(2) Other Related Report

1) Inception Report (Oct.2013)

Location Map of ECG Training Center
(Tema City in Ghana)

Overall Goal
Distribution system operation and maintenance in ECG and third countries is improved

Project Purpose
Training capacity on distribution system operation and maintenance for ECG and third countries is strengthened.

Output 4
Monitoring and management capacity of ECG Training Center is improved

Output 2
Training for technicians of ECG and third countries is improved

Output 3
Training for engineers of ECG and third countries is implemented

Output 1
Current situation of distribution system operation and maintenance is analyzed and training needs are identified.

Conception of the Project

Project on Electrical Engineers Training for African Countries
in Republic of Ghana
Inception Report (Draft)

Contents

1．Outline of the Project

1－1．Background

Republic of Ghana (herein after referred to as" Ghana") has achieved an electrification rate of 66% (2010) which is the third highest among Sub-Saharan African countries.

The Government of Ghana has emphasized on the development of the electricity sector and established target for achieving electrification of 100% until 2020 in National Energy Policy.

And the Government of Ghana formulated the Energy Sector Strategy and Development Plan in Feb. 2010 succeeding the National Electricity Scheme (NES) and Self-Help Electricity Plan (SHEP).

In this Development Plan the Government is promoting the improvement and modernization of the power distribution system under the target to decrease the electric loss rate from 25% to 18% until 2015 as one of the priority policy in the power system.

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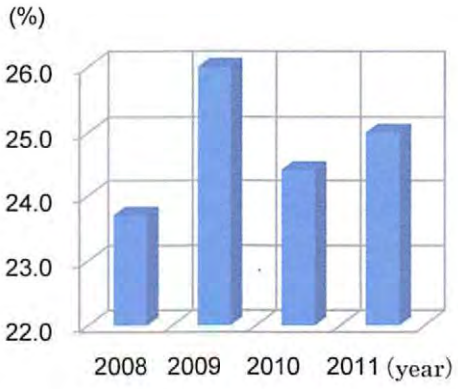


Table 1-1 Distribution loss (%)

As for the System Average Interruption Frequency Index (SAIFI), it is decreasing rapidly after 2010 as shown in Fig.1-2, but on the other hand the System Average Interruption Duration Index (SAIDI) is increasing in Fig1-3.

This shows the situation the number of blackout caused by equipment accidents are in decrease, but it takes a long time for the restoration. Fig. 1-4 shows the same index of an electric power company in Japan (KEPCO). In ECG, SAIFI is 5,800 times and SAIDI is 1,400 times compared to KEPCO and extremely low reliability is shown from the comparison of both.

From this, it may be said reduction of the frequency of power interruption by accident and reduction of duration time of interruption (accident restoration time) are important issues to make power supply quality of the ECG to the level which consumers satisfy.

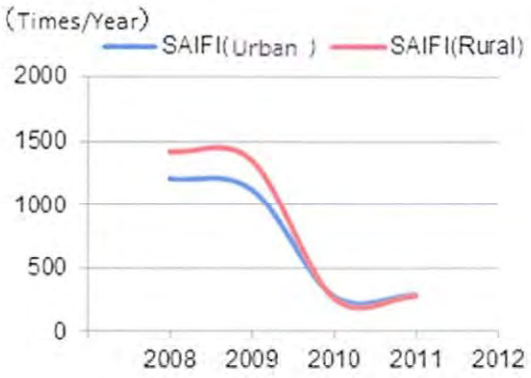


Fig. 1-2 SAIFI of ECG

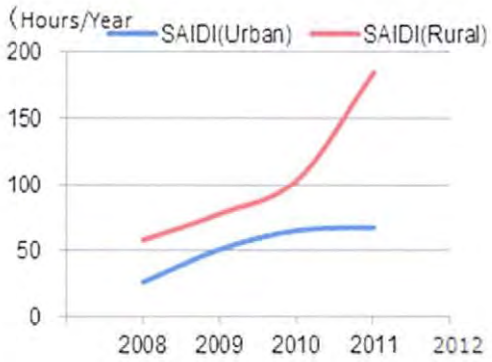


Fig. 1-3 SAIDI of ECG

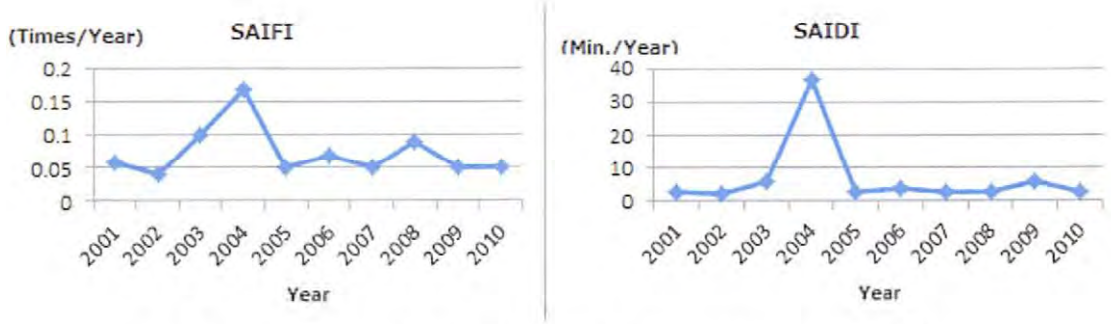


Fig. 1-4 SAIFI, SAIDI of Japanese Power Company (KPCO)

Based on this situation, ECG established the following issues as the important policy for improving the power facilities in the future.

(2011Annual Report and Financial Statements; ECG)

a. To secure the capacity of transformer and distribution line to deal with the growth of demand and expansion of distribution lines to non-electrified region
b. Improvement of a 33-kV distribution system
c. Reduction of power distribution loss
d. Expansion of service area
e. Computerization of operation of distribution system

In order to promote above mentioned improvement, it is indispensable to upgrade the capability of human resources especially electrical engineers and technicians.

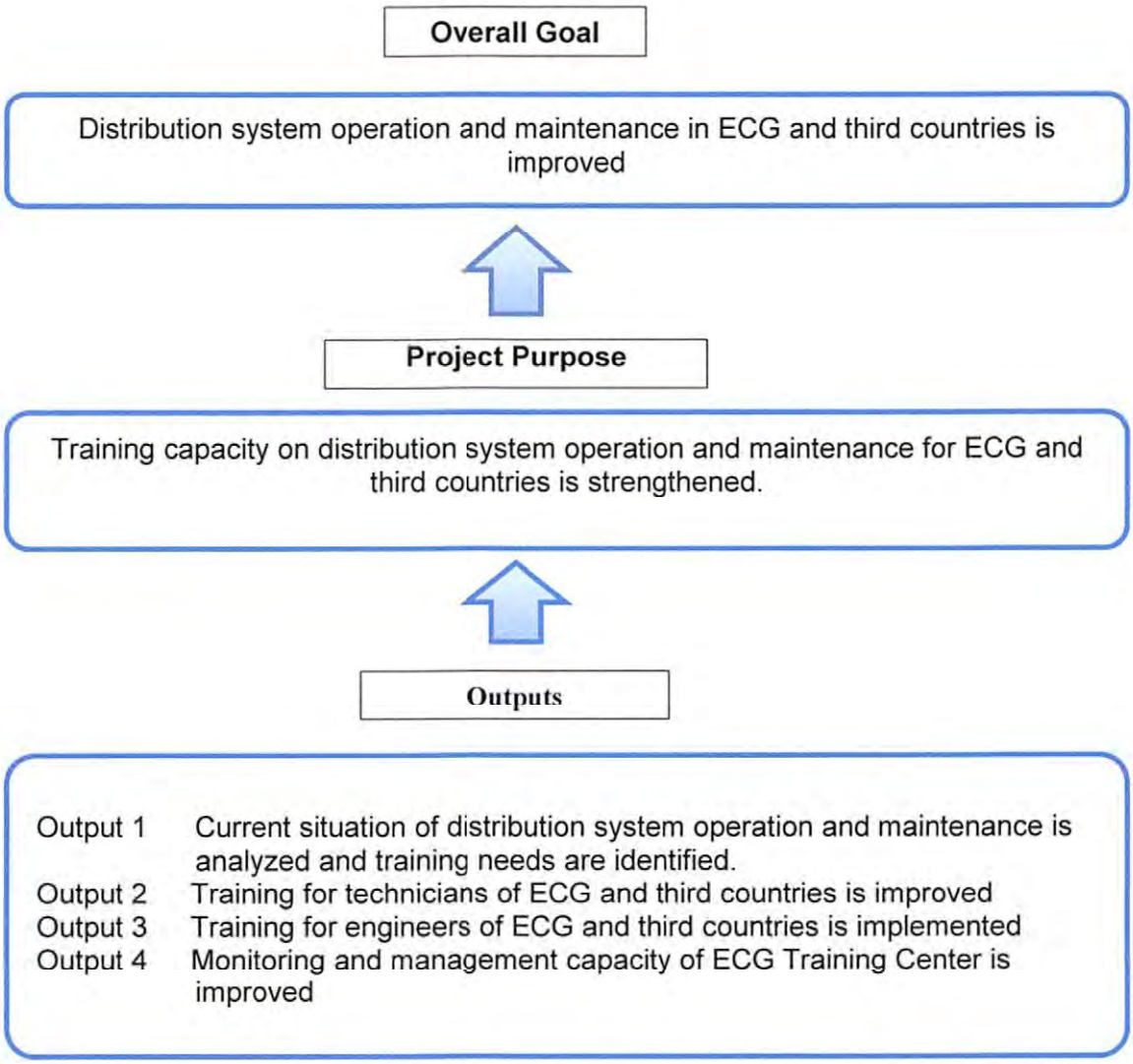
From this background technical cooperation for upgrading the capability of operation and maintenance of power facilities of ECG was requested to the government of Japan

1 － 2． Purpose of the Project

This Project shall be carried out based on the record of discussions (R/D) agreed among Japan International Cooperation Agency (JICA), Ministry of Energy in Ghana and Electricity Company of Ghana (ECG) on September 16, 2010.

The purpose of the Project is to enhance the capability of the operation and maintenance of a power distribution system of ECG and the third countries (Sierra Leone, Liberia, Gambia) through strengthening the training capability of ECG.

The relation among the Overall Goal, Project Purpose and Outputs is shown below.



The project activities for achieving the above-mentioned outputs are shown in the following.

Activities

Output 1 Current situation of distribution system operation and maintenance is analyzed and training needs are identified.

1-1 Review the electricity policy and plan of Ghana and regional cooperation framework
1-2 Review the current situation and challenges of distribution system of O&M in ECG and third countries
1-3 Review the current situation of human resources development of ECG engineers and technicians
1-4 Identify the training needs of ECG engineers and technicians and third countries

Output 2 Training for technicians of ECG and third countries is improved

2-1 Review the existing training courses of ECG for technicians
2-2 Replace training equipment and facilities of ECG
2-3 Update necessary training materials
2-4 Deliver training programs for ECG technicians
2-5 Deliver training programs for the third countries
2-6 Observe the training performance and feed-back to training courses

Output 3 Training for engineers of ECG and third countries is implemented

3-1 Develop syllabuses, curriculum and material for three training programs
3-2 Install new equipment and facilities for training
3-3 Strengthen skills and technology of ECG trainers
3-4 Deliver training programs for ECG engineers
3-5 Deliver training programs for the third countries
3-6 Observe the training performance and feed-back to training courses

Output 4 Monitoring and management capacity of ECG Training Center is improved

4-1 Observe and analyze the current capacity for monitoring and management of training
4-2 Prepare plan for methodologies and procedures for improvement
4-3 Improve ECG capacity for training monitoring and management

2．Basic policy of the project

This project is the technical cooperation project aiming at the improvement for operation and maintenance of power distribution facilities through the training program for the capacity development of engineers and technicians of ECG and third countries.

Therefore the engineers and technicians those who participated in the training courses should operate and maintain the power distribution facilities utilizing the knowledge and technology acquired through the training courses and have to contribute stable power supply.

And at the same time the work cycle from the development, implementation, monitoring to the improvement of the training courses should be firmly established in the routine management and operation of ECG as a training institute.

And all the training courses should sustainably continue after finishing the project.

Based on this basic idea, the basic policy for the implementation of the project was established as follows.

＜Basic policy of the Project＞

To develop the practical training courses taking problems of the power distribution facilities in Ghana and third countries into consideration

To establish the PDCA cycle for the training courses and to support to strengthen the capability of ECG Training center for providing the high quality training courses

Fig. 2-1 PDCA for strengthening ECG Training Center

The following concrete methods would be considered for realizing the above-mentioned PDCA cycle.

Method－1　To establish intelligible training courses （Plan and Do）

- ♦ To grasp the problem of power distribution properly and to formulate the effective syllabuses and curriculum （It can learn effectively in a short time.）
- ♦ To make good training materials with intelligible contents
- ♦ To assist the understanding with photos, figures and graphs

  To use the Video materials if necessary
- ♦ To add the practical training and exercises for deeper understanding
- ♦ To consider the teaching method with audiovisual equipment

Method－2　To support the establishment of monitoring system （Check and Act）

- ♦ To consider the monitoring methodology to grasp and judge the effectiveness of the training easily
- ♦ To measure the effectiveness of the training by the interviews before and after the training

  As the result of the interviews, problems of the training course and/or teaching method would be clarified, and then we can improve and upgrade the training courses by reviewing the syllabuses and curriculum.
- ♦ To held the evaluation meeting after finishing the training course and improve the training course if necessary by the interview from the trainees and lecturers
- ♦ To summarize a series of monitoring activities to a manual

Method－3　To aim the Systematic human resource development (development of engineers and technicians)

A long-term and systematic training system (career formation) would be advised in order to develop the excellent engineers and technicians taking existing training courses into account.

And we would provide the chance to consider how to develop the excellent engineers and technicians in the field of power distribution sector by introducing the Japanese career formation system in the training in Japan.

3．Implementation of the Project

Main components of the project are shown as follows.

＜Main Components of the Project＞

a. Development of Training Course for Technicians of ECG
Training Course on Maintenance Procedure for Electrical Equipment
・・・ 1st year

b. Development of Training Courses for Engineers of ECG
b-1 Training Course on System Protection and Control ・・・2nd year
b-2 Training Course on Distribution Network Planning ・・・・2nd year
b-3 「Training Course on Distribution Design ・・・・・・・・・・・・3rd year

c. Development of Third Countries Training
c-1 Third Countries Training for Technicians・・・・・・・・・・・・・1st year
c-2 Third Countries Training for Engineers ・・・・・・・・・・・・・2nd year

d. Installation of Substation and Procurement of Equipment
・・・ 1st ～ 2nd year

The items of above-mentioned a~c include the activities of development of syllabuses, curriculum and traininging-materials, technology transfer to the lecturer and other related works to develop the new training courses.

These components are to be carried out in three years.

Development procedure of each training course has common steps shown as follows.

-Needs Survey for the training course (in Ghana and in third Countries)
-Development of the training course (syllabus, curriculum and training-materials)
-Technology transfer to the teachers
-Implementation of the Training course
-Monitoring
-Improvement of the training course(syllabus, curriculum and training-materials)
-Re-instruction to the lecturers

3－1．Needs Survey for the training courses

Needs survey will be conducted in order to decide the contents of the training courses immediately after the Project start. Needs survey composed of two parts. One is for the training courses for ECG and the other is for the third countries (Sierra Leone, Liberia, Gambia).

（1）Needs Survey for the training for ECG

1） Confirmation of training needs

As for the training needs for ECG, we recognized that the following issues are prioritized based on the results of the last surveys and discussions.

(a) Training for Technicians of ECG: "Maintenance Procedure for Electrical Equipment"

(b) Training for Engineers of ECG: "System Protection and Control", "Distribution Network Planning", "Distribution Design"

In this needs survey, we will confirm the training needs again and collect the information about the operation method and standard of ECG additionally in order to make the training courses suitable for the actual works of ECG.

2） Method of the needs survey

We will carry out the needs survey by interviewing the related people of Human resource development Section in ECG headquarters and ECG Training Center.

Main issues of the survey and confirmation are as follows.

(a) General information about the Power Facilities of ECG

(b) Forecast for Power demand and future expansion plan of major facilities

(c) Standard for operation and power facilities

(d) Indexes of Power reliability and improving method

(e) Power distribution loss and measures for the improvement

(f) Human resource development plan

(g) Activities of ECG Training Center (including the allocation of budget)

(h) Syllabuses and curriculum and training materials of the training course in ECG Training Center

(j) Problems of the training courses and improving method

(k) Human resource development plan for the future

(l) Training needs and their priority

（2） Needs survey for the third countries

We will visit to the related organizations in the field of electric power sector in Sierra Leone, Liberia and Gambia which are planning to be invited to the training program for third countries. In this survey, training needs will be confirmed by grasping the situation of the electric sector and electric facilities and level of the engineers and technicians in those countries.

The principal of the ECG Training Center is expected to participate in this needs survey

to consider the contents of the third countries training courses.

It is confirmed that the common urgent technical problems of three countries are the reduction of power distribution loss and protection of power system by the last survey and the reports of short term experts.

Main items of this survey are as follows.

(a) General information about the Power Facilities
(b) Forecast for Power demand and future expansion plan of major facilities
(c) Standard for operation and power facilities
(d) Indexes of Power reliability and improving method
(e) Power distribution loss and measures for the improvement
(f) Human resource development plan
(g) Training needs and their priority

3－2. Implementation of the training courses

(1) Training for Technicians of ECG (the First Year)

It is recognized that "Maintenance procedure for Electrical Equipment" is the priority issue in the training for Technicians of ECG through the last survey and discussions.

And it is desirable that "Maintenance of Electrical Equipment" should be effective for improving the power reliability directly.

From this view point, we propose the training course focusing the technology for the reduction of number of the equipment accident (preventive maintenance) and the shortening of the restoration time from accident.

The photos and video materials of the equipment actually used in ECG will be utilized for the teaching materials so as for ECG technicians to understand easily.

And practical training for example "Cable accident point standardization method" (How to pinpoint the generating position of an accident) will be considered to be adapted to the curriculum.

The Syllabus (Draft) of the training for Technicians of ECG is shown in Attachment-1.

(2) Training for Engineers of ECG

It is confirmed that three (3) training courses on "System Protection and Control", "Distribution Network Planning" and "Distribution Design" will be implemented for the engineers of ECG through the last survey and discussions.

We are planning to implement the training courses on "System Protection and Control" and

"Distribution Network Planning" in the 2nd year of the Project and the training course on "Distribution Design" will be implemented in the third year of the Project.

1) Training for Engineers of ECG on "System Protection and Control" (the first half of the Second Year)

As for the facilities to handle in this course, power transforming equipment, 33kV sub-transmission lines and 11kV distribution lines. By previous discussion, protection of transformers (11kV/400V) and that of 400V power distribution lines are not included in this course.

On the protection relay, not only the standard type applied in ECG but also the non-standard type would be included to develop autonomous application power up of the students.

For the same reason, the training of the fault current calculation of the electric power system which is the base of various relay setting. It would deepen the understanding of the relationship between the phenomenon on the distribution line in trouble and the fault detection method of the relay.

Furthermore, since there are some variations about the constitution of the transmission system with the ECG (shown in Fig.3-1), forming method of protection system and setting method of relays corresponding to them which improves the ability in practice.

The Syllabus (Draft) of the training for Engineers of ECG on "System Protection and Control" is shown in Attachment-2.

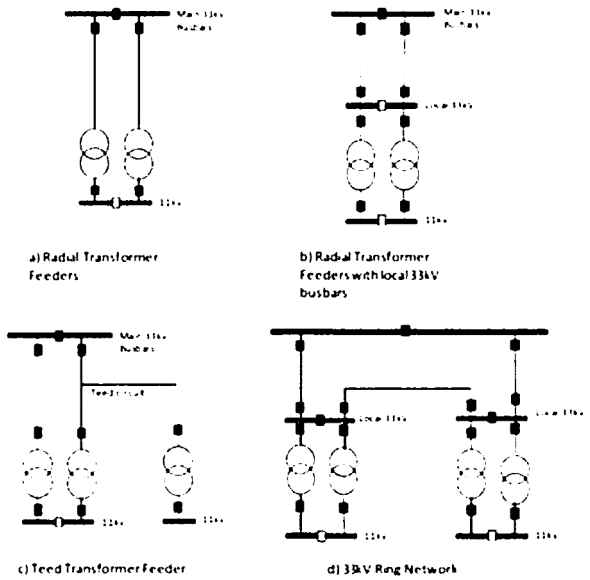


Table.3-1 The variation of composition of the transmission grid

2) Training for Engineers of ECG on "Distribution Network Planning" (the second half of the Second Year)

The work on the distribution network planning will give a big influence to the quality of customer's service and network management as follows.

- Construction cost of the facilities
- Quality of the power supply (Reliability of the power supply)
- Loss of the distribution network

Since these factors are considered to be influenced mutually, it is necessary to consider them in general and to draw a well-balanced development plan of equipment formation.

This will devise most suitable facilities plan under various limitation conditions. However, optimum state or the setting method of equipment planning depends on the unique condition of the Electric Company such as the management policy and the setting of the constraint condition and cannot be described sweepingly.

Therefore, the teaching materials of this training course are mainly focused on the basic matter necessary to be in consideration when making the most suitable formation of equipment. Practice using concrete construction example of the ECG is to be included in the course to let students trained under the practical condition of ECG.

It is necessary to collaborate with teachers of the ECG when making the materials for practice using the concrete construction examples of the ECG in which management policies and a standards (e.g. "Distribution Planning Manual" and "Distribution Design Manual") of ECG is reflected.

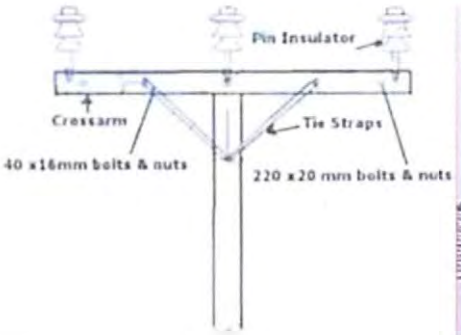
The Syllabus (Draft) of the training for Engineers of ECG on "Distribution Network Planning" is shown in Attachment-3.

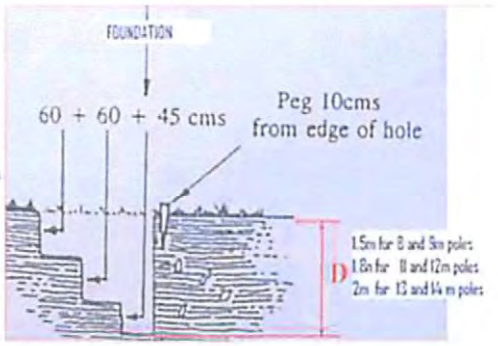
3) Training for Engineers of ECG on "Distribution Design" (the third Year)

Distribution design works are classified broadly into two groups.

The one is design work for construction by assembling materials and the other is design work of the outline of distribution line by viewing the distribution line as a electric power system.

Design work for construction includes drawing works as shown in Fig.3-2((a) the way to attach individual parts (b) the way of construction). "Substation and Distribution construction Standards" is already established in ECG and design work is carried out with this.





(a) Standard design of pole (b) Construction with hand drilling

Table 3－2 Examples of standard design of Overhead Lines

Design work is assumed to be carried out by using CAD as shown in Fig.3-3.

It is necessary to decide the specifications (e.g. size and length of wires, capacity of transformers) of each component appropriately with regarding local condition.

Therefore, the training materials of this training course is about the technical way of thinking to carry out the specifications design appropriately in the design of the electric power system.

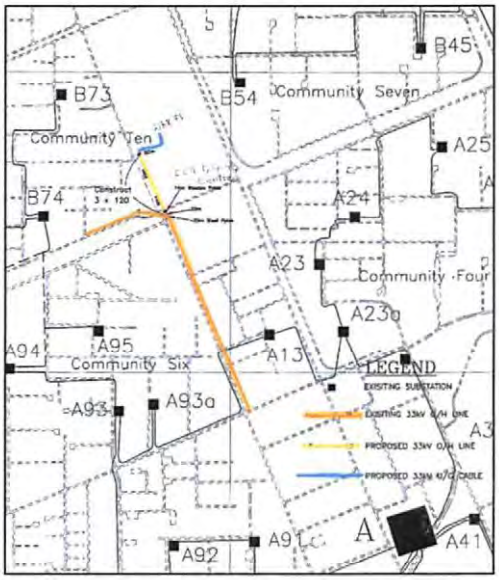


図3－3 33kV 配電線路ルート設計書の例

Since these indexes are based on limitation conditions and the target value regarding the standard of the ECG, it is necessary for making teaching course materials to stand on the contents of ECG standards such as "Distribution Planning Manual", "Distribution Design Manual" and "Sub-transmission and Distribution Design Guidelines", and also it is very important to have enough cooperation with the ECG lecturers.

The Syllabus (Draft) of the training for Engineers of ECG on "Distribution Design" is shown in Attachment-4.

（3） Third Countries Training Program

Based on the results of the needs survey conducted in the first year, training materials will be prepared.

The third countries training program will be principally established by combining the components of existing training courses in ECG and reflect the needs of the invited countries.

The syllabuses and curriculum for the third countries training program will be prepared by the co-working between expert team and counterpart personnel and the training materials will be re-composed from the existing training materials in ECG.

1） Training for technicians of third countries （the First Year）

ECG Training Center has enough knowhow to conduct the training courses for technicians and those curriculums contain enough necessary technologies for installation and operation of facilities.

Therefore training program for technicians of third countries will be re-composed by combining necessary component of existing training courses in ECG, taking the current situation of the facilities, level of the technology and needs of training into consideration.

Furthermore, one of the common problems in the third countries is the numerousness of the power failures including rolling blackouts, and it is considered that degradation of power equipment is the main reason of this problem.

Therefore in order to contribute the improvement of trust of the power facility in the third countries、the contents of the training for Technicians of ECG "Maintenance Procedure for Electrical Equipment" ,which will be implemented in the 1st year, should be taken into the consideration.

2） Training for Engineers of third countries （the Second Year）

According to the Report of the Detailed Planning Survey on Electrical Engineers training for African countries and the information from ECG, the engineers in the third countries are conducting the same job as ECG and it seemed that they have the problem of lack of manpower and delay of the technology.

Therefore the training program for engineers of third countries will be prepared by summarizing or revising the necessary items from the existing curriculums.

According to the information from ECG, the top priority needs for the engineers is to upgrade the technology in the field of protection system for the purpose of enhancing the trust of electric supply.

The consultant team will consider utilizing the contents which will be developed in the

new training courses for engineers in the Project such as "System Protection and Control", "Distribution Network Planning" and "Distribution Design".

3-3. Procurement

At the ECG training center, they want to raise its rate of practical training to be more than 70% in thc all training, but it is difficult because of its outmoded facilities and lacking of instruments and facilities to implement appropriate training. This project shall provide assistance for the procurement of following materials and facilities which are considered highly appalled in its practical training.

(1) Procurement of substation equipment for training and installation of 33kV Substation.(1st to 2nd year)

1) General Description of Facility

33kV Training Substation has been supposed to be installed in the ECG training center in this project. This Substation shall be utilized for the training for power system operation and control & operation, therefore this Substation has all the same functions and specification with the facilities which are practically operated in ECG.

As for Substation equipment, JICA will procure the materials, and ECG has been supposed to implement the laying of cable from commercial 33kV distribution line to this Substation and the construction of building.

2) Method of Construction Work and Division of Role.

As JICA will implement the procurement of Substation equipment and the relevant materials, the consultant team shall decide the specification of Substation equipment and like the requiring estimation to help JICA procure the materials.

On the other hand for ECG, consultant shall help drawing of Substation layout, design of bus configuration, design of earthing system, and give advice for detail design of protection system which are conformed to the standards of ECG to promote JICA's procurement of equipment and materials successfully.

In first (1st) year, depending on the progress of order for Substation equipment and relevant materials, the schedule might slightly change, we shall assist the order, bidding, and delivery.

In second (2nd) year, delivered Substation equipment and relevant materials shall be installed and regulated by contractor. After that we shall assist JICA implement last completion test from technical point of view, specifically we check whether each equipment

and materials can show their own performance and report the results to JICA.

In addition, we shall assist counterpart from technical point of view when contractor explain the delivered equipment, materials and instruction for operation & maintenance.

3) A propose for Securing Safety of Substation Facility

This training Substation shall be supposed to be energized the main circuit with 33kV to make it as same as practical Substation that ECG operating. This energization shall be implemented by connecting from ECG's commercial 33kV distribution line to this Substation facility with a cable. But, if some error operation happens in practical training in these real Substation facilities, commercial distribution line would be shut down by consequent of the accident and also trainee would be exposed to the fear of much discharge current.

To improve this situation above mentioned, we propose to use insulation transformer which raise the voltage 400V-AC to 33kV to energize the 33kV bus line of this Substation instead of connecting commercial 33kV distribution line to this Substation facility directly. It means that this Substation facility is not for provide electrical power but for training only, therefore we strongly propose above mentioned Substation facility.

(2) Procurement of Measurement Instruments and Devices (1st year)

Measurement Instruments and Devices to be supplied have been already agreed in the Record of Discussion on the Japanese Technical Cooperation for the Project on Electrical Engineers Training for African Countries (EETA) on 30th Nov, 2010.

The Measurement Instruments to be supplied shall be shown as in the Table3-1.

Table 3-1 Measurement Instruments and Devices

Measurement Instruments and Devices	Purpose for application
Primary and secondary injection test set	Test and maintenance for protection relay
Transformer oil tester	Aging test for transformer oil
Power quality analyzer	Quality control of Power Wave
Potable cable fault locator	Relocation of fault in power cable

3－4. Training in Japan (1st ~ 2nd year)

About ten (10) counterpart personnel are planning to be accepted to the training program in Japan in the three years of the Project.

In the training program in Japan, we want counterpart personnel to learn the power distribution technology which is difficult to learn in Ghana and the systematic development of engineers by the Japanese Power company.

And we are planning to arrange the site investigation to see the actual operation, the actual allocation of engineers and technicians and the opportunity for exchanging views of organization for operation, maintenance and human resource development.

Concerning the duration of the training in Japan, we are planning to accept around two (2) weeks in the 1st and 2nd year of the project and total ten (10) counterpart personnel will be accepted.

The schedule of the training in Japan (Draft) is shown in Table.3-2.

Contents of the training may be changed by the discussion for adjustment between ECG and related organizations which will provide the training in Japan.

Table 3-2 Training Program in Japan (Draft)

週	purpose	Training contents
First week	Confirmation of Training Purpose	a. Program Orientation
	Human resource Development in Power sector in Japan	b. Systematic Development for Engineers and Technicians in Japan
		c. Development of Engineers and Technicians in the field of operation and maintenance for the power distribution facilities
		d. Development Engineers and Technicians for the construction and installation works on the distribution facilities
	Introduction of development of technology and human resources by External Organizations	e. Visiting the research center developing the deterioration diagnosis technique of the Power equipment. (short circuit generator , thunder impulse withstand testing equipment , deterioration diagnosis technique)
Second week	Site Investigation of Power Facilities and Technical Training	
	① Automatic Distribution Operation System	f. Action for reliability improvement, loss reduction, facility management, improving work efficiency
		g. Demonstration of sub-systems such as remote control of switch, loss minimum operation,remote metering and load management of transformers
	② Visiting control center	h. Remote monitoring and operation of substation(using telemetering technology)

	③ Visiting control center	i. Optimum system operation corresponding to the supply and demand stringency condition
	④ Operation of distribution power system and interconnected distributed generation	j. System operation technology for the interconnection of IPP and renewable energy.
	⑤ R&D organization cooperated with manufacturers	k. Collaborative relationship of the technology development that reflected the needs of the electricity company and equipment(examination equipment of thunder impulse tolerance, smart grid demonstration system)
	Action Plan	l. To draft the Action Plan for utilizing the technology and knowhow obtained in this training.
	Evaluation Meeting	m. To summarize the result of the Training in Japan

3-5 Monitoring of training courses

(1) Establishment of Monitoring Framework

As training courses carry out, project team (hereinafter referred as "PT") will establish monitoring framework for the training course and measure the effect of training from following three perspectives. Result of monitoring will feed back to training courses.

a. Effectiveness measurement of the training courses
b. Confirmation of accordance with needs of electrical engineers/technicians training
c. Assessment on utilization of trained skills at practical work

1) Effectiveness Measurement of the Training Courses

In order to verify trainees' technical/ engineering understanding, PT is planning to measure the effect of training courses. Effectiveness of training courses is clarified by before-and-after performance review. Performance review is carried out at beginning and end of the training courses and measured trainees' depth of understanding comparing with the difference of them. This performance review will be done by questionnaire and/or interview. If there are items that is not confirmed the effectiveness of increasing trainees' capacity, ineffective reasons (training materials, method of teaching and etc.) should be identified as much as possible through interviews during the appraisal meeting and then they should be reflected to the training courses.

In addition to the above, questionnaire survey for supervisors whose staff took a training course would be carried out 2-3months after the training courses. PT will ask them to

evaluate trainees' engineering/ technical capacity and identify problematic and shortage points of training courses. Based on these results, training materials, teaching method and etc. should be revised and updated.

1) Confirmation of Accordance with Needs of Electrical Engineers/technicians Training

During the appraisal meeting, PT confirms whether trainees could improve their skill that they expected in the training course and identifies points what are lack of in the training courses.

If there is lack of technical contents as results of monitoring activities, syllabus and curriculum should be revised as needed and training materials and teaching method should be also reviewed. PT strives to provide training courses that meet trainees' expectations and have a high satisfaction level.

2) Assessment on utilization of trained skills at practical work

In order to develop the practical training courses that are described as the basic policy of the project, it is crucially important for trainees to utilize the expertise and knowledge that is learnt from the training courses in their practical work. To confirm this point, trainees are required to develop their action plan that is indicated how to use technique and knowledge by the appraisal meeting.

Moreover, PT will carry out a Post-training Review after 6 months of the training courses and trainees will report the status of the achievement of action plan. As a result of this review, PT will evaluate degree of utilization techniques and knowledge which are learnt in the training courses.

In addition, trainees will also report what kind of technique and knowledge is required at their practical work and these should be stored and utilize improvement of the training courses.

Monitoring framework is planning to be developed through the collaborative work with instructors and administrators of ECG Training Center on above-mentioned monitoring activities 1)-3).

Additionally, in order to be sustainable monitoring framework, following a) and b) are important; a) clarification of methodology and b) clarification of the division of the roles between concerning organizations and personnel. Terms of Reference (TOR) on training course monitoring should be focused on organization operation of the ECG Training Center.

Flowchart of monitoring framework is shown as Fig. 3-4.

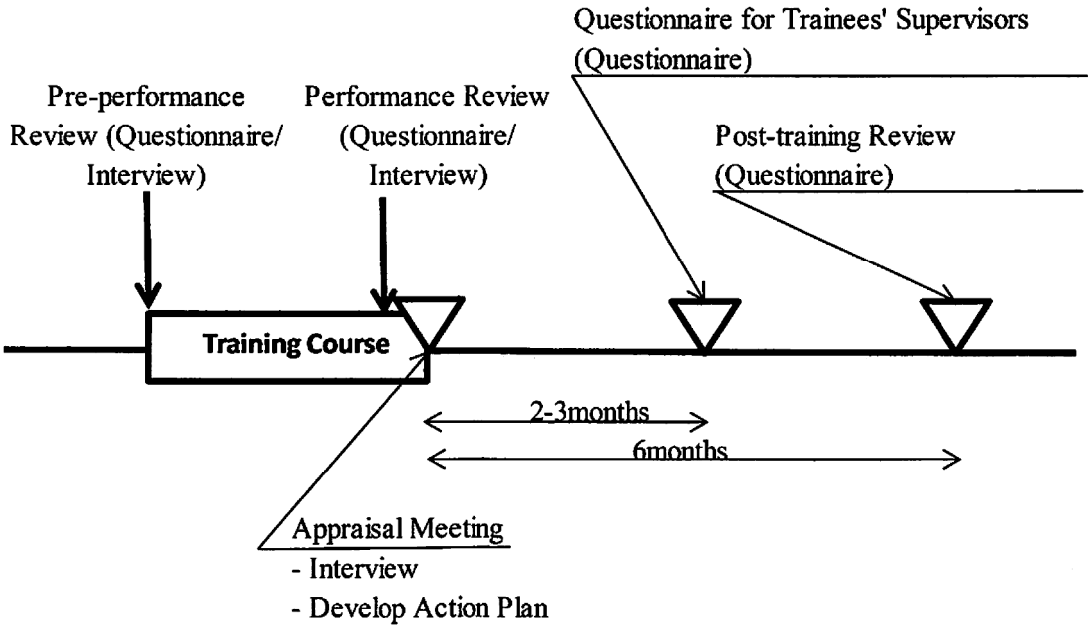


Fig.3-4 Flowchart of monitoring framework

(2) Recommendations for Improving Training Framework

Implementation of training courses is related more closely to a plan of human resources development in the organization. Besides the opinions of division which is executing practical operations should be reflected to training courses.

PT will mainly support on activities of training course in the ECG Training Center, however, based on lessons learned and know-how from the project should feed back to the plan of human resources development in ECG. Thus PT and the principal of ECG Training Center are planning to make recommendations to the division of human resources development in headquarter of ECG.

4. Implementation Schedule

Implementation Schedule of the Project is shown in Fig.4-1.

And the relation between the contents of the project and

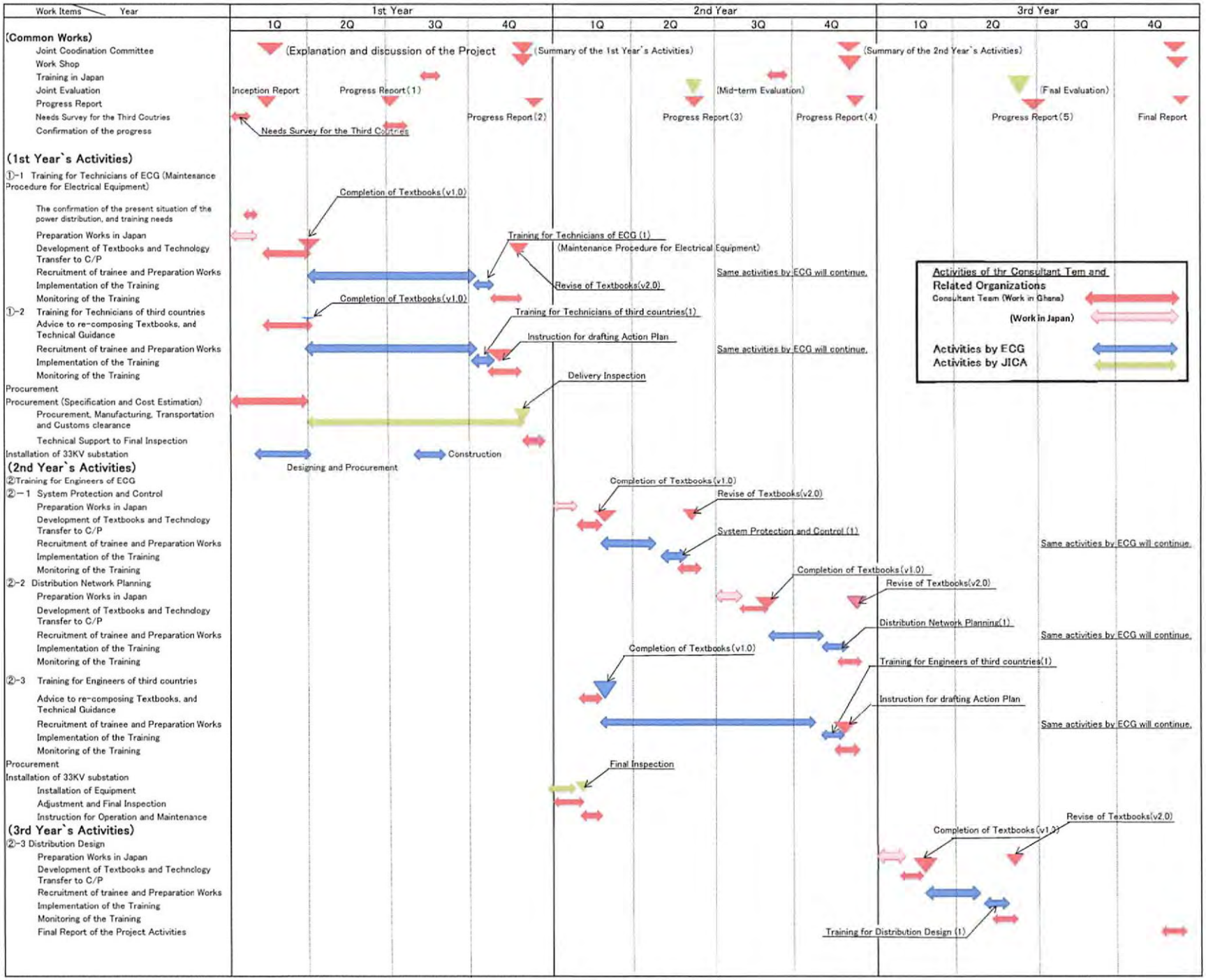
Year	Work Items	Output
All	**(1) Common Works (Total Project Management)**	all
First Year	(1) Implement Schedule of the Project	all
	1) Inception Report To draft the Inception Report which shows the schedule and activities of the three years cooperation in Japan and submit to the Ghanaian side after the approval of JICA	
	2) Discussion and confirmation of the implementation of the Project To discuss and agree on the Inception Report and then fix the schedule of the three years cooperation after the needs survey in the field of power distribution,	
	3) Implementation Schedule of Training in Japan About ten (10) counterpart personnel are planning to be accepted to the training program in Japan. In the training program, we want counterpart personnel to learn the power distribution technology which is difficult to learn in Ghana and the systematic development of engineers by the Japanese Power company. Duration of the training is to be around two (2) weeks. Detailed schedule, contents and others will be decided by the discussion with the Ghanaian side.	
	4) Agreement to the Inception Report To get the Agreement to the Inception Report with ECG and report the result to JICA Ghana Office	
	(2) The needs survey for the third countries To confirm the training need of Sierra Leone, Liberia, and Gambia to be invited to the third countries training program by visiting those countries and grasping the situation of the electric power sector To reflect the result of the survey to the Inception Report	Output 1
	Training for Technicians of ECG "Maintenance procedure for Electrical Equipment"	Output 2
	(3) Review the current situation of power distribution system and confirm the training needs	
	(4) Preparation of training materials in Japan To draft the syllabus, curriculum and training materials in Japan in advance	
	(5) To finalize the training materials and Technology transfer to the counterpart personnel Draft training materials mentioned above are to be finalized by the cooperation work with the counterpart personnel and to transfer the necessary knowhow and technology to the counterpart personnel	
	(6) Recruitment procedure of trainees / training preparation (conducted by ECG)	
	(7) Implementation of the training course (conducted by ECG)	
	(8) Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4
	Training for technicians of third countries	Output 2
	(9) Advice to the training materials and Technology Transfer Based on the results of the needs survey mentioned above (3), the syllabuses and curriculum for technicians of third countries will be principally re-composed by combining the components of existing training courses in ECG	
	(10) Recruitment procedure of trainees / training preparation (conducted by ECG) ECG conducts the recruitment procedure for this third countries training program by contacting related organizations of the third country and WAPP. The necessary technology transfer will be conducted by the consultant team in this recruitment procedure.	

Year	Work Items	Output
First Year	(11) Implementation of the training course(conducted by ECG)	
	(12)Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. And consultant team will help to draft the action plan how to utilize the acquired technology getting from the training course in thieir jobs. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4
	Procurement of Eqipment	Output 2, 3
	13) Procurement of Measurement Instruments and Devices (acquisition of specification and estimation, etc.) • Necessary items of materials, consumable goods and spare parts shall be picked up and decide the specification and quantity. • Consider the procurement method, require the estimation and assume the delivery. • Arrange above items as bidding document and submit it to JICA local office. • Implement bidding and make contract with winner agent.(JICA's affair) • When bidding and technical screening like are undertook, we shall assist JICA local office. • At inspection of delivery, we assist JICA local office from technical point of view.	
	(14) Construction of 33kV Substation • Make order for design and construction for 33kV Substation. (ECG & JICA affair) • Support above item technically and decide the specification and quantity of the equipment which are to be installed in the Substation. • Consider the procurement method, require the estimation and assume the delivery. • Arrange above items as bidding document and submit it to JICA local office. • Implement bidding and make contract with winner agent.(JICA's affair) • When bidding and technical screening like are undertaken, we shall assist JICA local office.	
	(15)Training in Japan Base on the agreement fore mentioned (1)3), training in Japan is to be conducted. Five counterpart personnel targeting senior officials and engineers are planning to be accepted in Japan for around two weeks.	
	(16)Joint Coordinating Committee The Joint Coordinating Committee will meet at the end of the 1st year and report the result of the activities in the 1st year. The overall progress of the Project will be reviewed and PO and PDM will be revised if necessary.	
Second Year	Training for Engineers of ECG on "System Protection and Control"	Output 3
	(1) Preparation of training materials in Japan To draft the syllabus, curriculum and training materials in Japan in advance	
	(2) To finalize the training materials and Technology transfer to the counterpart personnel Draft training materials mentioned above are to be finalized by the cooperation work with the counterpart personnel and to transfer the necessary knowhow and technology to the counterpart personnel	
	(3) Recruitment procedure of trainees / training preparation (conducted by ECG)	
	(4) Implementation of the training course(conducted by ECG)	
	(5) Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4
	Training for Engineers of ECG on "Distribution Network Planning"	Output 3
	(6) Preparation of training materials in Japan To draft the syllabus, curriculum and training materials in Japan in advance	
	(7) To finalize the training materials and Technology transfer to the counterpart personnel Draft training materials mentioned above are to be finalized by the cooperation work with the counterpart personnel and to transfer the necessary knowhow and technology to the counterpart personnel	
	(8) Recruitment procedure of trainees / training preparation (conducted by ECG)	
	(9) Implementation of the training course(conducted by ECG)	

Year	Work Items	Output
	(10) Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4
Second Year	Training for Engineers of third countries	Output 3
	(11 Advice to the training materials and Technology Transfer Based on the results of the needs survey mentioned above (3) , the syllabuses and curriculum for engineers of third countries will be principally re-composed by combining the components of existing training courses in ECG	
	(12) Recruitment procedure of trainees / training preparation (conducted by ECG) ECG conducts the recruitment procedure for this third countries training program by contacting related organizations of the third country and WAPP. The necessary technology transfer will be conducted by the consultant team in this recruitment procedure.	
	(13)Implementation of the training course(conducted by ECG)	
	(14)Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. And consultant team will help to draft the action plan how to utilize the acquired technology getting from the training course in thieir jobs. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4
	Procurement	Output 2, 3
	(15) Construction of 33kV Substation (Technical support) • Completion inspection shall be implemented after Substation materials and equipment are delivered, installed and regulated. We assist the completion inspection for JICA local office from technical point of view. • We shall assist C/P from technical point of view for the instruction of operation and maintenance training which are undertaken by contractor.	
	(16)Mid-term Evaluation The consultant team will provide the necessary information and technical support to the JICA's Mid-term evaluation team in the middle of the second year of the Project. The overall progress of the Project will be reviewed and PO and PDM will be revised if necessary in this Mid-term evaluation.	
	(17)Training in Japan Base on the agreement fore mentioned (1)3), training in Japan is to be conducted. Five counterpart personnel targeting senior officials and engineers are planning to be accepted in Japan for around two weeks.	
	(18)Joint Coordinating Committee Over all progress of the Project activities will be reported and exchange views about the Project.	
Third Year	Training for Engineers of ECG on "Distribution Design"	Output 3
	(1) Preparation of training materials in Japan To draft the syllabus, curriculum and training materials in Japan in advance	
	(2) To finalize the training materials and Technology transfer to the counterpart personnel Draft training materials mentioned above are to be finalized by the cooperation work with the counterpart personnel and to transfer the necessary knowhow and technology to the counterpart personnel	
	(3) Recruitment procedure of trainees / training preparation (conducted by ECG)	
	(4) Implementation of the training course(conducted by ECG)	
	(5) Monitoring of training course Monitoring of training course is to be conducted in the second half of the training course and the evaluation meeting is to be held for the interview to the trainees at the end of the training course. Base on the result of these monitoring activities, the syllabus, curriculum and training materials will be revised and the necessary improvement of the training course will be conducted.	Output 4

Year	Work Items	Output
	(6) Final Evaluation The consultant team will provide the necessary information and technical support to the JICA's Final Evaluation team in the middle of the third year of the Project. The consultant team will also report on the matters which are pointed out to be improved by Mid-term evaluation team and collect the indicators for the Final Evaluation in advance.	
	(7) Final check Before the final JCC, the consultant team will reconfirm the all the activities and all the outputs of the Project. If they find the matters unachieved, they will take necessary measures to improve.	all
	(8) Joint Coordinating Committee All the activities and outputs of the project will be reported and summarize the result of the Project by the consultant team.	

Fig. 4-1 Implementation Schedule



5．Allocation Plan of the Consultant Team

The Project Implementation Structure is shown as follows.

The composition of the consurtant team and the field in charge are shown in Table 5-1.

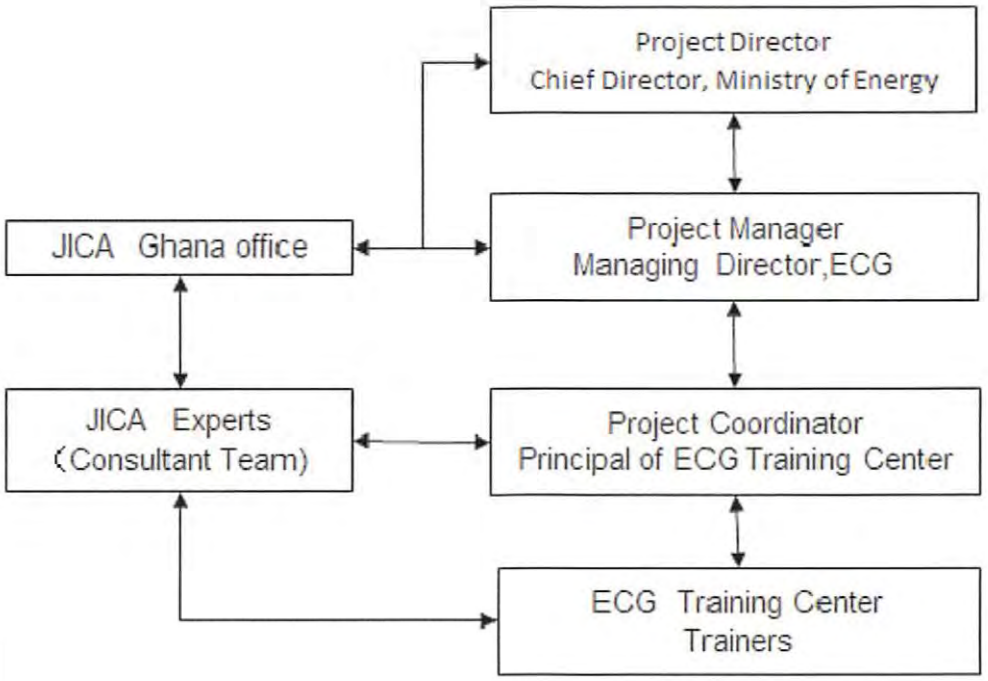


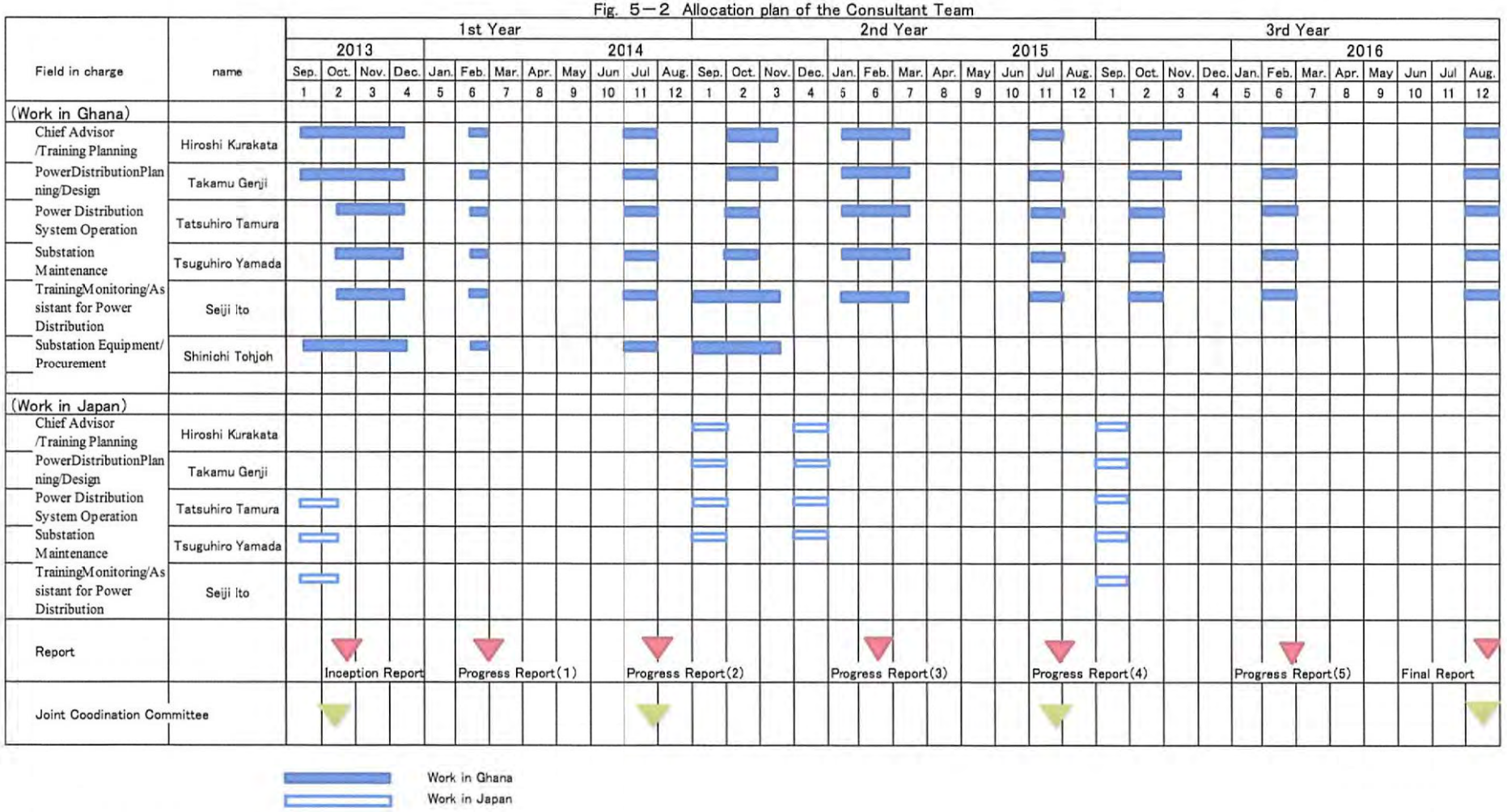
Fig.5－1 Project Implementation Structure

Table. 5 － 1 Composition of the Consultant Team and the field in charge

Field in charge		Name
(1)	Chief Advisor/Training Planning	Hiroshi Kurakata
(2)	PowerDistributionPlanning/Design	Takamu Genji
(3)	PowerDistributionSystemOperation	TatsuhiroTamura
(4)	Substation Maintenance	Tsuguhiro Yamada
(5)	TrainingMonitoring/Assistant for Power Distribution	Seiji Ito
(6)	Substation Equipment/Procurement	Shinichi Tohjoh

Allocation Plan of the Consultant Team is shown in Fig.5-2.

Fig. 5－2 Allocation plan of the Consultant Team



6. Undertakings requested to the Ghanaian side

The following Undertakings are requested to the Ghana side for the smooth implementation of the Project.

（1） Assignment of the counterpart personnel and administrative personnel for the Project

（2） Office space at ECG training Center in Tema with telephone, internet facilities, air conditioning, desks and other necessary furniture

（3） Provision of necessary information and related materials

（4） Use of equipment of ECG Training Center such as PC, printer, projector,and other necessary equipment for the activities of technology transfer

（5） Exemption of customs duties and other any charges
To exempt customs duties and any other charges imposed in Ghana on the equipment which is brought into Ghana by the consultant team

（6） To take necessary measures to get the permission promptly for the equipment which is brought into and take out by the consultant team

（7） To provide the information and offer the necessary measures for the safety

（8） To provide the necessary information for the medical services

7. Others

7-1. Revise of the Project Design Matrix (PDM)

ConsideringChapter-3." Implementation of the Project" and Chaper-4 "Implementation Schedule", PDM was revised as follows.

7-1. Revise of the Project Design Matrix (PDM)

PDM (Project Design Matrix)

1. Project Title: The Project for Electrical Engineers Training for African Countries (EETA)
2. Terms of Cooperation: From Sep. 2013 for three years
3. Target Group: Trainers of ECG

Blue letters : original indicator Red letters : proposed indicator

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MUANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Overall Goal Distribution System operation and maintenance in ECG and third countries is improved	・Technical loss of distribution systems(Ghana ○%, third countries ○%) ・Outrage statistics(Ghana ○%, third countries ○%) ・Distribution loss and SAIFI(The System Average Interruption Frequency Index) will decrease in Ghanazand third countries.	・Annual report of ECG and third countries	・ There is no drastic change in Energy Policy in Ghana. ・ Necessary budget shall be allocated for the training.
Project Purpose Training capacity on distribution system operation and maintenance for ECG and third countries is strengthened	・Number of certificated trainers of ECG(more than ○) ・Satisfactory rate for training(more than ○%) ・Number of training courses for technicians and engineers will increase. ・Syllabus, curriculum and training materials will be revised or newly developed.	・Annual report of ECG and third countries ・Quarterly Report of ECG and third countries	・ Trained trainers continue to work for ECG. ・Stakeholders fulfill their responsibilities in maintaining cooperation framework.
Outputs 1. Current situation of distribution system operation and maintenance is analyzed and training needs are identified	・Report compiled training needs	・Quarterly Report of ECG and third countries ・Project Progress Report	・Trainees from third countries continue to participate in the training courses in ECG. ・ Equipment will be properly maintained for the training courses.
2. Training for technicians of ECG and the third countries is improved	・Number of certificated trainees (Ghana: a more than ○, third countries: more than ○) ・Number of equipment and facilities for replacement, repair and new installation. ・ Nember of trainees for technicians courses will increase. ・Number of certificated trainees (Ghana: a more than ○, third countries: more than ○)	・Quarterly Report of ECG and third countries ・Project Progress Report ・Syllabus, curriculums and Training materials for the training courses ・Inventory list ・Result of the Monitoring	

3. Training for engineers of ECG and third countries is implemented	・Number of implemented training programs ・Number of trained trainers ・Number of equipment and facilities identified for replacement, repair and new installation ・Number of certificated trainees (Ghana: a more than ○, third countries: more than ○) ・Number of training courses for engineers will increase. programs ・Number of trainees (Ghana: a more than ○, third countries: more than ○)	・Quarterly Report of ECG and third countries ・Project Progress Report ・Syllabus, curriculums and Training materials for the training courses ・Result of the Monitoring	
4. Monitoring and management capacity of ECG and third countries is improved	・Quality of revised texts ・Quality of revised tools ・Number of JCC meetings	・Quarterly Report of ECG and third countries ・Project Progress Report ・Manuals and tools	

Activities	Inputs (Means and Cost)	Important Assumptions
1. Crrent situation of distribution system operation and maitenance is analyzed and training needs are identified 1-1Review the electricity policy and plan of Ghana and regional cooperation framework 1-2 Review the currenr situation callenges of distribution system O&M in ECG and the third countriesECG 1-3 Review the currenr situation of human resources development of ECG engineers and technicians 1-4 Identify the training needs of ECG engineers and technicians and the third countries 2. Training for technicians of ECG and the third countries is improved 2-1 Review the exisiting training course of ECG for technicians 2-2 Replace training equipments and facilities of ECG 2-3 Update necessary training materials 2-4 Deliver tarining programs for ECG technicians 2-5 Deliver tarining programs for the third countries 2-6 Observe the training performance and feed-back to training courses 3. Training for engineers of ECG and third countries is implemented 3-1 Develop syllabuses, culliculum and material for three training programs 3-2 Install new equipments and facilities for training 3-3 Strengthen skills and technology of ECG training 3-4 Deliver tarining programs for ECG engineers 3-5 Deliver tarining programs for the third countries 4. Monitoring and management capacity of ECG and third countries is improved 4-1 Observe and analize the current capacity of ECG for monitoring and management of training 4-2 Prepare plan for methodologies and procedures for inprovement 4-3 Inprove ECG capacity for training monitoring and management	**(Japanese Side)** A. Assignment of Experts -Chief Advisor/Training Planning -PowerDistributionPlanning/Design -PowerDistributionSystemOperation -Substation Maintenance -TrainingMonitoring/Assistant for Power Distribution -Substation Equipment/Procurement -Coodinator B.Training in Japan About ten (10) counterpart personnel are planning to be accepted to the training program in Japan in the three years of the Project. C. Provision of Equipment Equipment will be provided based on the R/D. D. Allocation of the necessary budget of trainings for third countries. - Allowance for third countries' trainees are provided by JICA. - Transportation fee of trainees is arranged by own (Ghanaian Side) A. Assignment of Counterpart personnel - Project Director - Project Manager - Project Coordinator - Technical Manager - Technical Counterpart B. Joint Coordinaing Committee C. Office Space and others ECG will provide necessary office facilities including electricity, air-conditioning, water and internet during the duration of the Project. D. Allocation of the necessary budget for the activities described in PDM. E. Training for trainees of third countries ECG assigns necessary lecturers in order to implement trainings for third countries.	**(Pre-conditions)** ・Counterparts are assigned. ・Necessatry budget, office space and facilities for the Project are allocated.

Plan of Operation

Project Title: The Project for Electrical Engineers Training for African Countries (EETA)

Terms of Cooperation: From Sep. 2013 for three years

Target Group: Trainers of ECG

	JFI2013		JFY2014				JFY2015				JFY2016		
	2013		2014				2015				2016		
	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q
Project Period 3 years													
1 Crrent situation of distribution system operation and maitenance is analyzed and training needs are identified													
1- 1 Review the electricity policy and plan of Ghana and regional cooperation framework													
1- 2 Review the currenr situation callenges of distribution system O&M in ECG and the third countries													
1- 3 Review the currenr situation of human resources development of ECG engineers and technicians													
1- 4 Identify the training needs of ECG engineers and technicians and the third countries													
2 Training for technicians of ECG and the third countries													
2- 1 Review the exisiting training course of ECG for technicians													
2- 2 Replace training equipments and facilities of ECG													
3 Update necessary training materials													
2- 4 Deliver tarining programs for ECG technicians													
2- 5 Deliver tarining programs for the third countries													
2- 6 Observe the training performance and feed-back to training courses													
3 Training for engineers of ECG and third countries is implemented													
3- 1 Develop syllabuses, culliculum and material for three training programs													
3- 2 Install new equipments and facilities for training													
3- 3 Strengthen skills and technology of ECG training													
3- 4 Deliver tarining programs for ECG engineers													
3- 5 Deliver tarining programs for the third countries													
3- 6 Observe the training performance and feed-back to training courses													
4 Monitoring and management capacity of ECG and third countries is improved													
4- 1 Observe and analize the current capacity of ECG for monitoring and management of training													
4- 2 Prepare plan for methodologies and procedures for inprovement													
4- 3 Inprove ECG capacity for training monitoring and management													
Evaluations													
Mid-term Evaluation of the Project													
Final Evaluation of the Project													

Attachment-1 **Syllabus of ECG training course for technicians (draft) "Operation and Maintenance technics of Power Distribution Equipment"**

	Top article	Middle article
1	Overview of the power distribution equipment	Configuration of power distribution equipment
		Outline of ECG distribution equipment
2	Overview of the deterioration of power distribution equipment	Deterioration of materials
		Progress of deterioration of each equipment
		Maintenance and preventive maintenance
3	Patrol and inspection	Patrol
		Separation distance
		Inspection and patrol of each equipment
		1) substation equipment
		2) overhead distribution equipment
		3) underground distribution equipment
4	Management of power distribution equipment maintenance data records	Management of power distribution equipment data
		Collection and storage of maintenance data
		Using maintenance data in distribution works
5	Restoration of power distribution lines	Status of accident in distribution lines
		Types of accidents
		Causes of accident and countermeasures
		Restoration work flow
		Fault location (Overhead lines)
		Fault location (underground lines)
		Fault Restoration process using SCADA
		Practice of fault location
6	Operation and Management of distribution line	Voltage management
		Current management
		Earth resistance measurement

Attachment-2 Syllabus of ECG training course for technicians (draft)

"Protection and Operation of Power Distribution System "

	Top article	Middle article
1	Overview of electric power system	overview of basic configuration & features of Distribution and transmission systems
		Configuration of substation equipment
		Instrument transformers
2	Overview of protection relay systems	The role of line protection relay
		system of line protection relay
		Types of protection relays
3	Neutral grounding system	Purpose of Neutral grounding system
		Comparison of neutral grounding system
4	Substation protection system	Transformer protection relay (current differential relay and various mechanical protection relays)
		Busbar protection relay (current differential relay)
5	Power transmission line protective relay system	Overview of the transmission line protective relay system
		Configuration of the protection system for power transmission system
6	Power line protection relay system	Overview of Power distribution line protection relay system
		Short circuit protection
		Ground fault protection
		Distribution line circuit reclosing system(In Substation and in transmission line)
7	Fault calculation	% Impedance by short-circuit fault current calculation
		Ground fault current calculation of Resistance grounded system (single wire earth fault, 2-wire earth fault)
		abnormal voltage and current calculations in failure
		Practice (accident current / voltage)
8	Value setting of protection Relay	about Value setting of relay
		Setting the value of Overcurrent relay (51 S)
		Setting the value of distance relays
		Protection coordination of relays

Attachment-3 Syllabus of ECG training course for technicians (draft)

"Planning of Distribution Line"

	Top article	Middle article
1	Power distribution equipment of ECG	Overview of the power distribution equipment
		Configuration of Middle voltage (33 kV) power distribution system.
		Configuration of High voltage (11 kV) power distribution system.
		Configuration of Low voltage (400 V) power distribution system.
		Configuration of all underground power distribution system
		Bid of Standard equipment construction
2	Load characteristics of power distribution lines	Indicators of load characteristics
		Load types and their characteristics
3	Demand assumption	Basic theory of demand expected
		Examples of the specifically regional demand expected
4	Quality of power distribution	electric supply reliability
		Voltage
		Flicker
		Harmonics
		Instantaneous power failure
6	Power distribution equipment planning	Basic concepts
		Expansion planning method
		Indicators for facility management

Attachment-4 Syllabus of ECG training course for technicians (draft)

"Designing of Distribution Line"

	Top article	Middle article
1	Voltage drop of power distribution line	Line Constants
		Voltage drop calculations
		Influential factors of voltage drop and voltage improvement measures
		Relationship between the voltage at network connection point of user and voltage drop in distribution line
		Selection of type and size of overhead lines
		Concept of voltage drop allocation
		Exercises (voltage drop in high-voltage line)
		Exercises (voltage drop in low-voltage line)
		Procedures of calculation(by using computer)*
2	Voltage regulation technology	Adjustment of the transmission voltage at substation
		Method of applying shunt capacitance
		Exercise (LDC (Line Drop Compensation) settling of substation)
3	Study of power distribution loss reduction	Relation between the type of power distribution system and power loss
		Calculation formula of Power distribution line loss
		Power losses of the transformer bank
		Exercises (power loss in high and low-voltage line) Exercises (power loss of the transformer bank and loss minimize design)
		Case study of electricity loss reduction measures
		Procedures of calculation(with computer)*
4	Power quality improving method	Supply reliability management
		Lightning protection
		Measures against Salt damage
		Measures against Flicker
		Measures against Harmonics
		Management of Power Factor

2) Training Needs Survey Report (for ECG) (Nov.2013)

Table of Contents

1. Electric Power Sector Overview

1.1 Electric Power Supply System

The electric power industry in Ghana is separated into major sectors; power generation, transmission and distribution and there are organization(s) in each sectors. Electric supply system in Ghana is that distribution companies supply electricity generated by the power production sector to consumers in each region via the transmission company.

The Volta River Authority (VRA) generates all the power in Ghana and the Ghana Grid Company (GRIDCO) covers power transmission for the entire country. The Electricity Company of Ghana (ECG) distributes power throughout six of Ghana's 10 regions that include major urban areas (Greater Accra, Volta, Eastern, Central, Western and Ashanti) while VRA and its subsidiary, Northern Electricity Department (NED) distribute power to the other four regions (Northern, Upper West, Upper East and Brong-Ahafo)

Table 1.1 Electric Power Supply System in Ghana

Sector	Operator	Voltage Class
Generation	Volta River Authority (VRA)	-
Transmission	Ghana Grid Company (GRIDCO)	161 kV & 69 kV
Distribution	Electric Company of Ghana (ECG)	33 kV, 11 kV, low voltage
	Volta River Authority (VRA) Northern Electricity Department (NED)	34.5 kV, 11.5 kV, low voltage

Source: Preparatory Survey Report on the Project for Power Distribution Facilities in the Republic of Ghana (March 2012)

1.2 Major Power Facilities

Table 1.2 shows power generation facilities in Ghana.

Table 1.2 Power generation facilities in the Republic of Ghana

Power Station Name	Type	Year Opened	Rated Output (MW)
Akasombo Power Station	Hydro	1965–1972	1,020
Kpong Power Station	Hydro	1981	160
Takoradi Power Station (Stage 1)	Thermal	1997–1999	330
Takoradi Power Station (Stage 2)	Thermal	2000	220
Tema T1 Power Station	Thermal		113
Mines Reserve Plant	Thermal		80
Total			1,923

ECG receives power from GRIDCO at 26 BSPs and distributes consumers through the main facilities. The BSPs and main facilities are shown in Table 2.2.

Table 2.2 ECG Main Facilities

Type of Facility	Unit	2008	2009	2010	2011
		Actual			
Bulk Supply Points	No.	26	26	26	26
33/11kV Primary Substations	No.	81	87	98	108
Secondary Substations	No.	8,222	8,378	8,787	9,550
33kV Overhead Lines	km	12,033.7	12,033.7	12.783.7	13,461.3
33kV Underground Cables	km	281.7	293.1	1,393.1	1,462.8
Total	km	12315.4	12,326.8	14,176.8	14,924.1
11 kV Overhead Line	km	13.970.8	14,166.9	14,441.5	14,946.2
11 kV Underground Cable	km	1,051.8	1,075.3	1,079.9	1,084.4
Total	km	15,022,6	15,242.2	15,521.4	16,030.6
LV Overhead Line	km	1,450,033.0	1,450,973.7	1,453,282.6	1,469312.4
LV Underground Lines	km	5,010.4	5,016.7	5,072.6	5.092.9
Total	km	1,455,043.3	1,455,990.4	1,458,355.3	1,474405.3

Source: ECG annual report 2011

ECG sold 6,087.87 GWh of power to over 2.5 million consumers in 2012, reaching a peak power of 1,258.2 MW in December 2012.

Peak power demand has risen nearly 10% in recent years, and 200 MW will need to be added over the medium term. (National Energy Policy; Ministry of Ghana, February 2010)

Table 2.3 shows major indicators that demonstrate the scale of ECG's operations.

Table 2.3 ECG Major Indicators

Year	2010	2011	2012
Purchased electricity (GWh)	6,771.29	7,258.66	7,943.72
Sold electricity (GWh)	4,972.36	5,285.61	6,078.87
Number of consumers	2,120,564	2,336,242	2,521,104
Power loss (%)	26.56	27.2	23.48
Peak power (MW)	1,115.60	1,156.00	1,258.20

ECG supplies nearly 70 percent of Ghana's power consumption, and Figure 2.4 shows a daily load curve of Accra, which is the largest consumer in Ghana. The curve is for December 18, 2012, when power demand was at its highest for December. Household use accounts for major

Japanese power companies (5,800 times the SAIFI, 1,400 times the SAIDI), so they need to show major improvement on their reliability indicators to increase the amount of power sold and attain a level of customer satisfaction.

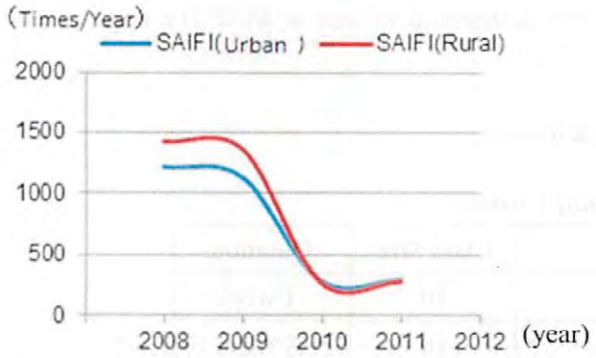


Figure 3.2 ECG Interruption Frequency per Consumer

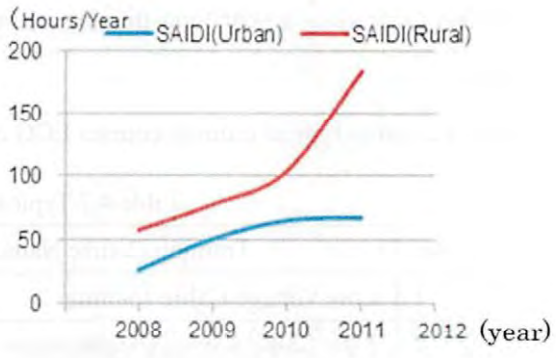


Figure 3.3 ECG Interruption Duration per Consumer

Given these circumstances, it is indispensable to upgrade the capability of human resources especially electrical engineers and technicians. ECG will strive to enhance electrical distribution facilities as well as upgrade the training capacity of the ECG Training Centre, which is responsible for employee training, in order to improve the capability for operations and maintenance of electrical facilities.

4. Overview of ECG Training Centre

The ECG Training Centre is ECG's central human resources development organization and it is a direct counterpart for the Project on Electrical Engineers Training for African Countries (EETA) which was launched on September 2013 under the guidance of the Japan International Cooperation Agency (JICA). The Training Centre is located in the city of Tema in the region of Greater Accra, which is 25 kilometers eastward away from the Ghanaian capital of Accra. 28

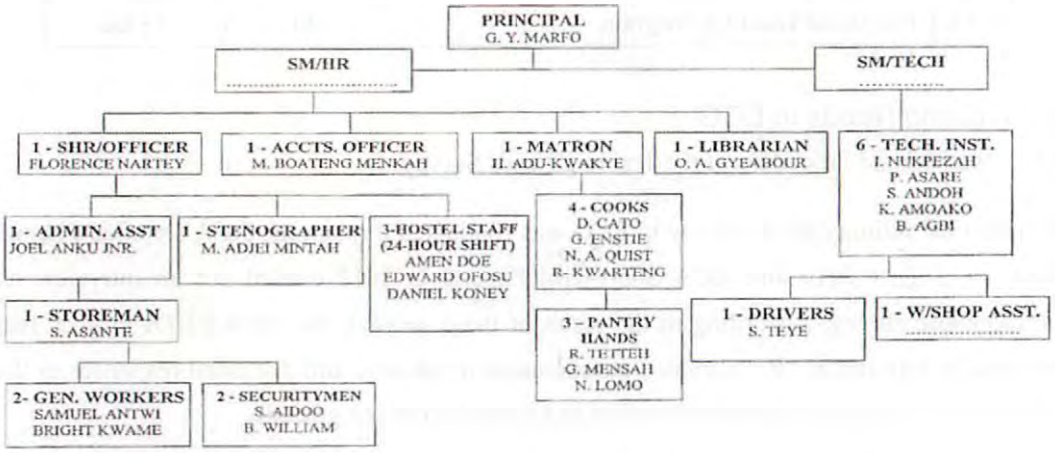


Figure 4.1 ECG Training Centre Organization Chart

Meanwhile, the contents of questionnaires included general information about ECG and other information related to EETA projects and it was submitted to ECG in advance. Document-5 in the Appendix contains questionnaire contents and responses.

5.2 Consultation on Training Needs

Through the results of the questionnaire survey, the PT successfully verified a general idea for requests of training courses for technicians and engineers. To discuss definitive contents more specifically, PT requested ECG to summarize in writing the technologies they want to transfer and then their requests for training courses were indicated as shown in Table-5.1. Through detailed discussions on their requests, PT matched ECG's needs to technologies that PT was able to provide.

Table 5.1 Training Requests from ECG

TECHNICIAN COURSES

1. Telemetry - (Communication)
2. Principles of Electric Power Testing equipment –cable fault locator, primary/secondary injection test kit
3. Maintenance procedure for electrical equipment.
   a. Transfers, Switchgears, b. Overhead network O/H line, C. Switchgear (gas, vacuum)

ENGINEER COURSES

1. Dist.: Network Planning
   a. Distribution loss reduction studies
   b. Power quality and reactive power management studies
   c. Engineering Economics
   d. Load demand & Energy forecasting
   e. Voltage regulation.
2. Dist. System Design
   Basics with software
3. System Protection & Control

(1) Training Courses for Technician

ECG indicated that following three topics would be trained by Japanese experts:

A) Telemetry (functions by using telecommunication systems for taking various measurements in remote areas and includes remote control rectification of malfunctioning of equipment)

B) Principles of electric testing/ measuring devices and operation procedures

5.3 Themes of Training Courses under the EETA Project

As a result of gathering information and discussions made through questionnaires, as well as concrete discussions held through the written requests from ECG, we decided to focus on the following themes in training courses during the EETA project:

- Training Courses for Technicians
  - i) Maintenance Techniques for Electrical Equipment and Implementation Mechanisms and Systems
- Training Courses for Engineers
  - i) Protection and Control
  - ii) Distribution Planning
  - iii) Distribution Design

6. Proposal of the Training Courses for ECG

6.1 Training for Technicians: Maintenance Techniques for Electrical Equipment and Implementation Mechanism and System

Given the business management issues in ECG, it is preferable that the training contents consist of directly improving the reliability of the power supply. In the light of this condition, PT would like to provide training courses that focus on techniques related to reducing the frequency of facility and equipment troubles (preventive maintenance) and shortening recovery times when trouble does occur.

PT determined that the curriculum would include practical exercises of techniques for finding cable fault location that enable the identification of places where faults occur, to improve the trainees' ability to execute operations.

Document-1 in the Appendix is a proposed syllabus for this training.

6.2 Training for Engineers

(1) System Protection and Operation

This training course is designed for substation equipment, 33-kV sub-transmission lines and 11-kV distribution lines; protection of distribution transformers (11 kV/400 V) and 400-V distribution lines are not included in this course.

This training course includes techniques for not only protective relay of transmission and the distribution system used in ECG's standards but also the relays not typically used in ECG, in

APPENDIX

Document-1: Syllabus of ECG training course for technicians (draft)

"Operation and Maintenance technics of Power Distribution Equipment"

	Top article	Middle article
1	Overview of the power distribution equipment	Configuration of power distribution equipment
		Outline of ECG distribution equipment
2	Overview of the deterioration of power distribution equipment	Deterioration of materials
		Progress of deterioration of each equipment
		Maintenance and preventive maintenance
3	Patrol and inspection	Patrol
		Separation distance
		Inspection and patrol of each equipment
		1) substation equipment
		2) overhead distribution equipment
		3) underground distribution equipment
4	Management of power distribution equipment maintenance data records	Management of power distribution equipment data
		Collection and storage of maintenance data
		Using maintenance data in distribution works
5	Restoration of power distribution lines	Status of accident in distribution lines
		Types of accidents
		Causes of accident and countermeasures
		Restoration work flow
		Fault location (Overhead lines)
		Fault location (Underground lines)
		Fault Restoration process using SCADA
		Practice of fault location
6	Operation and Management of distribution line	Voltage management
		Current management
		Earth resistance measurement

Document-3: Syllabus of ECG training course for technicians (draft)

"Planning of Distribution Line"

	Top article	Middle article
1	Power distribution equipment of ECG	Overview of the power distribution equipment
		Configuration of Middle voltage (33 kV) power distribution system.
		Configuration of High voltage (11 kV) power distribution system.
		Configuration of Low voltage (400 V) power distribution system.
		Configuration of all underground power distribution system
		Bid of Standard equipment construction
2	Load characteristics of power distribution lines	Indicators of load characteristics
		Load types and their characteristics
3	Demand assumption	Basic theory of demand expected
		Examples of the specifically regional demand expected
4	Quality of power distribution	electric supply reliability
		Voltage
		Flicker
		Harmonics
		Instantaneous power failure
6	Power distribution equipment planning	Basic concepts
		Expansion planning method
		Indicators for facility management

NEWJEC	QUESTIONNAIRE and REQUIRED INFORMATION	Plan Organization :	NEW JEC Inc.
PROJECT NAME: The Project on Electrical Engineers Training for African Countries (Information Gathering Survey)		Ref. No. :	
		Issue Date :	April 1, 2013
		Revision Date :	

No.	Questions	If possible, we would like to get the following documents	Remarks
1. ECG Headquarters (General Information)			
1	**Outline of ECG**		
(1)	Please provide us the latest Annual Report of ECG.	Annual Report & audited accounts (after 2011)	
(2)	**Please provide us the updated organization chart with the number of the staff by unit.**	Organization Chart of ECG	
(3)	Please explain the Human Resource Development Plan especially in the Engineering Field in ECG	Please contact to ECG Human Resource	
	What is the problem of the Human Resource Development in ECG?		
	Are you ready to support ECG Training Center by dispatching lecturers?		
(4)	Please explain the classification of an engineer, a technician and an artisan, what is the difference among them? Please explain the role of them respectively.		
(5)	If you received any Donor's assistance, please explain.		
(6)	Are you planning to receive any Donor's assistance in 2013?		
2	General Information in Electric Power Sector in Ghana		
(1)	Please explain the updated Policy in the Electric Power Sector, if any.	Refer to Ghana Grid Code	Ministry of Energy
(2)	Please provide us the latest following information.		GRIDCo & VRA
	a) present situation of Power Supply and Demand (Maximum Power Demand and Annual Power Consumption) Forecast of Power Demand in the future	Refer to ECG BSP Peak Loads 2000-2012	
	b) Daily Load Curve (Maximum and Minimum day)	Refer to Accra Daily Load Curve 2012	
	c) Structure of Power Supply (Power Supply by type)	Hydo Generation, Thermal/ Gas Generation, Solar Generation, Wind	

NEWJEC	QUESTIONNAIRE and REQUIRED INFORMATION	Plan Organization :	NEW JEC Inc.
PROJECT NAME: The Project on Electrical Engineers Training for African Countries (Information Gathering Survey)		Ref. No. :	
		Issue Date :	April 1, 2013
		Revision Date :	

No.	Questions	If possible, we would like to get the following documents	Remarks
	✓The transient and projection of power loss (if possible, separating technical and non- technical loss)		
(3-1)	✓The projection of energy sales in the future.	ECG Demand and Energy Forecast	
(4)	What measures have been carried out to reduce the losses (technical and non- technical) respectively?	Page 11 of GECE Report, Attached is a copy	
(4-1)	What measures will be planned in the future to reduce the losses?	Page 11 of GECE Report, Attached is a copy	
(5)	Please show us the data and indices about reliability shown as follows. ✓The latest transient of SAIFI (System Average Interruption Frequency Index) and SAIDI (System Average Interruption Duration Index) (if possible, separating planned interruption and fault interruption) ✓The latest transient of yearly number of system fault by cause	Average Outage Duration (Hrs/ Customer/ Year) 67.9 (Urban Communities) Average Outage Duration (Hrs/ Customers/ Year) 185 (Rural Communities) Average Outage Duration (Hrs/ Customer/ Year) 29 (Metropolitan Areas) Average No. of Outages (No./ Customer/ Year) 293 (Urban Communities)	(Please refer to ECGs Annual Report, 2011)
(5-1)	✓Will some measures be planned to address the administrative issue that is reported as facilities have been aging? Namely, will you carry out maintenance and inspection for the old facilities to reduce distribution fault?	Yes	
3	Organization for the Operation and Maintenance of Distribution Network		
(1)	Please provide us the organization of ECG, especially substation and distribution department.	Organization Chart Substation and Distribution department in ECG	
(2)	Please provide us one example of the organization of Branch Office relating substation and distribution work.	One example of the Organization Chart of Branch Office	

NEWJEC	QUESTIONNAIRE and REQUIRED INFORMATION	Plan Organization :	NEW JEC Inc.
PROJECT NAME: The Project on Electrical Engineers Training for African Countries (Information Gathering Survey)		Ref. No. :	
		Issue Date :	April 1, 2013
		Revision Date :	

No.	Questions	If possible, we would like to get the following documents	Remarks
	Have you developed the manual and procedure of recovery methods at substation equipment fault?		
(6)	Do you have the specification standards of equipment for distribution system and substation?	Yes, the specification was recently updated by PB Power of UK.	
(7)	Do you have the standards for settling control equipment and protection devices in a substation?	Yes	
(8)	In relation to the above, do you adopt the international standards and foreign standards for business? For example, DIN(Deutsche Industrie Normen) Standards , IEEE (Institute of Electrical and Electronics Engineers)Standards , ANSI(American National Standards Institute) standard, IEC standards and British Standard etc.	Yes	
2. ECG Training Center			
1	General Information of ECG Training Center		
(1)	**Please provide us the updated organization chart with the number of the staff by unit including administrative unit.**	Organization Chart of ECG Training Center	
(2)	Please explain the recent budgetary allocation.		
	If you received any Donor's assistance, please explain.	Budget Summary (after 2010)	
(3)	Please explain the budgetary plan in 2013.	Budgetary Allocation Plan in 2013	
	Are you planning to receive any Donor's assistance in 2013?	No	
(4)	Please explain the Human Resource Development Plan especially in the Engineering Field in ECG	Human resource development plan	
	What is the problem of the Human Resource Development in ECG?	When new technology is introduced, the technical guidance is received, but since the period is short, acquisition is difficult. Although the lecturer of a center will receive technical guidance, there is a difficulty to re-transfer the technology to a trainee.	

NEWJEC	QUESTIONNAIRE and REQUIRED INFORMATION	Plan Organization :	NEW JEC Inc.
PROJECT NAME: The Project on Electrical Engineers Training for African Countries (Information Gathering Survey)		Ref. No. :	
		Issue Date :	April 1, 2013
		Revision Date :	

No.	Questions	If possible, we would like to get the following documents	Remarks
		vocational school program and get the Diploma Engineer: graduate from the university	
3	Problems for implementing Training Courses		
(1)	What is the problem for implementing Training Courses?	(same as 1.(4))	
4	Training Courses for Technicians		
(1)	What kinds of Training Courses are prepared for the Technician?	List of the Training Courses for Technicians	
	Please explain the contents of above mentioned training courses.	(ditto)	
	Please explain the qualification requirements, duration of training course and number of participants of each training course.	(ditto)	
	Please explain the lecturers of the training course.	List of the lecturers	
	Please provide us the some example of curriculums and syllabus of the training courses.	Some example of Curriculums and Syllabus	
(2)	Please explain how you teach work skill. How do you implement the training of the work that must be carried out by a team? How do you intend to improve the current training methods?	It makes the team in training. An actual team is not to participate in training.(impossible) I would like to put the priority on practical training.	
(3)	Which system is intended to revise programs for either overhead system or underground system? Is the specification of materials for underground distribution line unified? Especially cable joint materials?	both overhead system 90%, underground cable 10% Yes, unified.	
(4)	Do you conduct training on SCADA (distribution automation system)?	No	

NEWJEC	QUESTIONNAIRE and REQUIRED INFORMATION	Plan Organization :	NEW JEC Inc.
PROJECT NAME: The Project on Electrical Engineers Training for African Countries (Information Gathering Survey)		Ref. No. :	
		Issue Date :	April 1, 2013
		Revision Date :	

No.	Questions	If possible, we would like to get the following documents	Remarks
	Please explain the contents of above mentioned training courses.	(ditto)	
	Please explain the qualification requirements, duration of training course and number of participants of each training course.	(ditto)	
	Please explain the lecturers of the training course.	List of the outside lecturers	
	Please provide us the some example of curriculums and syllabus of the training courses.	List of the standard training courses	
(2)	(Confirmation) We understand the following three training courses for engineers were agreed to be taken up in the JICA's Technical Assistance in the discussion between JICA's Detailed Planning Survey Team and ECG in August 2010. a. System Protection and Control b. Distribution Network Planning c. Distribution System Design We would like to confirm whether our understanding is right or not.	Yes, OK For the training courses for young or not experienced engineers	
(3)	Please explain the contents of each training course. What kind of Technical Assistance (Technology Transfer) are you expecting to the Japanese experts? May I understand that the counterpart personnel are the lecturers engaging in the training courses? Have you prepared for the curriculums and syllabus for the training courses? If yes, please provide us with them. Have you prepared for the textbooks for the training courses?	Requested paper was provided	
(4)	Which part of the system is focused in "Protection and control course", namely either substation &33kV line or transformer & low voltage line? Please explain about items and contents which are controlled	Transformer of 33/11kV	

3) Training Needs Survey Report for ECG Third Countries (Nov.2013)

Engineering Training for African Countries in Republic of Ghana (EETA)

- Needs survey of the training courses for the third countries -

Table of Contents

Appendix

Needs survey of the training courses for the third countries

1. Purpose of the Survey

This survey was aimed at the training courses for the third countries (Sierra Leone, Liberia and the Gambia) which will be planned to carry out during the Project on Electrical Engineering Training for African Countries (EETA) that has been launched on September 2013. And purposes of the survey are 1) to exchange contents of training courses with counterpart of the third countries, 2) to summarize and examine needs of training and common issues that they are facing and 3) to develop common training courses.

Procedure of the survey is that the Survey Mission (hereinafter referred to as "the Mission") visited and exchanged ideas and information with electricity company/ organization in each countries (Liberia Electricity Company: LEC, National Power Authority of Sierra Leone: NPA, National Water & Electricity Company, Gambia: NAWEC) and had a field trip on sites of electrical facilities.

2. Member of Survey Mission

Role	Name	Organization/ Title
Comprehensive Advisor	Mr. George Yaw Marfo	Principal, ECG Training Centre
Training Planning	Mr. Hiroshi Kurakata	EETA Chief Advisor/ Training Planning
Power Distribution Planning/ Design	Mr. Takumu Genji	EETA Power Distribution Planning/ Design
Project Coordinator/ Training Management	Ms Ritsuko Kawabe	EETA Project Coordinator/ Training Management

3. Schedules of Survey

The Mission made trips to each countries on itineraries as follows.

(1) Mission to Liberia (LEC)

Date	Activities
09/10/2013 (Wed.)	Accra ---> Monrovia
10/10/2013 (Thu.)	- Meeting with LEC - Field trip
11/10/2013 (Fri.)	- Meeting with JICA Field Office
12/10/2013 (Sat.)	Monrovia ---> Accra

(2) Mission to Sierra Leone (NPA)

Date	Activities
15/10/2013 (Tue.)	Accra ---> Free Town
16/10/2013 (Wed.)	- Meeting with JICA Field Office - Meeting with NPA
17/10/2013 (Thu.)	- Field trip
18/10/2013 (Fri.)	Free Town ---> Accra

(3) Mission to the Gambia (NAWEC)

Date	Activities
05/11/2013 (Tue.)	Accra ---> Banjul
06/11/2013 (Wed.)	- Meeting with NAWEC - Field trip
07/11/2013 (Thu.)	Banjul ---> Accra

4. Method and Procedure of the Training Needs Survey

Electrical training needs surveys have already conducted in Liberia, Sierra Leone and Gambia by JICA Detailed Planning Study which conducted in August 2010 and JICA Short-term Experts which conducted in August 2012.

In particular, questionnaire survey was carried out by JICA Short-term Experts. According to the result of this questionnaire survey, the Mission prepared and drafted training course that would be expected to be required in advance of surveys. During the surveys, the Mission discussed it with a counterpart of the third countries and tried to get feedback.

5. Result of surveys on the third countries

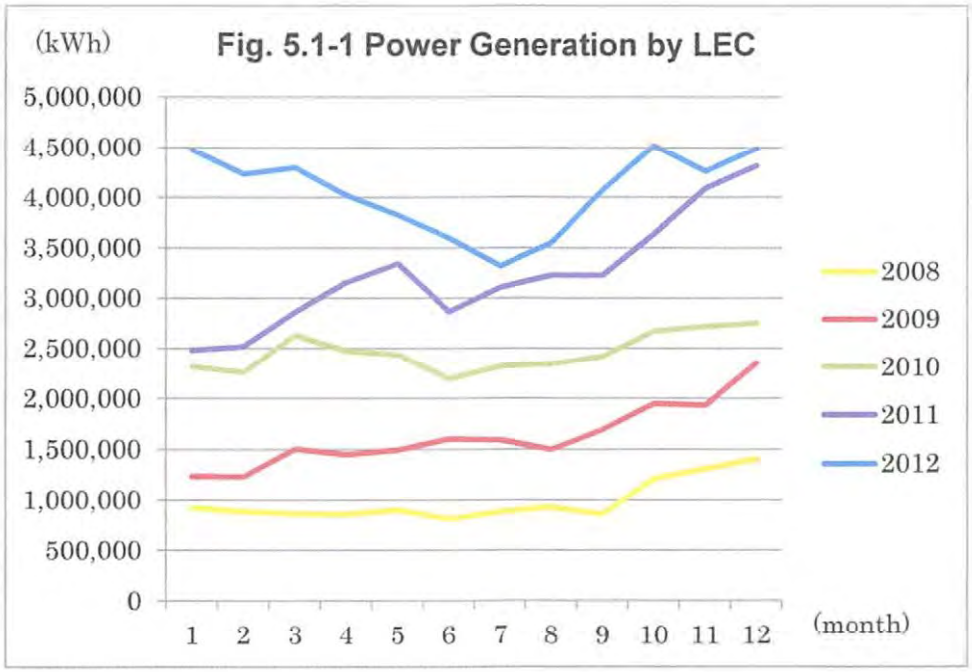
5.1 Liberia

(1) Current Status of Electrical Sector

The Liberia Electricity Corporation (LEC) is the only organization who is responsible for electricity supply industry in Liberia. LEC was established in 1973 and it is a public utility with a mandate to generate, transmit and distribute electric power throughout the nation. According to the annual report, LEC operated a power system consisting of hydro and thermal generating facilities with a combined installed capacity of 182 MW in 1989. However, LEC is currently operating installed capacity of 22MW only and most of facilities were lost during the Liberian Civil War from 1989 to 2003.

LEC explained that they are now planned to increase the installed capacity from 22MW to 80MW in 2016.

Fig. 5.1-1 shows monthly energy generation from January 2008 to December 2012. Trend of energy generation is ever-increasing. Monthly energy generation has quadrupled in the last 5 years and has been increasing throughout the year except for between June and July.



On the other hand, Liberia is importing 8MW energy from Cote d'Ivoire though CLSG electricity interconnection network and amount of imported energy will be increasing approximately 20MW in 2018.

The current electricity tariff for households is priced at 0.60 USD per kWh. It is extremely expensive for general consumer and limited population who are high-income households, are able to access to electricity. The reason of high tariff is that most of electric power in Liberia is generated by diesel generators.

Although it is recognized to have 800MW for potential hydro power resources in Liberia on behalf of low price electricity, government and LEC have financial difficulty for the development.

(2) Challenges in Electric Sector

As previously mentioned about challenges in electric sector of Liberia, a number of power-generating and transmission-distribution network facilities were broken in the Civil Conflict and a lack of installed capacity is significant problem in the sector.

Although all electrical facilities are located in Monrovia city area, there are many 66kV transmission lines and 66kV substation's facilities that have not been restored since they destroyed in the civil conflict. In order to utilize electrical power facilities more effectively

that will be reinforced in future, it is necessary to develop delivery system such as transmission and distribution network and substations which are harmonized with power-generating capacity. The term "Development of delivery system" includes rehabilitation of existing facilities and timely installation of new facilities. In addition to proceed such type of development, it is also required 1) suitable maintenance of existing facilities, 2) reasonable facility planning and its implementation and 3) flexible protection and power system operations which is able to adapt to structural change of facilities.

In order to meet changes of electrical facilities from a perspective software side, it is essential to input competent engineers. However, the loss of human resources by civilian war has an adverse impact on operations and maintenance of electrical facilities and there is a shortage of engineers and technicians in Liberia who are enough trained and experienced currently.

Under this circumstances, development assistance through training programme to LEC has enormous significance in capacity development in the energy sector of Liberia and the Mission confirmed that there is a tremendous needs for electrical engineers.

(3) Training Needs and Training Courses

It is essential to educate and train in all areas for Liberian engineers and technicians, because LEC is suffering a shortage of human resources and they are poorly educated. Presently on-the-job-trainings are being conducted by senior engineers who are invited from other developed countries.

The Mission pointed out that there are significant problems on "maintenance of electrical equipment" and "protection and control" that are based on the result of the questionnaire survey to LEC which conducted in August 2012.

Specifically, the Mission proposed that 1) Training Course on Maintenance of Electrical Equipment for technicians who are engaging in maintenance work widely and 2) Training Course on Protection and Control for engineers which is directly linked to effective utilization of existing facilities and increasing reliability of supply will provide in the ECG Training Centre. And LEC agreed Mission's proposal.

On the other hand, due to an extreme shortage of human resources in LEC, they expressed concern about interference their daily operations to be absence of engineers and technicians to participate to training courses.

According to this condition, LEC insisted that duration of training courses is for a maximum of two weeks and 2-3 trainees will be able to be dispatched.

The Mission responded that five seats for technician training course will be arranged for Liberian participants and contents, duration and date of training courses will be considered to

coordinate other two countries.

Additionally, Mr. Marfo, Principal of ECG Training Centre (hereinafter referred to as "the Principal"), mentioned that there had been only a few participants from Liberia on his experience at the training programme of the West African Power Pool (WAPP), even though Liberia had been offered 5 participants to the training. Thus he pointed out that it would be impractical, if an excessive number of participants from Liberia would be allocated.

Moreover, it may be problematic that basic education level (quality of education in middle and high school) is low in Liberia. Thus it is doubtful whether trainees obtain benefit from short term training such as a period of 2 weeks.

There is also suggestion that instructors of ECG would dispatch Liberia (and other countries) after the ECG training courses and follow up them on-site in order to increase the effect of training. Because of electrical system is different from Ghana and other countries, it needs to follow up trainees' skills on-site.

5.2 Sierra Leone

(1) Current Status of Electrical Sector

The Ministry of Energy and Power has oversight responsibility over the energy sector. The National Power Authority (NPA) which was established in 1982, and Bo-Kenema Power Services (BKPS) which is subsidiary organization of NPA are responsible for the distribution of electricity throughout the country. Before the Sierra Leone Civil War (1991 – 2002), the total installed capacity of electrical facilities in Sierra Leone was 120MW and its break-up was as follows; (NPA and BKPS: approx. 52MW, Mining sector: approx. 28MW and private owned electric generators: approx. 40MW). Most of these electrical facilities were lost during the civil war.

About 90% of Sierra Leone's electricity is consumed in the country's four major cities; the capital city of Freetown uses 82% of the country's electrical power. Although power supply in Freetown relied on Independent Power Produce (IPP) until 2009 that produced 14MW by Gas Turbine Generator, recently the power supply system has improved rapidly.

The hydro power plant Bumbuna I (25MW installed capacity, 18 MW firm generation capacity in the dry season) entered into operation late 2009. And also a 10 MW thermal plant (Diesel) was installed at the Kingtom Power Station 2010 with technical and financial assistance from the Japan International Cooperation Agency (JICA). Moreover, the hydro power plant Bumbuna II (25MW installed capacity) and two diesel-powered plants of total output capacity of 16.5MW were also installed in March 2011 at Black Hall Road in Freetown.
Power supply to Freetown is that Bumbuna Hydro Power Plant is devoting to the production

of baseload supply and other diesel power plants are covering to peak load and demand of dry season.
When the Mission did field trip on 17 October, 2013, all diesel power plants were on standby.

On the other hand, electricity transmission and distribution (T&D) networks in Sierra Leone are inadequate and aging largely. T&D networks in Freetown and its environs consists of 33kV and 11kV transmission lines, 11kV underground/ overhead distribution lines, distribution substations and 450V(three-phase) and 250V(single-phase).
But capacity of T&D networks is shortage because they are more than 50 years old and are poorly maintained due to damage of 11kV distribution lines, burnout of distribution substation and troubles in substations equipment. Therefore, these networks are currently not capable of transmitting more than 36 MW of power. This poses a serious bottleneck for additional generation capacity being added to the grid or in planning. The insufficient generation capacity in combination with the poor capacities of T&D network has led many industries as well as commercial and residential customers to purchase imported diesel generators.
Although electricity rate is becoming more affordable than before hydro power plants installed, the current tariff for households is still priced at 0.28 USD per kWh. Before hydro power plants installed, power generation had depended on diesel power plants whose fuel is needed to import from abroad.

(2) Challenges in Electric Sector

As previously mentioned about electrical facilities in Sierra Leone, a number of power-generating and T&D network facilities were broken by the Civil Conflict and rehabilitation is now being made a great effort. Effective electricity distribution is subject to the restriction from T&D problems, while the power plants are smoothly restoring and generating electricity steadily. T&D networks in Freetown are faced with various problems as listed below;

- Transmission system consists of 33kV and 11 kV lines; it causes to be small transmission capacity and high rates of loss in transmission.
- Most of middle voltage (11kV) distribution system consists underground cables and most of them are aging. And it leads to an increase in troubles of cables as well as an increase rate of cable loss.

  In order to handle with these problems, reinforcement of 11kV underground distribution cable is needed. But to install and/or restore of underground cable includes technical and financial difficulties, therefore fundamental review of planning should be needed that underground cable is replaced with overhead line.
- Even though energy demand in Freetown is increasing due to population inflow by the civilian conflict, adequate facilities have not been installed. As result of this condition,

most of facilities are aging and a large number of distribution transformers are not function and/or burnout due to electrical overload. In order to handle with this problem, it is required suitable maintenance including electrical load management to transformers.

- Protection and T&D system operation are needed that is adapted to structural changes according to system change with cable/ line troubles and electrical facilities reinforcement. However, there is not enough number of engineers/ technicians in Sierra Leone, NPA couldn't handle with these problems.

As mentioned above, it is urgent that distribution sector would be upgraded on the grounds of shortage of distribution capacity and unstable supply of energy which are caused by aging of distribution facilities and maintenance issues.

Meanwhile, in order to resolve abovementioned issues, JICA project for "Capacity Development for Maintaining Power Supply Facilities (2011 – 2016)" is ongoing which is focused on practical capacity building and human resources development of the improvement of implementation procedures in actual electrical works.

(3) Training Needs and Training Courses

The Mission pointed out that there are significant problems on "Maintenance of Electrical Equipment" and "Protection and Control" in Sierra Leone that are based on the result of the questionnaire survey to NPA which conducted in August 2012. According to this condition, the Mission proposed training courses that is focused on such areas and NPA agreed Mission's proposal.

The Mission explained two training courses that 1) Training Course on Maintenance of Electrical Equipment would be targeted for technicians who are engaging such type of jobs on a daily basis and 2) Training Course on Protection and Control would be targeted for engineers. NPA also agreed Mission's ideas.

On the other hand, NPA suggested that approximately 10 trainees per one training course would be accepted, because of human development needed urgently.

Besides NPA suggested that 2-week training course would be too short for trainees. And they requested ECG that would develop 3-week course and it would contain enhancement of practical trainings.

Moreover, there is an opinion that analytical software also would be provided in for engineers' training course of the "Protection and Control". Because trainees need to have analytical software to utilize their trained skills in their actual work.

Meanwhile, according to JICA Expert in Sierra Leone, financial condition of NPA is extremely

tight, therefore, it is not realistic that 10 participants would travel that financed by NPA and they would be apart from their work for 2-3 weeks during busy season. As can be attested to JICA Expert's suggestion, NPA asked for financial help for the cost of one way airline ticket to travel to Accra for trainees, despite the existence of the Minutes of Understanding (MOU) which was confirmed that Sierra Leone should be financed trainee's round trip airline tickets.

The Principal indicated on his experience at the programme of WAPP as follows; 1) since Sierra Leonean trainees have an adequate level of technical capacity, there is no problem to have a training. 2) NPA will have enough capacity to dispatch training course 10 participants per year.

5.3 Gambia

(1) Current Status of Electrical Sector

Gambia's National Water and Electricity Company (NAWEC) is responsible for power supply in Gambia which was established in 1996 and Gambian government owns 97% of the company's stock.

Presently, number of employees in NAWEC is 1,671. Breakdown of number of employees are 245 in water supply sector and remaining is for the power supply sector. There are 40 engineers and 544 technicians in the power supply sector.

NAWEC is responsible for power supply to Banjul, the capital of Gambia and other six small scale provincial grids. NAWEC explained that national electrification rate is approximately 6% and growth rate of electricity demand is 5%. This means that expansion of electrical facilities leads increase of demand, therefore, when there is no expansion plan in a year, increasing rate of electricity demand is 0%. In fact, increase of power supply capacity means increase of electricity demand.

Power supply to Banjul is provided by three diesel power plants whose installed capacity are 81MW in total. The breakdown of installed capacity is Kotu Power Plant is 36MW, Brikama Power Plant No.1 is 36MW and Brikama Power Plant No.2 is 9MW. NAWEC introduced that maximum demand is 45MW and it usually occurs in October when it is the hottest in Gambia and daily peak load occurs in the evening.

NAWEC explained that overhead line is 300 km for 33 KV and 250 km for 11 KV. Underground cable is 30 km that is around 10 % of overhead line regarding transmission.

Gambia participates in the West African Power Pool (WAPP). However, they have no connection between their neighboring countries, such as Senegal.

NAWEC has 5 primary substations of 33/11 KV. The installed capacity is 55 MVA and each substation has 10 – 15 MVA capacity. The loss of transmission is around 23 % for both

commercial and technical categories. NAWEC does not compute the up-to-date SAIFI (The System Average Interruption Frequency Index) and SAIDI (The System Average Interruption Duration Index). According to the answer from NAWEC that was submitted after the mission, SAIFI=1.1 number of interruptions/year/customer, SAIDI=1.5 hour/year/customer.

Regarding management of power supply, NAWEC explained that load-flow operates manually at the Control Centre.

The electricity tariff is highly fixed (0.28 US$/kWh for household and 0.29 US$/kWh for commercial use) due to all power is generated by diesel plants and its fuel cost.

NAWEC stated that the electricity tariff concerning a grid of small scale for six provincial grids was the same as Banjul, the application system is however cheaper in the East Africa. NAWEC also mentioned that renewable sources of energy, such as solar energy or hydropower, would be needed in future although the initial cost is expensive. Meanwhile, prepaid system is adopted to collect rate in the six provincial areas.

(2) Challenges in Electric Sector

Electrical condition in Gambia is better than Liberia and Sierra Leone where the Mission has ever visited. Gambia developed electric facilities which is relatively small in scale and they have been well maintenance.

However national electrification rate remains low, primarily enhancement of power supply is the biggest challenge in Gambia.

In order to achieve the challenge, enhancement of power generation facilities, transmission and distribution network as well as development of operation technique and maintenance capacity represent an important issue in the sense of promoting a balanced development of human resources and technical capacity.

Additionally, NAWEC emphasized training needs of safety work on transmission and distribution network that is expected to increase the number of equipment and repair works in future.

(3) Training Needs and Training Courses

Based on the result of the questionnaire survey to NAWEC which conducted in August 2012, the Mission introduced that common theme of training course for three countries, which would be provided in the ECG Training Centre in Ghana, is selected as "Maintenance of Electrical Equipment" and "Protection and Control"

The Mission introduced concrete contents of training courses as follows; 1) "Maintenance of

Electrical Equipment" course will be provided to improve quality of maintenance works on electrical equipment for technicians and 2) "Protection and Control" course will be focused to professional and specific technique, so that target will be for engineers. NAWEC agreed the Mission's proposal.

The Mission also proposed that approximately five participants would be able to accept per one training course from Gambia. NAWEC insisted that five and up to 10 trainees could be dispatched. NAWEC explained that their work procedure is standardized in the organization and their daily routine work isn't interfered, if 10 trainees dispatch to training course.

The Principal indicated on his experience of the WAPP programme which had been carried out at the ECG Training Centre that Gambian trainees have good technical skills and background of organizational framework compared with Sierra Leone and Liberia and 10-participant from Gambia would be appropriate allocation in the course.

After the meeting with NAWEC, the Mission visited the Kotu Power Station and the Training Centre that is located beside the Kotu Power Station. And the Mission confirmed that capacity development including theoretical and practical skills for technicians and others is being provided actively in Gambia. Therefore, the Mission evaluated that maintenance and operations capacity would improve through the training courses are implemented.

6. Proposal of the training courses for the third countries

6.1 Proposal of the training courses

In advance of proposal of training courses, a comparative review between questionnaire survey in 2012 that had been conducted by the Short-term JICA Experts and this training needs survey was made and put the result in the Attachment-1. Items that are confirmed the necessity to improve technical capacity place a check mark in the table.

Result of this review, two training courses are proposed as follows; 1) "Training Course on Maintenance of Electrical Equipment for Technicians" that is covered all required contents and 2) "Training Course on Protection and Control for Engineers" which is focused to professional and specific technique. These training courses will be satisfied and covered with most of needs and requirements from the third countries. The followings are concrete contents of each training courses.

(1) Training Course for Technicians

As mentioned above in the section of 6.1 and each countries' report of (3) Training Needs and Training Courses in the chapter 5, training course for technicians is proposed that is focused on theme of Maintenance of Electrical Equipment and aimed to enhance and improve related techniques of the theme by theoretical and practical exercise. Since practical exercises are

important to develop/ improve technicians' skills, concentrating theme of the training course will be able to be acquainted with techniques.

The third counties' technicians are engaging in specialized works in their actual jobs. In view of this circumstance, following training course will be planned during 3-year of technical cooperation of JICA Electrical Engineering Training for African Countries (EETA) Project (Table 6.1-1).

Table 6.1-1 Proposed Training Course for Technicians

Year	Name (Subject)	Duration
First year:	Maintenance of Electrical Equipment (Skills on Overhead Line Jointing)	2 weeks
Second year:	Maintenance of Electrical Equipment (Skills on Underground Cable Jointing and Termination)	3 weeks
Third year:	Maintenance of Electrical Equipment (Maintenance and Inspection on Substations)	2 weeks

Table 6.1-2 shows overview of syllabus and curriculum for third countries' technician course (3-year framework).

Basic technique of equipment maintenance with a focus on preventive maintenance will be learned in the first half of the training course in every years using training material that is developed for the ECG Training Centre. Practical exercise will be carried out in the second half of the course. Practical exercise will be introduced ECG Training Centre's curriculum of the hands-on training and aimed to build up skills on maintenance work that is focused in a topic.

Table 6.1-2 Overview of Syllabus and Curriculum for Technicians' Training Course (3-year framework of the training course)

Year	Subject	Contents		
		1st week (Lecture)	2nd week (Exercise & Lecture)	3rd week (Exercise & Lecture)
1st	Skill on Overhead Line Jointing	-Basic of the Maintenance & Operation Technologies (Distribution System) -Procedure for Safe Operation	- Procedure for Safe Operation (How to Isolate Apparatus for Work/ Where to Earth Apparatus to Allow Work/ Reconnection of Apparatus) - Jointing Skills (Tension Wire Joint/ Non-tension Wire Joint/ Binding Joint)	**********
2nd	Skill on Underground Cable Jointing & Termination	- Basic of the Maintenance & Operation Technologies (Distribution system) - Procedure for Safe	- Procedure for Safe Operation (How to Isolate Apparatus	- Jointing Skills (11kV Cable Straight Joint/

Year	Subject	Contents		
		1st week (Lecture)	2nd week (Exercise & Lecture)	3rd week (Exercise & Lecture)
		Operation	for Work/ Where to Earth Apparatus to Allow Work/ Reconnection of Apparatus) - Jointing Skills (LV Cable Straight Joint/ LV Cable Termination)	11kV Cable Termination)
3rd	Maintenance and Inspection for Substations	- Basic of the Maintenance & Operation Technologies (Primary Substation) - Procedure for Safe Operation	- Procedure for Safe Operation (How to Isolate Apparatus for Work/ Where to Earth Apparatus to Allow Work/ Reconnection of Apparatus) - Methods of Equipment Inspection of Equipment (Main Transformer/ Circuit Breaker & Switchgear/ Metering Instrument/ Relay Testing & Setting/ Battery)	**********

Table 6.1-3 shows the draft syllabus of the training course on "Maintenance of Electrical Equipment (Skills on Overhead Line and Underground Cable Jointing)" for technicians.

Table 6.1-4 shows the draft syllabus of the training course on "Maintenance of Electrical Equipment (Maintenance and Inspection on Substations)" for technicians.

Table 6.1-3 Syllabus of the training course "Maintenance of Electrical Equipment (Skills on Overhead Line and Underground Cable Jointing)" for technicians (draft)

Category	Items	Contents
Overview of the power distribution equipment		
	Configuration of power distribution facilities	- Configuration of standard power distribution system for ECG and function of each equipment in distribution system
	Outline of ECG distribution facilities	- Trend in the amount of facilities and specification of equipment (to understand differences of facilities between ECG and each countries)
Overview of the deterioration of power distribution equipment		
	Deterioration of materials	- Stress on the power distribution equipment (Current, heat, atmosphere, ultraviolet light, external force) and basic condition of degradation of material (metal, insulation, concrete) - Thermal degradation of the insulator (Arrhenius law).
	Deterioration progress of equipment	- Show typical failure mechanism of power distribution equipment (Electric poles, support, wires, transformers, switchgear, insulators) to understand the point of degradation process - To introduce actual data of accident and deteriorated or faulty equipment
	Maintenance and preventive maintenance	- Significance of preventive maintenance, Relationship between inspection frequency and bathtub curve, reasonable maintenance planning.

Category	Items	Contents
Patrol and inspection		
	Patrol	- Types, frequency, method and point of attention - Management for emergency on the site conditions.
	Separation distance	- Separation distance from equipment during the patrol
	Inspection and patrol of each equipment 1) Overhead distribution facilities 2) Underground distribution facilities	- Point of the patrol and inspection on each equipment with showing degradation situation photos - Pole(Wooden/ concrete), insulators, pall switch, wires and pole transformer - Cables, termination box, junction box, pit, transformer, switch and ring main unit
Management of maintenance records for power distribution equipment		
	Management of power distribution equipment data	- Items to record (i.g. specifications, date of construction/repair) on each equipment. Overview of work flow of data management.
	Collection and recording of maintenance data	- Specific method for collection and recording of maintenance data.
	Analysis and utilization of data in distribution works	- Analysis of maintenance data (assessment of equipment status and defects) - How to reflect the result of data analysis to the maintenance plan or decision making of repair priorities - QC(Quality Control) approach method (PDCA cycle, Factual approach to decision making, Priority oriented, Upstream control)
Restoration of power distribution lines		
	Status of failures and faults of distribution lines	- Showing the number of distribution line faults, reclosing, SAIDI and etc., learn trend, background and challenges of faults and its countermeasure
	Type of fault	- Understand the feature of faults (Ground fault / short circuit and overhead/ underground lines)
	Causes of fault and countermeasures	- Case study some typical distribution line faults by classifying cause (maintenance deficiencies, nature, negligence, and contact) and explain prevention measures to them (maintenance or equipment upgrading)
	Restoration work flow	- Grasp of situation - Fault search and restoration procedure
	Fault location (Overhead lines)	- How the fault locator works and how to use it
	Fault location (Underground cables)	- How the fault locator works and how to use it
Operation and Management of distribution line		
	Line Voltage management	- Significance of voltage management from the point of view of power-supply quality (value management, unbalance, harmonics). - Overview of operational rules and procedure for voltage management. - Influence of the harmonic. - Learn calculation and value setting procedure of voltage regulator by practical training - Learn the proper use of voltage recorder for voltage management works(control value, unbalance, harmonics)
	Line Current management	- Overview of operational rules and procedures for current management - Learn proper use of voltage recorder for current management
Overview of operation and maintenance for power distribution equipment		
	Work flow of power distribution	- Work flow (planning, design, construction, and maintenance) and responsibility of power distribution in ECG

Category	Items	Contents
	Overview of maintenance works	- Overview of maintenance work (planning, patrol and inspection, construction and management)

Table 6.1-4 Syllabus of the training course "Maintenance of Electrical Equipment (Maintenance and Inspection on Substations)" for technicians (Draft)

Category	Items	Contents
Overview of the substation equipment		
	Outline of substation configuration and function of equipment	- Configuration of substation and major equipment (transformer, circuit breaker, disconnecting switch, instrument transformer, arrester, battery, protective relay, reactive power supplier and etc.) and function of each equipment
	Outline of ECG substation facilities	- Understanding Overview of specification of equipment and amount of equipment
Deterioration diagnosis about distribution transformer		
	Dissolved gas analysis of insulation oil	- Interpretation of dissolved gas analysis can presume the existence of failure that occurs inside the transformer, such as local overheating and partial discharge.
Patrol and inspection		
	Patrol	- Interpretation of types, frequency, method, confirmation items for each equipment and trouble response. (Including hands-on training)
	Periodical inspection	- Interpretation of inspection items, method and criteria of periodical inspection.
Management of substation equipment data		
	Restoration work flow	- Interpretation of typical alarm items (for fault indicator) for each substation equipment and the way of fault detection based on those alarms.
	Fault examples at ECG	- Introduction of fault examples (including the cause and the countermeasure) for substation equipment at ECG
Operation and Management of Power transformers		
	Overload operation of power transformers	- Policy of overload operation of transformers in consideration of remaining life
		- Transformer protection relay setting for overload operation

Then, number of participants of technicians' training course for three countries is allocated as below.

Table-5 Allocation of number of participants for technicians' training course (draft)

Year	Subject	Liberia	Sierra Leone	Gambia	Total
1	Skill on Overhead Line Jointing	3	3	6	12
2	Skill on Underground Cable Jointing & Termination	3	6	3	12
3	Maintenance and Inspection for Substations	4	4	4	12

(2) Training Course for Engineers

Training needs for Engineers was confirmed techniques on "Protection and Control" in this

needs survey as same as the Short-term JICA Experts had emphasized in the questionnaire survey 2012.

Especially, there has been a delay in the development/ restoration of transmission and distribution network in Liberia and Sierra Leone who are in the process of recovering from the civil wars. Due to shortage of skills and knowledge on protection and control, malfunction and faults of protection devices of distribution system have been occurred.

As a result of consideration on common technical challenges for three countries and urgency of assistance, following training course for engineers is proposed during 3-year of technical cooperation of JICA Electrical Engineering Training for African Countries (EETA) Project.

Training Course on Protection and Control for Engineers (Duration: 2 weeks)
(Actual training course will be carried out on the second and third year.)

Table 6.1-6 shows overview of syllabus and curriculum for third countries' engineering course.

Technologies on system protection based on fault analysis of electrical power system will be illustrated theoretically in the first half of the training course using training material that is developed for the ECG Training Centre. Practical exercise of methods on relay testing and setting will be carried out in the second half of the course using ECG Training Centre's curriculum and simulator.

In addition, facilities of new substation which will be constructed in the ECG Training Centre by JICA EETA Project, should be considered to utilize in practical exercises.

Table 6.1-7 shows the draft syllabus of the training course "Protection and Control (First Half: For Theory)" for Engineers.

Table 6.1-6 Overview of Syllabus and Curriculum for Engineers' Training Course (2-year framework)

Year	Subject	Contents	
		1st week (Lecture)	2nd week (Exercise & Lecture)
2nd and 3rd	Protection and Operation of Power System	- Theory of Power System Fault - Analysis and Application - Theory of Protection Relay - Theory of Protective Relay Setting and Coordination - Understanding of Fault Phenomena in Power System (Power System Faults	- Relay Setting Exercise of Basic Relays (Earth fault Over Current, Short circuit Over Current, Distance, Earth fault Directional, Differential-Transformer) - Relay Coordination Exercise (Short circuit Over Current, Distance, Main Protection and Backup Protection, In case of Generator Connection) - Relay Testing Exercise of Basic Relays

Year	Subject	Contents	
		1st week (Lecture)	2nd week (Exercise & Lecture)
		Demonstration using by Simulator)	

Table 6.1-7 Syllabus of third countries Engineers' training course on "Protection and Control (For Theory)" for Engineers (Draft)

	Category	Items
1	Overview of electrical power system	Overview of basic configuration & features of distribution and transmission systems
		Configuration of substation equipment
		Instrument transformers
2	Overview of protection relay systems	Role of line protection relay
		System of line protection relay
		Types of protection relays
3	Neutral grounding system	Purpose of neutral grounding system
		Comparison of neutral grounding system
4	Substation protection system	Transformer protection relay (current differential relay and various mechanical protection relays)
		Busbar protection relay (current differential relay)
5	Power transmission line protective relay system	Overview of the transmission line protective relay system
		Configuration of the protection system for power transmission system
6	Power line protection relay system	Overview of power distribution line protection relay system
		Short circuit protection
		Ground fault protection
		Distribution line circuit reclosing system (In substation and in transmission line)
7	Fault calculation	% Impedance by short-circuit fault current calculation
		Ground fault current calculation of resistance grounded system (single wire earth fault, 2-wire earth fault)
		abnormal voltage and current calculations in failure
		Practice (accident current / voltage)
8	Value setting of protection relay	About value setting of relay
		Setting the value of overcurrent relay (51S)
		Setting the value of distance relays
		Protection coordination of relays

Then, number of participants of engineers' training course for three countries is allocated as below.

Table 6.1-8 Allocation of number of participants for engineers' training course (draft)

Year	Subject	Liberia	Sierra Leone	Gambia	Total
2 & 3	Protection and Control	2	2	2	6

6.2 Points of concern to propose training courses

(1) Capacity limitations to financial burden for every electric power companies of third countries

Proposing training courses for the third countries, the Mission made efforts to build contents of training courses with consideration for circumstances of the third countries by visiting to Liberia, Sierra Leone and Gambia and exchanging ideas and information in advance.

1) Liberia has the lowest capacity to burden for the cost and extremely shortage of human resources. NPA can't afford to dispatch a number of engineers/ technicians to training courses with their regular work. Therefore, the proposal is allocated minimum number of participants for Liberia and is reduced their cost burden to the minimum.

2) Although Sierra Leone doesn't have enough capacity to cover the financial cost of training course as well as Liberia, they have higher motivation than Liberia to participate training course positively. It is proven from the experiences of WAPP Programme. Thus, the proposal is allocated a number of additional participants in the subject of the Underground Cable Jointing and Termination in the Maintenance of Electrical Equipment, due to a high percentage of underground cable in the transmission and distribution network.

3) As compared to two other countries, Gambia has little impact on to participate in the training courses in Ghana from the perspective of not only financing and human resources but also electrical facilities. But it is necessary to improve capacity of the maintenance of electrical equipment in order to enhance electrical facilities. The proposal is allocated to priority in the subject of overhead line jointing in the light of circumstances.

(2) Allocation of Seats for the Engineers Training Course

Subject on "Protection and Control" of engineers' training course is common theme of three countries to improve the current situation and the proposal is allocated two seats for each countries.

Meanwhile, technology on Protection and Control should not be shared with many engineers because of it is highly-professional and specialized. Therefore two engineers should be selected from each countries to the training course.

(3) Financing on implementation of training courses

In order to master maintenance technologies (repair work) on underground cable and overhead line, a dozen types and kinds works are needed to train. Parts charge will be necessary to implement practical exercises to master the techniques.

It is necessary to secure the budget for approximately 8 million US$ for the training of underground cable jointing and approximately 3,000 US$ for the training of overhead line for consumable supplies (jointing parts) for three years.

(Reference: Cost estimation is based on fare of materials (parts) will be purchased in Japan.)

a) Materials (parts) for underground cable jointing

- 30kV Cable : 1,000 (US$) x 3 (year) x 16 (trainee) = 4.8 million US$
- 10kV Cable : 500 (US$) x 3 (year) x 16 (trainee) = 2.4 million US$

  Subtotal: 7.2 million US$

b) Materials (parts) for overhead line jointing

- 50 (US$) x 3 (year) x 16 (trainee) = 2,400 US$

4) Syllabus and Curriculum for Technicians of ECG and Third Countries (Mar.2014)

The consultant Team submitted the Syllabus and Curriculum for Technicians of ECG and Third Countries as follows.
These results are the output of the joint working with the instructors of ECG Training Center from Sep.2013 to Mar.2014.

Training Course for Technicians of ECG

Course Title	"Maintenance Techniques for Power Equipment and Implementation Procedure"
・Duration	2days for distribution line equipment (5days in total)
・Targets of the Training	ECG technicians
・Aimed Result	Learn basic concept and basic knowledge of power distribution maintenance work and related equipment
・Textbook	(newly prepared)

< Syllabus(draft) >

Top article	Middle article	Contents	days
Orientation			0.2
1 Outline of Power Distribution Facilities			0.2
	1. Outline and Features of Power Distribution Facilities	-Configuration of standard power distribution system for ECG and number of distribution equipment	
	2. Outline of Equipment Constituting Power Distribution Facilities of ECG	-Learn outline of function and specification of main Distribution Equipment	
	3. Outline of Distribution System Protection	- Outline of protection system, composed with relays and fuses etc., in Power Distribution line against extraordinary current occurred by accidents and overload.	
2 Deterioration Mechanism of Power Distribution Equipment			0.2
	1. Deterioration of Insulation Materials	-Typical deterioration incidents(i.e. heat, voltage, salt etc.) of the power distribution equipment and their effects.	
	2. Deterioration Progress Mechanism of Distribution Equipment	-Typical deterioration steps to the fault occurrence on main distribution equipment(poles, transformers, wires, insulators) which helps understanding of deterioration progress mechanism.	
	3. Maintenance/Inspection and Preventive Maintenance	-Significance of preventive maintenance. General idea of life prolongation by Preventive Maintenance which is explained with using bathtub curve.	
3 Inspection and Preventative Maintenance of Distribution Lines			0.6
	1. Types of maintenance	-Types of maintenance works defined in the ECG.	
	2. Methods of Inspection and Preventative maintenance	-Check points and frequency of maintenance for main distribution equipment with showing degradation situation photos. -Learn how to deal with the Faulty Parts when they're Found(Sorting by Urgency).	
	1) Distribution transformers	-Transformer and related equipment.	
	2) Overhead lines	-Pole, wire, switchgear	
	3)MV Underground System	-Cable termination and related equipment(cable ,arrester ,earth wire).	
	3. Technologies for Power Cable Degradation Diagnosis	-Mechanism of degradation of XLPE cables. Learn outline of degradation diagnosis with DC Leakage Current Method and Dielectric Dissipation Factor Method .	
4 Management and Utilization of Maintenance Data			0.2
	1. Management of Data of Power Distribution Equipment	-Significance of data management of distribution equipment. Items to be recorded on each equipment(e.g. specifications, date of construction/repair).	
	2. Collection, Analysis and Utilization of Maintenance Data	-Outline of collection, analysis and utilization of maintenance data. Significance of data management for effective power distribution work.	
5 Distribution Line Faults and Fault Investigation			0.2
	1. Types of Faults	-Feature of faults by types(Overhead/Underground or MV/LV)	
	2. Fault Causes	-Give some typical cases of distribution line faults by classifying cause (maintenance deficiencies, nature, negligence and contact)	
	3. Measures to Prevent Faults	-General measures to prevent faults	
	4. Recovery from Fault	-Procedures when fault occurred.	
	5. Fault Investigation Techniques(Overhead lines)	-Out line of typical fault locators.	
	6. Fault Investigation Techniques(Cables)	-Principles of typical cable fault investigation methods.	

6 Procedure of Cable Fault Location			
	Practical procedure of cable fault location	Practical procedure with using cable fault locator	0.2
7 Operation and Management of Power Distribution System			
	1. Line Voltage Management	-Explain the significance of voltage management on the distribution line with showing standard values(Upper/Lower Limit of voltage, voltage drop available in each part of distribution line) provided in the ECG standard. -Measures for voltage regulation at substation and on the distribution line. -Measurement of user terminal voltage.	0.05
	2. Current Management	-Significance of Load management of distribution transformers. -Index, causes and measures of Harmonic distortion.	0.05
	3.Measurement/management of Earth resistance	-Significance and types of grounding in power distribution system. -Principal of earth resistance measurement.	0.1
8.Overview of the Substation Equipment			
	Outline of configuration and function of substation equipment	-Learn the configuration of major substation equipment (Transformers, Circuit breakers, Isolators, Instrument transformers, Arresters, Battery system, Protective relays, Reactive power supplier and etc.)and the function of each equipment	
	Outline of ECG's substation equipment	-Learn the basic specification of ECG's substation equipment and etc.	
9.The Deterioration Diagnosis about Power Transformer			0.2
	Dissolved gas analysis of insulation oil	-Learn about the relationship between the inside failure of the transformer, such as a partial discharge and local overheating, and pyrolysis gas of the	
10.Patrol and Periodical Inspection			
	Patrol	Learn about the types, frequency, method and confirmation items of the patrol for each equipment and trouble response.	0.2
	Periodical inspection	Learn about the inspection items, method and criteria of periodical inspection for each equipment.	0.4
11.Management of Substation Equipment Data			0.2
	Management of substation equipment data	Introduction of how to manage equipment data and maintenance information, such as inspection records, failure history, etc., that contribute to the efficient maintenance.	
12.Restoration of Substation Equipment			
	Failure of main substation equipment and Method of failure statistics	Explain the cause of failure based on the result of failure statistics of substation equipment and the method of failure statistics, and impress the importance of the failure statistics and fault analysis.	0.2
	Standard Information to be monitored and Fault Restoration of Substation	Explain standard information to be monitored learn about the fault restoration based on those information.	0.2
	Fault examples at ECG	Introduction of fault examples (including the cause and the countermeasure) for substation equipment at ECG	
	Countermeasure against human error	In order to prevent troubles by the human error at the time of inspection etc., explain the accident example of human error and impress the importance of preventive measures of human error.	0.2
13.Operation and Management of Power Transformers			
	Overload operation of power transformers	-Learn about the overload operation of transformers in consideration of remaining life -Lean about the relay setting of transformer protection in consideration of overload operation	0.2
14.Safety Management			

	Electrical safety practices and precautions for safety work	Learn about the electrical safety practices and precautions for safety work in substations, such as switching procedures, voltage check, working clearance, work area control, warning signs and etc.	0.4
TOTAL			5.0

Curriculum (Draft)

Training Course for Technicians of ECG

Course Title : Maintenance Techniques for Power Equipment and Implementation Procedure

Duration : five(5) days

Class size :

		1st	2nd	3rd	4th	5th
AM	1st	Orientation	Ditto (3.Overhead line/Underground Cable)	Outline of Substation Equipment	Patrol	Procedure of Restration
	2nd	Outline of Distribution Facilities	Management & Application of Maintenance Data	Ditto	Periodical Inspection	Prevention of Human Error
	3rd	Deterioration mechanism of Power Distribution Equipment	Distribution Line Faults and Fault Investigation	Ditto	Ditto	Overload Operation of Transformer
Lunch						
PM	4th	Inspection and Preventative Maintenance of Distribution Lines (1.Types and Methods)	Procedure of Cable Fault Location	Ditto	Data Management of Substation Equipment	Safety Management
	5th	Ditto (2.Transformer)	Operation and Management of Power Distribution System (1.Management of Voltage and Current, 2.Measurement of Earth Resistance)	Insulation Oil Analysis	Statistics & Analysis of fault	Monitoring and Evaluation

Training Course for Technicians of Third Countries (1st year)

- Course Title "Maintenance Techniques for Power Equipment (Overhead Line)"
- Duration 10days
- targets of the training Technicians from neighboring countries
- aimed result Learn basic concept and basic knowledge of power distribution maintenance work and related equipment
- textbook (newly prepared)

< Syllabus(draft) >

Top articl	Middle article	Contents	days
1 Outline of Power Distribution Facilities			0.2
	1. Outline and Features of Power Distribution Facilities	-Configuration of standard power distribution system for ECG and number of distribution equipment. Learn the difference of distribution system configuration between ECG and neighbour country.	
	2. Outline of Equipment Constituting Power Distribution Facilities	-Learn outline of function and specification of main Distribution Equipment.(Explained with using example of ECG's equipment)	
	3. Outline of Distribution System Protection	- Outline of protection system, composed with relays and fuses etc., in Power Distribution line against extraordinary current occurred by accidents and	
2 Outline of Deterioration and Maintenance of Power Distribution Equipment			0.2
	1. Deterioration of Insulation Materials	-Typical deterioration incidents(i.e. heat, voltage, salt etc.) of the power distribution equipment and their effects.	
	2. Deterioration Progress Mechanism of Distribution Equipment	-Typical deterioration steps to the fault occurrence on main distribution equipment(poles, transformers, wires, insulators) which helps understanding of deterioration progress mechanism.	
	3. Maintenance/Inspection and Preventive Maintenance	-Significance of preventive maintenance. General idea of life prolongation by Preventive Maintenance which is explained with using bathtub curve.	
3 Inspection and Preventative Maintenance of Distribution Lines			0.6
	1. Types of maintenance	-Types of maintenance works defined in the ECG.	
	2. Methods of Inspection and Preventative maintenance	-Check points and frequency of maintenance for main distribution equipment with showing degradation situation photos. -Learn the measures when Faulty Parts are Found.	
	1) Distribution transformers	-Transformer and related equipment.	
	2) Overhead lines	-Pole, wire, switchgear	
	3) MV Underground System	-Cable termination and related equipment(cable ,arrester ,earth wire).	
	3. Technologies for Power Cable Degradation Diagnosis	-Mechanism of degradation of XLPE cables. Learn outline of degradation diagnosis with DC Leakage Current Method and Dielectric Dissipation Factor Method .	
4 Management and Utilization of Maintenance Data			0.2
	1. Management of Data of Power Distribution Equipment	-Significance of data management of **distribution** equipment. Items to be recorded on each equipment(e.g. specifications, date of construction/repair).	
	2. Collection, Analysis and Utilization of Maintenance Data	-Outline of collection, analysis and utilization of maintenance data. Significance of data management for effective power distribution work.	
5 Fault Locating in Distribution Line and Restoration			0.2
	1. Types of Faults	-Feature of faults by types(Overhead/Underground or MV/LV)	

	2. Fault Causes	-Give some typical cases of distribution line faults by classifying cause (maintenance deficiencies, nature, negligence, and contact)	
	3. Measures to Prevent	-General measures to prevent faults	
	4. Recovery from Fault	-Procedures when fault occurred.	
	5. Fault Investigation Techniques(Overhead lines)	-Out line of typical fault locators.	
	6. Fault Investigation Techniques(Cables)	-Principles of typical cable fault investigation methods.	
6 Operation/Management of Power Distribution System			
	1. Line Voltage Management	-Significance of voltage management from the point of view of power-supply quality with regulated values(Upper/Lower Limit of voltage, voltage drop available in each part of distribution line). -Measures for voltage regulation at substation and in distribution line. -Measurement of user terminal voltage.	0.1
	2. Current Management	-Significance of Load management of distribution transformers. -Index, causes and measures of Harmonic distortion.	0.2
	3.Measurement/management of Earth resistance	-Significance and types of grounding in power distribution system. -Principal of earth resistance measurement.	0.1
7 Hands on training			
	Safety Skills & Procedure		
		Isolation to Allow Work	0.4
		Earthing to Allow Work	0.2
		Reconnection of Apparatus	0.4
	Key point & Method of Patrol		
		Lecture	0.6
		Practice of Patrol(Field)	0.4
	Practice of Remedy Work		
		Fixing Broken Tension Wire	0.6
		Fixing Broken Jumper	0.4
		Replacing Transformer	1.0
		Replacing Arrester	0.4
		Replacing Pin & Post Insulator	0.6
		Replacing Tension Insulator	0.6
		Erecting Tilted Pole	0.4
		Replacing Isolatior	0.6
		Replacing Primary Cutout	0.4
8 Site Visit			
	Primary Substation	-Learn outline of equipment and operation of Primary Substation	0.6
9 Guidance etc.			
	Orientation	on purpose and outline of the course	0.2
	Questionnaire for Evaluation	to measure the effect of the course	0.2
	Making Action Plan	to put the knowledge obtained throughe this course to practical use	0.2
		Total	10.0

Curriculum (Draft)

Training Course for Technicians of Third Countries

Course Title : Maintenance Techniques for Power Equipment (Overhead Line)

Duration : 10 days

Class size

		1st Week					2nd Week				
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
AM	1st	Orientation	Management & Application of Maintenance Data	Safety Skills & Procedure(1) (Isolation to Allow Work)	Key point & Method of Patrol (Lecture)	Practice of Remedy Work (Broken Tension Wire)	Practice of Remedy Work (Replacing Transformer)	Practice of Remedy Work (Pin & Post Insulator)	Practice of Remedy Work (Tension Insulator)	Practice of Remedy Work (Isolator)	Site Visit (Primary Substation)
	2nd	Outline of Distribution Facilities	Distribution Line Faults and Fault Investigation	Safety Skills & Procedure(2) (Isolation to Allow Work)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
	3rd	Deterioration Aspects and Mechanism of Equipment	Voltage Regulation of Distribution System(1)	Safety Skills & Procedure(3) (Earthing to Allow Work)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
PM	4th	Patrol & Inspection Technique (Line)	Voltage Regulation of Distribution System(2) /Load Management	Safety Skills & Procedure(4) (Reconnection of Apparatus)	Practice of Patrol (Field)	Practice of Remedy Work (Broken Jumper)	Ditto	Practice of Remedy Work (Replacing Arrester)	Practice of Remedy Work (Tilted Pole)	Practice of Remedy Work (Primary Cutout)	Making Action Plan & Questionnair for Evaluation
	5th	Patrol & Inspection Technique (Equipment)	Measuring Skill(Voltage, Current, Earth Resistance)	Safety Skills & Procedure(5) (Reconnection of Apparatus)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto

Training Course for Technicians of Third Countries (2nd year)

- Course Title: "Maintenance Techniques for Power Equipment (Underground Cable) "
- Duration: 15 days
- Targets of the Tra: Technicians from neighboring countries
- Aimed Result: Learn basic concept and basic knowledge of power distribution maintenance work and related equipment
- Textbook: (newly prepared)

Top article	Middle article	Contents	days
1 Outline of Power Distribution Facilities			0.2
	1. Outline and Features of Power Distribution Facilities	-Configuration of standard power distribution system for ECG and number of distribution equipment. Learn the difference of distribution system configuration between ECG and neighbour country.	
	2. Outline of Equipment Constituting Power Distribution Facilities	-Learn outline of function and specification of main Distribution Equipment.(Explained with using example of ECG's equipment)	
	3. Outline of Distribution System Protection	- Outline of protection system, composed with relays and fuses etc., in Power Distribution line against extraordinary current occurred by accidents and overload.	
2 Outline of Deterioration and Maintenance of Power Distribution Equipment			0.2
	1. Deterioration of Insulation Materials	-Typical deterioration incidents(i.e. heat, voltage, salt etc.) of the power distribution equipment and their effects.	
	2. Deterioration Progress Mechanism of Distribution Equipment	-Typical deterioration steps to the fault occurrence on main distribution equipment(poles, transformers, wires, insulators) which helps understanding of deterioration progress mechanism.	
	3. Maintenance/Inspection and Preventive Maintenance	-Significance of preventive maintenance. General idea of life prolongation by Preventive Maintenance which is explained with using bathtub curve.	
3 Inspection and Preventative Maintenance of Distribution Lines			0.6
	1. Types of maintenance	-Types of maintenance works defined in the ECG.	
	2. Methods of Inspection and Preventative maintenance	-Check points and frequency of maintenance for main distribution equipment with showing degradation situation photos. -Learn the measures when Faulty Parts are Found.	
	1) Distribution transformers	-Transformer and related equipment.	
	2) Overhead lines	-Pole, wire, switchgear	
	3) MV Underground System	-Cable termination and related equipment(cable ,arrester ,earth wire).	

	3. Technologies for Power Cable Degradation Diagnosis	-Mechanism of degradation of XLPE cables. Learn outline of degradation diagnosis with DC Leakage Current Method and Dielectric Dissipation Factor Method .	
4 Management and Utilization of Maintenance Data			0.2
	1. Management of Data of Power Distribution Equipment	-Significance of data management of distribution equipment. Items to be recorded on each equipment(e.g. specifications, date of construction/repair).	
	2. Collection, Analysis and Utilization of Maintenance Data	-Outline of collection, analysis and utilization of maintenance data. Significance of data management for effective power distribution work.	
5 Fault Locating in Distribution Line and Restoration			0.2
	1. Types of Faults	-Feature of faults by types(Overhead/Underground or MV/LV)	
	2. Fault Causes	-Give some typical cases of distribution line faults by classifying cause (maintenance deficiencies, nature, negligence, and contact)	
	3. Measures to Prevent Faults	-General measures to prevent faults	
	4. Recovery from Fault	-Procedures when fault occurred.	
	5. Fault Investigation Techniques(Overhead lines)	-Out line of typical fault locators.	
	6. Fault Investigation Techniques(Cables)	-Principles of typical cable fault investigation methods.	
6 Operation/Management of Power Distribution System			
	1. Line Voltage Management	-Significance of voltage management from the point of view of power-supply quality with regulated values(Upper/Lower Limit of voltage, voltage drop available in each part of distribution line). -Measures for voltage regulation at substation and in distribution line. -Measurement of user terminal voltage.	0.1
	2. Current Management	-Significance of Load management of distribution transformers. -Index, causes and measures of Harmonic distortion.	0.2
	3.Measurement/management of Earth resistance	-Significance and types of grounding in power distribution system. -Principal of earth resistance measurement.	0.1
7 Hands on training			
	1.Safety Skills & Procedure		
		Isolation to Allow Work	0.4
		Earthing to Allow Work	0.2
		Reconnection of Apparatus	0.4

	2.Cable Jointing Skill		
		LV Cable Jointing Skill (Straight)	1.0
		LV Cable Jointing Skill (Termination)	1.0
		11kV Cable Jointing Skill (soldering)	1.0
		11kV Cable Jointing Skill (Straight)	2.0
		11kV Cable Jointing Skill (Termination)	2.0
		33kV Cable Jointing Skill (Straight)	2.0
		33kV Cable Jointing Skill (Termination)	1.0
	3.Cable Testing Skill		
		Practice of Test & Fault Finding(11kV Cable)	1.0
8 Site Visit			
	Primary Substation	-Learn outline of equipment and operation of Primary Substation	0.6
9 Guidance etc.			
	Orientation	on purpose and outline of the course	0.2
	Questionnaire for Evaluation	to measure the effect of the course	0.2
	Making Action Plan	to put the knowledge obtained throughe this course to practical use	0.2
		Total	15.0

Curriculum (Draft)

Training Course for Technicians of Third Countries

Course Title : **Maintenance Techniques for Power Equipment (Underground Cable)**

Duration : **15 days**

Class size

		1st Week					2nd Week					3rd Week				
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
AM	1st	Orientation	Management & Application of Maintenance Data	Safety Skills & Procedure(1) (Isolation to Allow Work)	LV Cable Jointing Skill (Straight)	LV Cable Jointing Skill (Termination)	11kV Cable Jointing Skill (soldering)	11kV Cable Jointing Skill (Straight)	11kV Cable Jointing Skill (Straight)	11kV Cable Jointing Skill (Termination)	11kV Cable Jointing Skill (Termination)	Practice of Test & Fault Finding(11kV Cable)	33kV Cable Jointing Skill (Straight)	33kV Cable Jointing Skill (Straight)	33kV Cable Jointing Skill (Termination)	Site Visit (Primary Substation)
	2nd	Outline of Distribution Facilities	Distribution Line Faults and Fault Investigation	Safety Skills & Procedure(2) (Isolation to Allow Work)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
	3rd	Deterioration Aspects and Mechanism of Equipment	Voltage Regulation of Distribution System(1)	Safety Skills & Procedure(3) (Earthing to Allow Work)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto
PM	4th	Patrol & Inspection Technique (Line)	Voltage Regulation of Distribution System(2) /Load Management	Safety Skills & Procedure(4) (Reconnection of Apparatus)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Making Action Plan & Questionnaire for Evaluation
	5th	Patrol & Inspection Technique (Equipment)	Measuring Skill(Voltage, Current, Earth Resistance)	Safety Skills & Procedure(5) (Reconnection of Apparatus)	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto	Ditto

Training Course for Technicians of Third Countries (3rd year)

- Course Title "Maintenance Techniques for Power Equipment (Inspection on Substation)
- Duration 10days (2weeks)
- Targets of the Trai Newly employed technicians
- Aimed Result Learn about the basic knowledge of substation equipment and the way of the operation and maintenance
- Textbook (Newly prepared)

< Syllabus >

Top article	Middle article	Contents	Days
Orientation			0.2
1.Overview of the Substation Equipment			1.4
	Outline of configuration and function of substation equipment	Learn the configuration of major substation equipment (Transformers, Circuit breakers, Isolators, Instrument transformers, Arresters, Battery system, Protective relays, Reactive power supplier and etc.)and the function of each	
2.The Deterioration Diagnosis about Power Transformer			0.4
	Dissolved gas analysis of insulation oil	-Learn about the relationship between the inside failure of the transformer, such as a partial discharge and local overheating, and pyrolysis gas of the insulation oil	
3.Patrol and Periodical Inspection			
	Patrol	Learn about the types, frequency, method and confirmation items of the patrol for each equipment and trouble response.	0.4
		-The above hands-on training	0.6
	Periodical inspection	Learn about the inspection items, method and criteria of periodical inspection for each equipment.	0.6
		-The above hands-on training (33kV Power Transformers)	0.6
		-The above hands-on training (Circuit Breakers)	0.4
		-The above hands-on training (Isolators/Earthing Switch)	0.4
		-The above hands-on training (Instrument Transformers)	0.4
		-The above hands-on training (Arresters)	0.2
		-The above hands-on training (11kV Switch gears)	0.8
		-The above hands-on training (Battery System)	0.2
		-The above hands-on training (Over-current Relays)	0.2
		-The above hands-on training (Ratio Differential Relays)	0.4
		-The above hands-on training (Distance Relays)	0.4
4.Management of Substation Equipment Data			0.2
	Management of substation equipment	Introduction of how to manage equipment data and maintenance information, such as inspection records, failure history, etc., that contribute to the efficient	
5.Restoration of Substation Equipment			
	Failure of main substation equipment and Method of failure statistics	Explain the cause of failure based on the result of failure statistics of substation equipment and the method of failure statistics, and impress the importance of the failure statistics and fault analysis.	0.2
	Standard Information to be monitored and Fault Restoration of Substation	Explain standard information to be monitored learn about the fault restoration based on those information.	0.4
	Fault examples at ECG	Introduction of fault examples (including the cause and the countermeasure) for substation equipment at ECG	
	Countermeasure against human error	In order to prevent troubles by the human error at the time of inspection etc., explain the accident example of human error and impress the importance of preventive measures of human error.	0.2

6.Operation and Management of Power Transformers			
	Overload operation of power transformers	-Learn about the overload operation of transformers in consideration of remaining life	
		-Lean about the relay setting of transformer protection in consideration of overload operation	0.2
7.Safety Management			
	Electrical safety practices and precautions for safety work	-Learn about the electrical safety practices and precautions for safety work in substations, such as switching procedures, voltage check, working clearance, work area control, warning signs and etc.	0.4
		-The above hands-on training	0.8
		TOTAL	10.0

Curriculum (Draft)

Training Course for Technicians of Third Countries

Course Title : Maintenance Techniques for Power Equipment (Inspection on Substation)

Duration : 10 days

Class size

		1st Week					2nd Week				
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
AM	1st	Orientation	Outline of Substation Equipment	Patrol	Data Management of Equipment	Over Load Operation of Transformer	Safety Management (Operation procedure)	Periodical Inspection of 33kV Transformers	Periodical Inspection of 33kV Isolators/Earthing Switches	Periodical Inspection of 11kV Switchgears	Periodical Inspection of RDf
	2nd	Outline of Substation Equipment	Ditto	Ditto	Statistics & Analysis of Fault	Safety Management	Ditto	Ditto	Ditto	Ditto	Ditto
	3rd	Ditto	Ditto	Periodical Inspection	Fault Restration	Ditto	Patrol	Ditto	Periodical Inspection of Instrument Transformers	Ditto	Periodical Inspection of DZR
PM	4th	Ditto	Insulation Oil Analysis	Ditto	Ditto	Safety Management	Ditto	Periodical Inspection of Circuit Breakers	Ditto	Periodical Inspection of Battery	Ditto
	5th	Ditto	Ditto	Ditto	Prevention of Human Error	Ditto	Ditto	Ditto	Periodical Inspection of Arrester	Periodical Inspection of OCR	Monitoring and Evaluation

5) Syllabus and Curriculum for Engineers of ECG and Third Countries（Aug.2015）

－System Protection and Control Course

－Distribution Planning Course

<Overview of New Engineer Course>

- Course Title: System Protection and Control
- Duration: 1 Week (5 days)
- Target of Training: Newly Employeed Engineers
  To understand the basics of the protection system of the power system, and to learn the procedures of relay setting
- Text Book: (Newly prepared)

< Syllabus >

	Large Item	Middle Item	Contents
1	Overview of Electric Power System	Overview of basic configuration & features of Transmission and Distribution systems	Configuration and Characteristics of Transmission and Distribution system
		Configuration of Substation Equipment	Function of Substations, Types of substations, Busbar Arrangement, Main Substation Equipment and its Function
		Instrument Transformers	Purpose of Use, Structure of VT,CT, Operating Suggestions of VT,CT
2	Overview of protection relay system	Basic Objectives of Protection System	Basic Objectives of Protection System
		Configuration of Protection Relay System	System Configuration, Fail-safe System, Protection Zone and Blind Spot
		Type of Protection Relay System	Classification of Objectives, Type of Protective Relays, Type of detection method (Outline of Over-current, Directional, Distance, Differential Relay)
3	Neutral Grounding System	Objectives of Neutral Grounding	Overview of neutral grounding system
		Classification of Neutral Grounding System	-Overview of Each Method and Characteristics (Solidly, Resistance, Ungrounded grounding system) - Fault type and Vector Diagram of Voltage and Current for Each Neutral Grounding System - Voltage rise of Sound Phase at the time of Single line Ground Fault and Effective Grounding System
		Neutral Grounding System and Waveform of Voltage and Current	To understand how to analyze the fault and operating status of the protective relay, from the relay signal and the operating voltage and current waveforms which are recorded in the oscilloscope, when the system fault occurs.
4	Protection System for Substation	Transformer Protection System	Outline of Differential Relays and Mechanical Relays
		Bus Protection System	Characteristics of Bus Protection System, Bus Protection by Bus Configuration, Countermeasures against CT Saturation
5	Transmission Line Protection System	Outline of Transmission Line Protection System	- Outline of Transmission Line Protection System - Outline of Transmission Line Protection without Signal Transmission (Overcurrent, Distance, Directional Grounding Relays) - Outline of Transmission Line Protection with Signal Transmission (Pilot-wire, Current Differential, Directional Comparison, Phase Comparison Protection)
		Outline of High-speed Reclosing System	Purpose of High-speed Reclosing System and Outline of each method of reclosing
6	Distribution line Protection System	Outline of Distribution Line Protection System	Outline of Distribution Line Protection
		Short Circuit Protection	Outline of Short Circuit Protection (Overcurrent, Directional Overcurrent)
		Ground Fault Protection	Outline of Ground Fault Protection (Ground Overcurrent, Directional Ground, SEF[Sensitive Earth Fault Protection])
		Automatic Reclosing Equipment for Distribution Line	- Outline of Reclosing System of Distribution Lines - Reclosing System of Distribution Line in Japan
7	Fault Calculation	Fault calculation by the percent-impedance method	Outline of Percent impedance and Per-unit method and Exercise
		Impedance Map	Outline of Management of Impedance Map
		Fault calculation by the method of symmetrical components	Outline of Symmetrical Components and Fault Calculation Example
8	Relay Setting	Overview of Relay setting	Work flow of Relay Setting, Basic Policy of Relay Setting, General Consideration for Relay Setting
		Protection Coordination	Point of view for Time Coordination and Sensivity Coordination
		Example of Relay setting for Overcurrent relay	Example of Relay setting for Overcurrent relay
		Example of Relay setting for Distance Relay	Example of Relay setting for Distance Relay

Curriculum of "System Protection and Control" Training for ECG Engineer

DAYS	8:30am – 9:00am	9:00am – 10:00am	10:00am-10:15am	10:15am –12noon	12noon - 1pm	1pm – 3:30pm
Day 1	**Registration and Opening Ceremony**	0. Orientation 1. Overview of Electric Power System ***Name (lecturer):*** ***ING. George Hommey***	Snack Break	1. Overview of Electric Power System ***Name:*** ***ING. George Hommey***	Lunch Break	2. Overview of protection relay system ***Name:*** ***ING. George Hommey***
Day 2	3. Neutral Grounding System ***Name:*** ***ING. Rodnell Bilson***			4. Protection System for Substation (Transformer Protection System) ***Name:*** ***ING. Rodnell Bilson***		4. Protection System for Substation (Transformer Protection System) ***Name:*** ***ING. Rodnell Bilson***
Day 3	4. Protection System for Substation (Bus Protection System) 5. Transmission Line Protection System ***Name:*** ***ING. Rodnell Bilson***			5. Transmission Line Protection System ***Name:*** ***ING. Rodnell Bilson***		6. Distribution line Protection System ***Name:*** ***ING. Frank Osei Owusu***
Day 4	6. Distribution line Protection System ***Name:*** ***ING. Frank Osei Owusu***			7. Fault Calculation ***Name:*** ***ING. Frank Osei Owusu***		8. Relay Setting ***Name:*** ***ING. Frank Osei Owusu***
Day 5	8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel***			8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel***		8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***ING. Maxwell Graham*** ***Engr. Maxwell Essel*** Evaluation

Note: Name in bold means a name of Instructor

Annex-2. Curriculum for Third Countries "System Protection and Control" (First week)

DAYS	8:30am – 9:00am	9:00am – 10:00am	10:00am-10:15am	10:15am –12noon	12noon - 1pm	1pm – 3:30pm
Day 1	**Registration and Opening Ceremony**	0. Orientation 1. Overview of Electric Power System ***Name (lecturer):*** ***ING. George Hommey***	Snack Break	1. Overview of Electric Power System ***Name:*** ***ING. George Hommey***	Lunch Break	2. Overview of protection relay system ***Name:*** ***ING. George Hommey***
Day 2	3. Neutral Grounding System ***Name:*** ***ING. Rodnell Bilson***			4. Protection System for Substation (Transformer Protection System) ***Name:*** ***ING. Rodnell Bilson***		4. Protection System for Substation (Transformer Protection System) ***Name:*** ***ING. Rodnell Bilson***
Day 3	4. Protection System for Substation (Bus Protection System) 5. Transmission Line Protection System ***Name:*** ***ING. Rodnell Bilson***			5. Transmission Line Protection System ***Name:*** ***ING. Rodnell Bilson***		6. Distribution line Protection System ***Name:*** ***ING. Frank Osei Owusu***
Day 4	6. Distribution line Protection System ***Name:*** ***ING. Frank Osei Owusu***			7. Fault Calculation ***Name:*** ***ING. Frank Osei Owusu***		8. Relay Setting ***Name:*** ***ING. Frank Osei Owusu***
Day 5	8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***Engr. Maxwell Essel***			8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***Engr. Maxwell Essel***		8. Relay Setting (Practice using Simulator) ***Name:*** ***ING. Frank Osei Owusu*** ***Engr. Maxwell Essel*** **Evaluation**

Note: Name in bold means a name of Instructor

Annex-2. Curriculum for Third Countries "System Protection and Control" (Second week)

DAYS	8:30am – 10:00am	10:00am-10:15am	10:15am –12noon	12noon - 1pm	1pm – 3:30pm
Day 6	Introduction of the substation for the training ***Name (lecturer):*** ***ING.***	Snack Break	Fault calculation for relay setting of the substation (for short circuit) ***Name:*** ***ING.***	Lunch Break	Fault calculation for relay setting of the substation (short circuit) ***Name:*** ***ING.***
Day 7	Fault calculation for relay setting of the substation (for short circuit) ***Name:*** ***ING.***		Fault calculation for relay setting of the substation (for ground fault) ***Name:*** ***ING.***		Fault calculation for relay setting of the substation (for ground fault) ***Name:*** ***ING.***
Day 8	Instruction of distance relay of the substation and set or confirm the relay setting ***Name:*** ***ING.***		Characteristic test of distance relay (Practice using measuring instrument) ***Name:*** ***ING.***		Characteristic test of distance relay (Practice using measuring instrument) ***Name:*** ***ING.***
Day 9	Instruction of differential relay of the substation and set or confirm the relay setting ***Name:*** ***ING.***		Characteristic test of differential relay (Practice using measuring instrument) ***Name:*** ***ING.***		Characteristic test of differential relay (Practice using measuring instrument) ***Name:*** ***ING.***
Day 10	Instruction of overcurrent and earth fault relay of the substation and set or confirm the relay setting ***Name:*** ***ING.***		Characteristic test of overcurrent relay (Practice using measuring instrument) ***Name:*** ***ING.***		Characteristic test of overcurrent relay (Practice using measuring instrument) ***Name:*** ***ING.*** **Evaluation**

Note: Name in bold means a name of Instructor

Syllabus of【Distribution Planning】

・Course Title: Distrinution Planning
・Duration 3Days
・Target Trainee of the training: Newly engaged and young Engineer
・Aimed result : To understand the basic concept of power distribution planning work and to learn the
・Text: Newly Devoloped

「Distrinution Planning」 Syllabus

No.	Large item	middle item	Contents
1	Purpose and the outline of distribution planning tasks	・Aims of power distribution planning ・Implementation procedure of power distribution planning work	・Understanding the significance of the power distribution planning ・Explaining the key points of each element and the flow of the major implementation elements in the power distribution
2	Basic configuration and characteristics of distribution systems	・Basic configuration of distribution system ・Characteristics of different configuration of primary distribution system ・Loss generation characteristics of the low-voltage distribution systems	Organizing in viewpoint shown in the middle item the characteristics of distribution system which is basic information for forming proper facilities.
3	Configuration of distribution facilities in ECG (Reconfirmation)	Overview of the power distribution facilities	Understanding of the basic conditions and properties through Reconfirmation
		Configuration of Medium voltage (33 kV power distribution system.	Ditto
		Configuration of Medium voltage (11 kV) power distributuion system.	Ditto
		Configuration of Low voltage (400 V) power distributuion system.	Low voltage system including distribution transformer
		Configuration of all underground power distribution system	11kV and Low voltage system including distribution transformer
		Unit construction cost of standard facilities	Setting the standard unit construction cost of each voltage class and facilities installation manner. (Information about the unit price is not included in the text because of in-house information.)
4	Quality of power distribution	The following items should be considered as a constraint condition in order to appropriately form facilities.	
		electricity supply reliability	Understanding the definition in ECG or international standards
		voltage standards and regulation	Understanding the definition in ECG or international standards
		supply frequency	Understanding the definition in ECG or international standards
		Flicker	Understanding the definition in ECG or international standards
		Harmonics (Voltage wave distortion)	Understanding the definition in ECG or international standards
		Instantaneous power failure	Understanding the definition in ECG or international standards
5	Load characteristics of distribution lines	Indicators of demand characteristics	To understand the definition of load factor, demand rate, diversity factor etc.
		Load types and their characteristics	To describe the characteristics of various loads that compose the load curve of a distribution line. For example, the type of load (contract type, industry, etc.), examples of demand structure analysis by region. Based on this, to explain the relationship of diversity factor
6	Demand projection	Basic theory of demand projection	To understand the overview of projention methods such as assumption by the trend or correlation analysis etc.
		Examples of the specifically regional demand projection	To get better understanding of the methods based on concrete case of the demand forecast.
7	Analysis and Evaluation of System characteristics	・System Loss Analysis ・Voltage Regilation Analysis ・Fault Level Analysis	・Explaining the principle of power flow calculation and loss generation caracteristic of distribution system ・Explaining fault calculation method for the system with resistance erthing of neutral , and the application of the method for various system configulations (circuit topology) ・Explaining the voltage drop calculation method and voltage regulation technology for each voltage level
8	Reliability Analysis and evaluation of the distribution system	Reliability evaluation index	・Explaining the definitions of various reliability index and the significance of them. . ・Understanding the relation between each reliability index and equipment, and the method of utilizing an index.
9	Economic evaluation (Engineering Economics)	Economic calculation methods	Method of calculating present value considering interest rate (Engineering-Economy Method)
		Economic comparison (Applied Cost -benefit method)	Cost accounting method and Annual Value Model method
		Specifications of Economic calculation	Calculation period and expenses (facility-related costs, loss cost)
10	How to proceed with distribution facilities planning	Basic concepts	Issues to consider in the distribution planning such as ensuring availability and reliability (Reconfirmation)
		Expansion planning method	Bbasic policy for power distribution line expansion and detailed procedures
		Indicators for facility management	To understand objective indicators for measuring and analyzing actual demand, facilities, services and how to use these indicators. (Normal capacity and Emergency capacity , Divereity factor,

11	Exsercise of distribution planning	Following Exercises 1.Study of the proposed measures by engineering analysis. 2.Selection of the optimal plan using system analysis, profitability calculations and investment appraisals.)	1. Learning methods on the technical analysis by a system simulation using the real system , thereon considering the improvement plan based on simukation results. 2. Through the case studies using the model cases, understanding the way of thinking(concept of forming facilities and break even colculations) and investigation procedures of ECG.

JICA Programme for ECG Engineer Training on Distribution Planning

DAYS	8:30am – 10:00am	10:00am-10:15am	10:15am – 12noon	12noon - 1pm	1:00pm – 3:30pm
13/Jul /2015	1.Registration , Opening Ceremony 2.Questionnaire *ECG Training center*	Snack Break	1.Purpose and the outline of distribution planning tasks 3.Configuration of distribution facilities in ECG *Mr.George Edufu*	Lunch Break	2.Basic configuration and characteristics of distribution systems 4.Quality of power distribution *Mr.George Edufu*
14/Jul /2015	5.Load characteristics of distribution lines 6.Demand projection *Mr.Issah B.Majeed*		***7.Analysis and Evaluation of System characteristics*** *Mr.George Edufu*		7.Analysis and Evaluation of System characteristics *Mr.George Edufu*
15/Jul /2015	***7.Analysis and Evaluation of System characteristics*** *Mr.George Edufu*		8.Reliability Analysis and evaluation of the distribution system 9. Economic evaluation *Mr.Issah B.Majeed*		10.How to proceed with distribution facilities planning *Mr.Issah B.Majeed*
16/Jul /2015	11. Practice of planning 11-1 Demand Projection 11-2 Load flow / Optimization of networks *Mr.Issah B.Majeed*		11. Practice of planning 11-3 Technical losses estimation 11-4 Short circuit analysis *Mr.Issah B.Majeed*		11. Practice of planning 11-5 Reliability Analysis 11-6 Distribution automation) *Mr.Issah B.Majeed*
17/Jul /2015	11. Practice of planning 11-7 Economic Engineering *Mr.Issah B.Majeed*		Evaluation, Making Action plan, and Closing Ceremony *ECG Training center*		

6) Syllabus and Curriculum for Engineers of ECG (Feb.2016) —Distribution Design Course

< Course Title > Distribution Design

- Duration : 5Days
- Target Trainee : Newly engaged and young Engineer
- Aimed result : To understand the basic concept of power distribution design work and to learn the key points to implement the works.
- Text : Newly Developed

< Syllabus >

Items	Contents
1. Introductory Lessons	
	1-1 Purpose of the document
	1-2 What is required of a design engineer?
	1-3 An Overview of the Energy and Power Sectors
	1-4 The Core business of ECG
	1-4-1 The ECG Distribution Network
	1-4-2 Organizational Structure of ECG
	1-5 Responsibilities & job function of the design engineer
	1-5-1 Design Criteria & Equipment/material standardization
	1-5-2 Job function of the design engineer
2. General Design Considerations	
	2-1 Environmental considerations and data
	2-2 Design and construction parameters
	2-2-1 Loading calculations
	2-2-2 Safety factors
	2-2-3 System electrical data and insulation levels
	2-2-4 System internal clearances
	2-2-5 Clearance from ground
	2-2-6 Clearance from residential and other buildings
	2-2-7 Clearance from antennas, street lamps(on different pole), flag poles, advertising signs and other similar structures
	2-2-8 Minimum clearances to other power lines or overhead telecommunication lines
	2-3 Power quality standards (Voltage)
3. Overhead line designs	
	3-1 Mechanical designs
	3-1-1 Supports
	3-1-2 Foundations
	3-1-3 Stays
	3-1-4 Line conductor system
	3-1-5 Selection of pole length
	3-2 Electrical designs
	3-2-1 Line Constants of transmission / distribution line
	3-2-2 Theory on voltage drop calculations
	3-2-3 Power loss estimation
	3-3 General guidelines for design of overhead power distribution lines
	3-3-1 Selection of the line route
	3-3-2 Location of the pole positions (example in Japan)
	3-3-3 Basic points to follow in designing
	3-3-4 Measures for trees
	3-4 ECG standards of overhead line components
	3-4-1 Supports
	3-4-2 Line conductor
	3-4-3 Insulators and fittings
	3-5 Standard rules for overhead line design
	3-5-1 33kV standalone long feeder
	3-5-2 11kV standalone feeder
	3-5-3 11/33kV feeder added to existing network mesh, no space constraint route
	3-5-4 11/33kV feeder added to existing network mesh, space constraint route
	3-5-5 11/33kV feeder added to existing network mesh, space constraint route with houses too close to route or partially blocking the route
	3-5-6 Sectionalizing
	3-5-7 LV lines
	3-5-8 Low voltage service connections - simple rules

Items	Contents
4. Underground network designs	
	4-1 Roles and features of underground network
	4-1-1 Introduction
	4-1-2 Advantages and disadvantages of underground cable system
	4-1-3 Outline of insulated cables
	4-2 Components of an underground circuit
	4-2-1 Structure of underground line
	4-2-2 Distribution cable components
	4-2-3 Cable accessories
	4-3 The design criteria/parameters for underground network
	4-3-1 Road and railway conflicts
	4-3-2 Service and utility conflicts
	4-3-3 Standard Power Cables
	4-3-4 Short-circuit current capacity
	4-4 Cable network design
	4-4-1 Cable route design
	4-4-2 Cable installation methods
5. Substation designs	
	5-1 Types of Substations & their relevance to the ECG network
	5-1-1 Function of Substations
	5-1-2 Overview of substation Types
	5-2 Equipment constituting each type of substation
	5-2-1 Configuration of primary substation
	5-2-2 Configuration of Distribution substation
	5-3 Sizing of transformers and selection of installation location
	5-3-1 Primary substation
	5-3-2 Distribution substation
6. Protection & Earthing	
	6-1 Protection for substations
	6-2 Neutral Grounding System
	6-2-1 Objectives of Neutral Grounding
	6-2-2 Classification of Neutral Grounding System
	6-3 Protection for overhead line
	6-3-1 Transmission Line Protection System
	6-3-2 Protection for distribution line
	6-3-3 Recloser in overhead line
	6-3-4 Sectionalizer in overhead line
	6-4 Protection & Earthing for underground line
	6-5 Equipment earthing
	6-6 Lightning protection
	6-6-1 Necessity of lightning protection
	6-6-2 Lightning surge
	6-6-3 Lightning Protection Methods
	6-6-4 Lightning Arrester Installation
7. Power quality issues for a distribution network	
	7-1 Causes of voltage drop in a distribution network and ways of solving them.
	7-1-1 Factor of the voltage drop
	7-1-2 Improvement measures against voltage drop
	7-2 Voltage regulation technology
	7-2-1 Voltage Standard of ECG
	7-2-2 Voltage Regulation Methods
	7-3 Power quality management (improving) method
	7-3-1 Countermeasure against Salt contamination
	7-3-2 Phenomena of Flicker
	7-3-3 Reduction method of Harmonics distortion
8. Improvement of distribution network reliability	
	8-1 Configuration of the network
	8-1-1 Distribution Systems
	8-1-2 Configuration of Primary Distribution System
	8-2 Creation of redundancies in a network
	8-2-1 Setting the supply reliability level
	8-2-2 Measures to improve supply reliability
	8-2-3 Effect of redundancy in substation bus arrangement

JICA Programme for ECG Engineer Training on Distribution Design (Feb.2016)

DAYS	8:30am – 10:00am	10:00am-10:15am	10:15am – 12noon	12noon - 1pm	1:00pm – 3:30pm
15th Feb	- Registration - Opening Ceremony - Questionnaire *ECG Training center*	Snack Break	1. Introductory Lessons 2. General conditions and requirements for design 3. Overhead Line designs *3.1 Mechanical designs* *3.2 Electrical designs*	Lunch Break	3. Overhead Line designs *3.3 General guidelines for design of OHL* *3.4 ECG standard of OHL components* *3.5 Standard rules for OHL design* 4. Underground network designs
16th Feb	5. Substation designs *5.1 Types of Substations* *5.2 Equipment for each type of substations* *5.3 Sizing and Installation position of transformers*		6. Protection & Earthing *6.1 Protection & earthing for substations* *6.2 Neutral grounding system* *6.3 Protection & earthing for OHL*		6. Protection & Earthing *6.4 Protection & earthing for UGL* *6.5 Equipment earthing* *6.6 Lightning protection*
17th Feb	7. Power quality issues for a distribution network 8. Improvement of distribution network reliability		- Evaluation, - Making Action plan - Closing Ceremony *ECG Training center*		