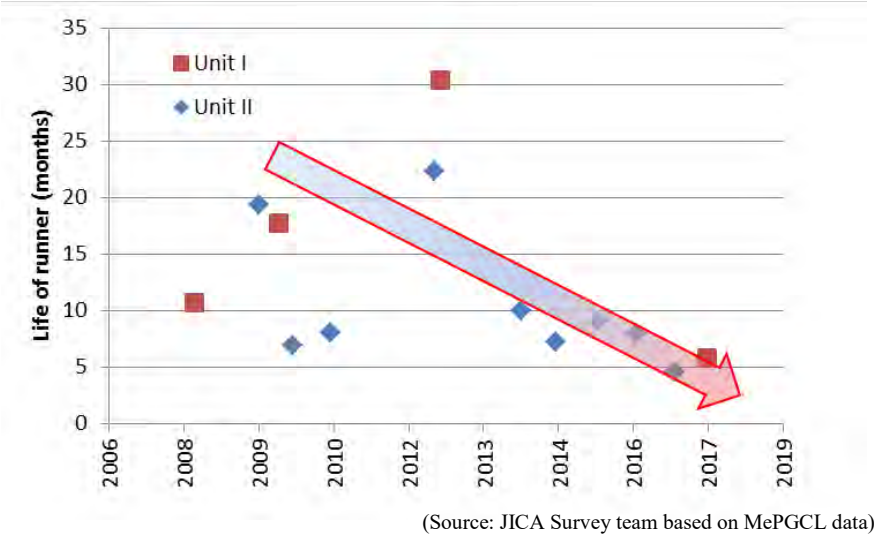
As described in Chapter 5, annual generation of Umiam Umtru Stage III HEPP has been low due to its frequent trouble including breakdown of the runners.

A runner is one of the most important pieces of equipment in the HEPP, and the runner performance is closely related to the generation. In general, runners are manufactured carefully in consideration of the site condition because the generation decreases as the runner deteriorates. In case of reservoir type hydroelectric power station having less sedimentation and application of turbine runner made of stainless steel material, it is expected that such runner will be used for more than 30 years.

For this reason, the breakdown of turbine runners for Umiam Umtru Stage III HEPP is rare case, but it has been happening many times in this HEPP. One of the major reasons for the issue seems to be improper design of a hydro turbine which is not specifically designed for this HEPP but instead is designed for several HEPPs that have different conditions.

When the runner is broken, it is transferred to the factory in order to repair it. The runner is reused after the repair. This measure is proper but it is difficult to repair the broken runner completely and repeated repairs cannot continue forever. It is expected that, therefore, generation of this HEPP will decrease further and the HEPP will not be able to generate at all in the near future based on the following current situations.

- The spare runner has been broken severely and further repair is impossible.
- Lifetime of the runner after repair has been on a decreasing trend. The lifetime is expected to decrease by less than five months after each repair. Refer to Figure 6-2.
- During the site survey with dewatering in December 2017, a crack was found in the repaired runner even though only three months had passed since re-start after the runner repair.



(Source: JICA Survey team based on MePGCL data)

Figure 6-2 Life time of repaired runner

6.1.2 Applicability of Renovation of Umiam Umtru Stage III HEPP

Expected advantages after implementation of Umiam Umtru Stage III HEPP renovation project are listed below. There seem to be no negative influences, including environmental impacts, observed in this project. Therefore, the renovation project of Umiam Umtru Stage III HEPP seems applicable for the candidate of the Japanese ODA Loan project.

<Expected advantages by the renovation>

- Improvement of reliability of generation by reducing forced outage
- Improvement of generation efficiency by introducing optimal design

- Increase of generation
- Preventing loss of 60MW generation capacity by extending life of the power station
- Increase of peak supply capacity of MePGCL; 6MW (10% of 60 MW)

6.2 Impact of the Renovation

The main purpose of the renovation is re-establishment of the functions of Umiam Umtru Stage III HEPP, whose generation performance is expected to be lost in the near future. Additional improvements from the renovation are quite limited but are listed as follows.

- Increase of annual generation
- Increase of peak supply capacity

(1) Expected improvements

(a) Annual generation

As described in Section 5.2.1, the actual generation is lower than the expected. After renovation is completed, annual generation is expected to increase to 157.5 MU, which is the planned value of this HEPP. Expected lost energy seems significant, as is shown in Table 6-1.

Table 6-1 Expected lost energy

Annual Generation (MU)		
Plan	Latest 10-years average	Lost energy
157.5	125.1	32.4

(b) Peak supply capacity

Increased capacity is 6 MW, which is 10% of the current installed capacity. Total installed capacity after renovation will be 66 MW, which will be able to be used for peak supply.

(2) Impact to the Power system in Meghalaya State

Benefit of the renovation will be provided to Meghalaya state. Power supply measures to meet the demand, which are power banking, power share, and power market, have been prepared. The remaining issue seems to be generation cost, which is preferable to be reduced.

An increase of generation will contribute to reducing the power share and market, which have a unit cost that is higher than that of Umiam Umtru Stage III HEPP. The financial advantage is roughly expected as follows; there seems to be an advantage but the impact seems insignificant.

Table 6-2 Expected impact to the Meghalaya power system

	Expected increase of generation (GWh)	Unit cost (Assumption) (INR/kWh)	Equivalent cost/year (Crore/year)	Comparison of advantage/year (Crore/year)
Umiam Umtru Stage III HEPP	32.4	1.81 (FY2017-18 cost)	5.9	―
Power share	-	3.08	10.0	-4.1
Power market (peak)	-	2.5 ～5.5	8.1～17.8	-2.2～-11.9

Increase of unit cost of Stage III seems insignificant since the renovation cost is basically not included.

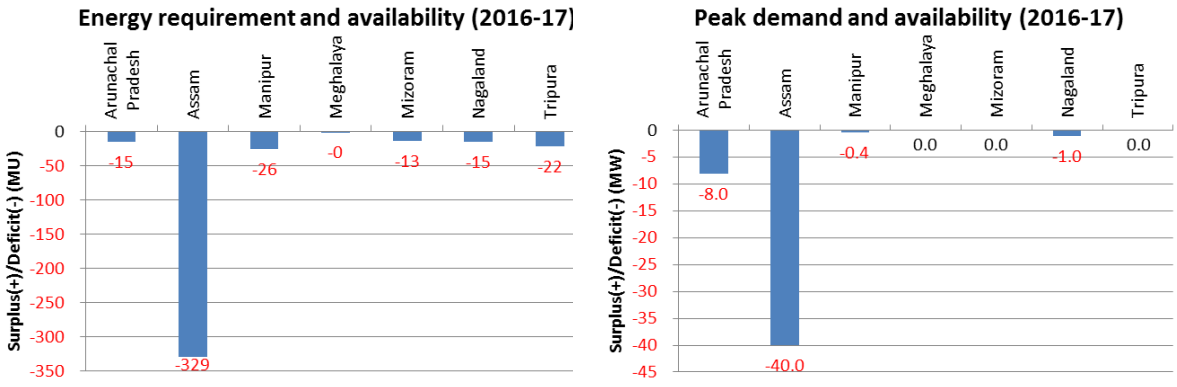
(Source: JICA Survey team)

(3) Impact of the renovation to the neighboring states

Impact to the neighboring states seems to be quite small but a few benefits is expected.

The supply demand balance, energy (MU) and peak (MW), in the northeastern region in the year 2016-17 is shown in Figure 6-3. The supply demand balance in Meghalaya state is balanced but there are deficits which occurred in other states, and the deficit in the Assam state is especially remarkable.

It seems that there will be some impact to mitigate the deficit in the region via the increase of generation and installed capacity in the renovation of Umiam Umtru Stage III HEPP. The expected effect for mitigation of the deficit is summarized in Table 6-3. Therefore, the effect seems insignificant.



(Source: JICA Survey team based on CEA LGBR data)

Figure 6-3 Annual deficit of electricity (MU)/peak demand (MW) in North Eastern Region

Table 6-3 Expected effect for mitigation of the deficit in Assam state

	Deficit in Assam state (2016-17)	Increase by renovation of the Umiam Umtru Stage III HEPP	Mitigation effect
Annual generation (MU)	-329 MU	32.4 MU	10%
Peak demand (MW)	-40 MW	6 MW	15%

(Source: JICA Survey team)

(4) Impact of the renovation to Neighboring countries

Regarding the impact to the neighboring countries of the North Eastern Region, a study on the interconnection transmission line development plan with Bangladesh and Bhutan has been conducted by JICA. It is assumed that the capacity of the power transfer capacity in this study is approximately in the 5,000 MW class, which is a scale that is large enough compared to the additional capacity of 6 MW in the project. Therefore, the impact of the increase via the renovation project is quite small.